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Climate Hazards and the Health-Remittance Trade-off: Experimental Evidence from Rural Bangladesh

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Keywords

remittances, health expenditures, climate vulnerability, natural experiment, instrumental variable estimation, dynamic stochastic optimization

JEL Classification

I15, F24, Q54

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JEL Classification: I15 – Health and Economic Development; F24 – Remittances; Q54 – Climate; Natural Disasters and Their Management; Global Warming

Keywords: Remittances; Health Expenditures; Climate Vulnerability; Natural Experiment; Instrumental Variable Estimation; Dynamic Stochastic Optimization

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1 Introduction

Three pressing global challenges intersect in a way that has profound implications for healthcare financing in developing countries: the reliance on out-of-pocket (OOP) health expenditures, the rise of remittances as a critical financial lifeline, and the growing impact of climate change on public health. Understanding how these forces interact is essential for designing sustainable health financing mechanisms in vulnerable regions.

First, in many developing countries, financing healthcare remains a formidable challenge due to the overwhelming dependence on OOP payments. In Bangladesh, for instance, nearly 70% of total health expenditure (TEH) is financed directly by households, a figure that surpasses even the regional average for South Asia (Global Burden of Disease Health Financing Collaborator Network, 2019). This financial burden forces many families to make difficult trade-offs—depleting savings, taking on debt, or forgoing essential care altogether (O'Donnell et al., 2008). Second, international migration and remittances have emerged as a crucial economic force in developing nations. Today, an estimated 258 million people live outside their country of birth, and the money they send home—totalling hundreds of billions of dollars annually—has significantly improved household incomes (World Bank, 2018)[1]. For many families, remittances represent a vital source of funding for healthcare, supplementing traditional coping mechanisms such as borrowing or asset liquidation (McIntyre et al., 2006). Studies have shown that remittances often translate into increased health expenditures, potentially improving access to care and health outcomes (Adams and Cuecuecha, 2010, 2013; Amuedo-Dorantes and Pozo, 2011).

However, a third factor complicates this dynamic: climate change. The health effects of climate change are particularly severe in low-income countries, exacerbating health disparities and increasing healthcare costs (Confalonieri et al., 2007; WHO, 2002, 2009). Extreme weather events—such as floods, cyclones, and heatwaves—place immense strain on public health infrastructure and increase disease burdens, particularly among vulnerable populations (Haines and Patz, 2004; Kovats and Haines, 1995). These additional health costs may force households to reallocate remittance income, reducing its effectiveness as a stable source of healthcare financing.

This paper seeks to answer a critical question: How do remittances and climate vulnerability interact in shaping household health expenditures? While existing studies have established that remittances contribute to increased healthcare spending, they have largely overlooked the role of climate stress in moderating this relationship. If remittances are increasingly diverted toward climate adaptation—such as rebuilding homes or fortifying infrastructure—households may find themselves less able to use these funds for healthcare.

To explore this question, I investigate how the exposure of migrant households to climate hazards alters the remittances-health expenditure relationship. By integrating economic, migration, and climate per-

[1]According to the World Bank estimates officially recorded remittances to developing countries will increase by roughly 11 percent to reach $528 billion (USD) in 2018. (https://www.worldbank.org/en/news/press-release/2018/12/08/accelerated-remittances-growth-to-low-and-middle-income-countries-in-2018)

spectives, this study contributes to a deeper understanding of the sustainability of remittance-financed healthcare in the face of escalating climate risks.

The precise mechanism through which climate vulnerability conditions the relationship between remittances and health expenditures is not obvious. However, a compelling hypothesis emerges: climate-induced financial pressures may cause a reallocation of remittance income, forcing households to make trade-offs between healthcare and adaptation costs. In principle, remittances possess attributes—predictability, stability, and accessibility—that align with the financial requirements for climate adaptation (Bendandi & Pauw, 2016). While traditionally viewed as a means to support household consumption and investment, remittances are increasingly recognized as a vital resource for climate resilience, particularly in highly exposed regions.

There is growing evidence that remittances are being steered—either by migrant households themselves or through policy initiatives—toward climate adaptation efforts. For instance, Australia and New Zealand have encouraged migrant workers participating in seasonal labor programs to allocate remittances toward adaptation expenditures in Pacific island nations (Maclellan & Mead, 2016). Empirical studies further suggest that remittance flows often contribute to investments in flood mitigation infrastructure, resilient housing, and improved drainage systems (IPCC, 2014). A study by Mahmud and Hassan (2018) corroborates this, showing that in the aftermath of extreme weather event Cyclone Sidr, remittances in Bangladesh have been utilized to finance private storm protection investments, such as home fortifications.

This raises a crucial question: to what extent does climate-induced financial stress divert remittances away from health expenditures? If households in climate-vulnerable areas must reallocate funds toward adaptation—effectively substituting long-term resilience investments for immediate healthcare needs—then the health benefits traditionally associated with remittances may be significantly attenuated. Preliminary anecdotal evidence suggests that this is already happening. A survey conducted by the non-profit organization Uttaran in Asashuni Upazila, a coastal region of Bangladesh severely impacted by Cyclone Amphan, revealed that many households coped with disaster-induced income shocks by cutting back on both consumption and healthcare expenses to finance adaptation efforts[2].

This possible substitutive relationship between adaptation and health expenditures suggests a complex and dynamic interplay between remittances and climate vulnerability—one that requires a more formal theoretical and empirical investigation. In the following sections, I develop a framework to rigorously examine how climate stress alters the remittances-health nexus and whether remittances can remain a sustainable source of healthcare financing in an era of increasing climate uncertainty.

2 Climate Vulnerability, Remittances, and Health Expenditures: Theoretical Context

In this section, I put forward a theoretical context for understanding the moderating role of climate hazards on the remittance-health expenditure nexus, as documented in the literature. In doing so I draw on economic theories of household resource allocation, the role of remittances as informal insurance, and climate-induced expenditure trade-offs to provide a structured framework for interpretation. The theoretical context elucidates the mechanisms through which climate stress may force households to reallocate remittance income—potentially diluting its intended health benefits. This framework serves as a critical bridge between the empirical evidence presented in the paper and the policy implications, offering a more nuanced understanding of how climate hazards interact with financial flows to shape household health expenditures in vulnerable regions.

2.1 Household Resource Allocation under Climate Stress

Households allocate income across multiple categories, including consumption, health, and adaptation expenditures. Climate-induced shocks introduce an additional constraint, altering the optimal allocation of remittance income. This aligns with Grossman's (1972) Health Capital Model, which posits that health is an investment good that yields future returns. However, when households face climate vulnerabilities, they may reallocate funds away from health investments toward adaptation needs.

[2] https://en.gaonconnection.com/bangladesh-coronavirus-covid19-poverty-water-food-security-amphan-cyclone/

The presence of climate vulnerability means that households are often forced to make difficult choices between maintaining current consumption levels, investing in long-term health improvements, and mitigating environmental risks (Dasgupta et al., 2009). Dasgupta et al. argue that climate vulnerability exacerbates economic insecurity by introducing unpredictable shocks to income, making it more difficult for households to engage in long-term financial planning. In such contexts, remittances serve as a crucial safety net, but their effectiveness in supporting health expenditures diminishes as households prioritize immediate adaptation measures. Dasgupta et al. highlights that households in high-risk areas often adopt coping mechanisms that trade-off health investment for short-term survival, such as reducing food intake, deferring medical expenses, or reallocating resources to reinforce housing structures. These findings align with the broader literature on consumption smoothing and expenditure substitution under climate stress, where climate-vulnerable households are more likely to divert financial inflows into adaptation rather than health-enhancing expenditures.

2.2 Remittances as a Coping Strategy

Remittances function as a form of informal insurance, smoothing consumption and investment in the face of income shocks (Lucas & Stark, 1985). Migration decisions are often motivated by risk diversification, and remittances serve as a financial buffer during adverse economic or environmental conditions. Yang and Choi (2007) demonstrate that remittances tend to increase in response to rainfall shocks, providing much-needed liquidity to affected households. However, when climate hazards impose high adaptation costs, remittance income may be diverted away from health spending to finance reconstruction and resilience-building measures (Bendandi & Pauw, 2016).

This substitution effect is particularly pronounced in regions where formal insurance mechanisms or social safety nets are weak (McKenzie & Sasin, 2007). Households may prioritize short-term disaster relief over long-term investments in human capital, such as healthcare and education. In some cases, remittances serve as a direct mechanism for funding infrastructural resilience, including reinforcing homes against floods or building storm shelters, which might reduce direct health expenditures but increase overall resilience to future shocks (Mahapatra et al., 2009). These trade-offs highlight the complex role of remittances, not only as financial inflows but also as strategic resources that households allocate in response to external vulnerabilities.

2.3 Climate-Induced Income Shocks and the Remittance-Health Nexus

Theoretical risk-sharing models (Dercon, 2004) suggest that households adjust their expenditure patterns in response to environmental shocks. Climate hazards exacerbate income uncertainty, prompting households to prioritize immediate adaptation over long-term health investments. This substitution effect leads to a decline in the marginal effect of remittances on health expenditures in climate-vulnerable households, a key finding of this study.

The interaction between climate shocks and household financial decision-making has been explored in multiple contexts. For instance, in Ethiopia, Hoddinott (2006) finds that households experiencing droughts adjust their expenditures away from education and healthcare towards food security. Similarly, Jha et al. (2018) find that in South Asia, exposure to climate risks significantly alters remittance usage patterns, often shifting funds from productive investments to short-term coping strategies. These findings align with our study, demonstrating that climate vulnerability acts as a mediator that weakens the traditional positive effect of remittances on health expenditures. Additionally, migration itself can be a response to climate stress, reinforcing the dependency on remittance flows (Black et al., 2011). However, when remittances are primarily used for adaptation expenses—such as fortifying homes against storms or securing alternative water sources—fewer resources remain available for health-related expenditures. This illustrates the dual function of remittances as both a safety net and an adaptation strategy, complicating their direct impact on household well-being.

3 Dynamic Stochastic Optimization Framework: The Model

Given the discussion in section 2, I formalize the theoretical context within a dynamic stochastic optimization framework to model the long-term trade-offs between health expenditures and adaptation spending under climate risk by incorporating uncertainty, inter-temporal decision-making, and household optimization behavior. The following section shows how the model can be structured:

A representative household maximizes its lifetime expected utility over consumption (C_t), health expenditures (H_t), and climate adaptation (A_t), subject to uncertainty in income and climate shocks:

$$\max_{\{C_t,H_t,A_t\}} \mathbb{E}\sum_{t=0}^{\infty}\beta^t U(C_t,H_t,A_t) \tag{1}$$

where:

- $U(\cdot)$ is the household's utility function, assumed to be increasing and concave in all arguments.
- $\beta \in (0,1)$ is the household's time discount factor, capturing the preference for current vs. future consumption.
- t indexes time.
- Expectation $\mathbb{E}$ accounts for stochastic climate shocks affecting household resources over time.

3.1 Budget Constraint

Each period, the household allocates its income between consumption, health, and adaptation:

$$Y_t + R_t = C_t + H_t + A_t \tag{2}$$

where:

- Y_t is stochastic domestic income (affected by climate shocks).
- R_t represents remittances received, which may respond to income and climate conditions.

Climate vulnerability introduces uncertainty in Y_t, making future income unpredictable.

3.2 Climate Risk Dynamics

Climate vulnerability (V_t) evolves based on adaptation investments:

$$V_{t+1} = (1-\delta)V_t - \gamma A_t + \xi_t \tag{3}$$

where:

- δ captures the natural rate of degradation of climate resilience.
- γ captures the effectiveness of adaptation spending in reducing vulnerability.
- ξ_t is a stochastic climate shock (e.g., a cyclone), following a probability distribution.

Higher A_t lowers future vulnerability but reduces current funds for health.

3.3 Health Investment and Productivity

Health status S_t^H is linked to both health expenditures and climate conditions:

$$S_{t+1}^H = f(H_t, V_t) + \eta_t \tag{4}$$

where:

- $f(H_t, V_t)$ captures how health expenditures improve health but are offset by climate vulnerability.
- η_t represents health shocks.

Better health increases future income-earning capacity and reduces medical costs.

3.4 Bellman Equation and Recursive Formulation

The household's dynamic problem can be solved using Bellman's equation, defining the value function:

$$V(Y_t, V_t) = \max_{C_t, H_t, A_t} U(C_t, H_t, A_t) + \beta \mathbb{E}[V(Y_{t+1}, V_{t+1})] \tag{5}$$

subject to:

- The budget constraint.
- The evolution of V_t and S_t^H.
- Stochastic income and climate shocks.

3.5 Bellman Equation with Explicit Utility Function

The household's value function is given by:

$$V(Y_t, V_t) = \max_{C_t, H_t, A_t} \left[\frac{C_t^{1-\sigma}}{1-\sigma} + \theta_H \frac{H_t^{1-\rho}}{1-\rho} + \theta_A \frac{A_t^{1-\tau}}{1-\tau} + \beta \mathbb{E} V(Y_{t+1}, V_{t+1}) \right] \tag{6}$$

where:

- $\sigma > 0$ controls risk aversion in consumption.
- $\rho > 0$ controls risk aversion in health expenditures.
- $\tau > 0$ controls risk aversion in adaptation expenditures.
- θ_H and θ_A are weights on health and adaptation in the utility function.
- $\beta \in (0, 1)$ is the household's discount factor.
- Expectation $\mathbb{E}$ accounts for stochastic changes in income and climate vulnerability.

3.6 Solution for Policy Functions

From the F.O.C. solving for the policy functions for H_t, A_t, and C_t:

$$H_t = \left(\frac{\theta_H}{\lambda_t} \right)^{\frac{1}{\rho}}, \quad \text{(Optimal health spending is positively related to remittance income.)} \tag{7}$$

$$A_t = \left(\frac{\theta_A}{\lambda_t \left(1 + \beta \gamma \mathbb{E} \frac{\partial V}{\partial V_{t+1}} \right)} \right)^{\frac{1}{\tau}}, \quad \text{(Adaptation spending is influenced by future climate vulnerability expectations.)} \tag{8}$$

$$C_t = \left(\frac{1}{\lambda_t} \right)^{\frac{1}{\sigma}}. \quad \text{(Consumption is determined by the shadow value of income.)} \tag{9}$$

3.7 Steady State Analysis

The steady state is where variables no longer change over time, i.e., the system has reached equilibrium. From the climate vulnerability equation (3) it is found that at the steady state:

$$V_{t+1} = V_t = V^* \tag{10}$$

Solving for steady-state vulnerability:

$$V^* = \frac{\gamma A^*}{\delta} \tag{11}$$

The steady-state values for *H, A* and *C* are:

$$H^* = \left(\frac{\theta_H}{C^{-\sigma}}\right)^{\frac{1}{\rho}}, \quad A^* = \left(\frac{\theta_A}{C^{*-\sigma}(1+\beta\gamma/\delta)}\right)^{\frac{1}{\tau}}, C^* = Y + R - H^* - A^*. \tag{12}$$

3.8 Log-Linearization of Health Expenditure

To log-linearize around steady-state values, define the percentage deviation of a variable X_t from its steady-state value X^* as:

$$\hat{X}_t = \frac{X_t - X^*}{X^*} = \ln X_t - \ln X^* \tag{13}$$

Taking log of the steady-state health expenditure equation and Log-linearizing it around H^*:

$$\hat{H}_t = \frac{1}{\rho}(\sigma \hat{C}_t) \tag{14}$$

Since C_t is a function of income and remittances:

$$\hat{C}_t = \alpha_Y \hat{Y}_t + \alpha_R \hat{R}_t - \alpha_H \hat{H}_t - \alpha_A \hat{A}_t \tag{15}$$

Solving for $\hat{H}_t$:

$$\hat{H}_t = \alpha_0 + \alpha_1 \hat{R}_t + \alpha_2 \hat{V}_t \tag{16}$$

where:

$$\alpha_1 = \frac{\sigma \alpha_R}{\rho}, \quad \alpha_2 = -\frac{\sigma\gamma}{\rho\delta} \tag{17}$$

Thus the model predicts the following relationships:

$$\frac{\partial H}{\partial R} > 0, \quad \frac{\partial^2 H}{\partial R \partial V} < 0 \tag{18}$$

- Remittances positively impact health:

$$\alpha_1 > 0 \tag{19}$$

- The impact of remittances on health decreases as climate vulnerability V rises, i.e., higher climate vulnerability reduces remittance effectiveness on health:

$$\alpha_2 < 0 \tag{20}$$

3.9 Empirical Model

To validate the theoretical predictions, the paper estimates an empirical equation of the following form:

$$H = \beta_1 R + \beta_2 V R + \text{controls} + \varepsilon. \tag{21}$$

where the expected sign of $\beta_2 < 0$, which is tested by using survey data from Bangladesh. The next section will briefly discuss the empirical strategy of the paper, followed by the literature review and the empirical findings.

4 Empirical Strategy: A Natural Experiment

The simultaneous nature of decisions related to migration, remittances, expenditure allocation, and healthcare poses a fundamental challenge in isolating the causal effect of remittances on health spending. A significant body of research has tackled this issue by employing instrumental variable (IV) techniques, using historical migration rates (Hildebrandt & McKenzie, 2005), municipal rainfall patterns (Lopez Cordoba, 2006), remittance transaction costs (Ponce et al., 2011), and distance to migration hubs (Amuedo-Dorantes & Pozo, 2011) as instruments. While these approaches offer valuable insights, they typically fall short in addressing non-random selection, limiting their ability to provide a true experimental measure of remittances' impact.

This paper advances the empirical literature in two key ways. First, it employs a natural experiment that simultaneously mitigates endogeneity and non-random selection biases—a methodological refinement largely absent in previous studies. By leveraging plausibly exogenous variation in remittances induced by weather shocks, this strategy enables a more robust causal identification of the remittances-health expenditure relationship. Second, it extends the literature by developing a theoretical framework that explicitly models the conditional impact of climate vulnerability on this relationship, an aspect that remains largely unexplored.

Climate hazards do not affect all regions equally, making it imperative to study their impact in highly exposed contexts. Bangladesh, a low-lying deltaic nation, is disproportionately vulnerable to climate-induced extreme weather events such as cyclones, storm surges, and floods (GCRI, 2019)[3]. The southern coastal regions, frequently battered by natural disasters, offer an ideal setting to examine how remittance-dependent households navigate trade-offs between health spending and climate adaptation.

Given that remittances are influenced by a range of factors—including economic opportunities abroad, transaction costs, and household needs—the challenge of endogeneity arises when estimating their effect on health expenditures. This study circumvents this issue by employing a natural experiment, using rainfall variability as an exogenous source of variation in remittance flows. Specifically, I construct an instrument that interacts deviations in district-level rainfall from historical trends with the distance of cyclone-affected migrant households to the nearest weather station. This interaction captures remittances' responsiveness to climate-induced income shocks, enabling a cleaner estimation of their effect on health expenditure.

The justification for this instrument is twofold. First, rainfall serves as a crucial determinant of agricultural income in monsoon-dependent economies like Bangladesh, where fluctuations in precipitation directly affect household earnings. Migrants from agricultural households are known to adjust remittance flows in response to such income shocks, making rainfall-driven remittance variation an effective instrument (Yang & Choi, 2007)[4]. Second, the interaction with distance to weather stations ensures that the instrument captures regional heterogeneity in climate exposure, further strengthening its exogeneity.

An additional advantage of this approach is that it minimizes concerns of reverse causality and measurement error—two common sources of bias in remittances-related studies. By exploiting rainfall deviations rather than household-level shocks, the instrument is unlikely to be influenced by unobserved household characteristics that simultaneously affect remittance receipts and health expenditures. Furthermore, this identification strategy addresses non-random selection by leveraging a natural shock—the landfall of Cyclone Roanu[5] in Bangladesh—which created quasi-random variation in the intensity of climate exposure among remittance-receiving households.

Using household health expenditures as the dependent variable, the instrumental variable results from primary data gathered from a survey in southern Bangladesh confirm that remittances significantly increase health spending. However, the effect is not uniform: households facing higher climate vulnerability exhibit a weaker remittances-health expenditure relationship. Specifically, for a one Taka increase in remittances, health expenditures rise by 0.24 Taka in the absence of climate hazards, but this impact diminishes significantly when climate vulnerability increases by one standard deviation.

The robustness of these findings is reinforced through multiple checks. Alternative specifications and instruments—including crop yield deviations—produce consistent results. Additionally, potential omitted variable bias is addressed by controlling for post-disaster expenditures, ensuring that adaptation costs financed by remittances do not confound the estimates. Further, I examine four alternative channels—domestic income fluctuations, competing household expenditures, labor market effects, and credit access—to rule out competing explanations for the observed patterns.

In contrast to previous studies that rely on IV strategies prone to selection bias, this paper provides an experimental measure of remittances' impact using a natural experiment, reducing both endogeneity and selection concerns. Furthermore, it theoretically and empirically models the role of climate vulnerability

[3]Global Climate Risk Index (GCRI) (2019) Who suffers Most from Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017, Bonn: Germanwatch e.V.

[4]The instrumentation strategy is similar to Yang and Choi (2007) but with a key difference: Yang and Choi (2007) use rainfall to instrument for income shock, I use rainfall to instrument for remittances.

[5]The Cyclone Roanu made its landfall on 21 May 2016 in southern coastal regions of Bangladesh (survey area) and the data for this project was collected during October-November 2016. The random assignment of treatment is achieved through multiplying the instrument with an indicator variable equal to one if the remittances-recipient household suffered losses due to the cyclone-Roanu and zero otherwise.

in shaping the remittances-health nexus, a dimension largely overlooked in existing research. By integrating insights from migration economics, climate adaptation, and health finance, this study offers a novel and rigorous approach to understanding how climate hazards mediate financial flows in developing economies.

5 Literature Review

In the health-remittance literature, there are typically two types of studies. The first type examines the impact of remittances on health expenditure, while the second focuses on health outcomes. The relationship between overseas remittances and health outcomes is less frequently explored in academic literature, which often concentrates on family health indicators such as infant mortality or child weight. Consequently, it is not immediately clear how remittance income affects health outcomes. Migration can disrupt family life and increase stress on the family members who remain behind.

On the other hand, remittances may relax income constraints and allow households to invest in human capital. Earlier studies have found that remittances often lead to investments in households' health and education (see; Adams, 2005 and 1998; Edwards and Ureta, 2003; Yang, 2005; Alderman, 1996). Besides, migration may allow households access to better healthcare information, reinforced by health expenditures financed by remittance income (Lopez-Cordova, 2006; McKenzie and Sasin, 2007).

Using retrospective data collected in Mexican communities located in central Mexico, Kanaiaupuni and Donato (1999) explore the effects of migration on infant mortality but finds that infant mortality increases as migration rates intensify. Similarly, Hildebrandt and McKenzie (2005) evaluate the impact of international migration on child health outcomes in rural Mexico and find that children in households with a migrant member are estimated to be less likely to die in the first year. Lopez Cordoba (2006), using a cross-section data of Mexican Municipalities, finds that increases in the fraction of households receiving international remittances are generally correlated with better schooling and health outcomes and reductions of dimensions of poverty.

Ponce et al. (2011) find no significant impact on long-term child health variables but observe that remittances impact preventive health activities and health expenditures in Ecuador. Amuedo-Dorantes and Pozo (2011) find that international remittances raise health care expenditures among remittance-receiving households in Mexico. Ambrosius and Cuecuecha (2013) find that being a substitute for credit remittances finance hospitalisation cost in case of a major health shock in the migrant family in Mexico. Valero-Gil (2009) considers the effect of remittances on the share of health expenditures in total household expenditure in Mexico and finds a positive and statistically significant effect of remittances on the household health expenditure. At the macro level, using a dataset on workers' remittances, health outcomes, and educational attainment of 122 developing countries from 1990 to 2015, Azizi (2018) finds remittances raise per capita health expenditures and reduces child mortality rate.

Decisions on migration, remittances, expenditure allocation, and health care are usually made simultaneously. A set of academic papers analyse the impact of international migration and remittances on health outcomes, taking the endogeneity problem into account. These studies have used different instruments as the identification strategy to address the endogeneity issue. Hildebrandt and McKenzie (2005) use historic state-level migration rates as an instrument, while Lopez Cordoba (2006) adopts municipal rainfall patterns and the distance to Guadalajara as instrumental variables. Acosta et al. (2008) create a counterfactual income prior to migration by multiplying remittances dummy with the second quintile of the income distribution to compare post-migration welfare. Ponce et al. (2011) exploit exogenous variation in the transaction costs of international transfer as an instrument for remittances to identify its causal effect on health. Likewise, Amuedo-Dorantes and Pozo (2011) use distance to U.S. border and U.S. wages in Mexican emigrant destination states as an instrument. Azizi (2018) uses bilateral remittances to create weighted indicators as instruments. While these instruments address the identification problem, it does not solve the problem of non-random selection. In the next section, I describe the detailed empirical strategy, followed by econometric results and sensitivity analysis.

6 Data, Empirical Results, and Analysis

6.1 Regression Equation of Interest

Building on the theoretical predictions developed in Section 3, the empirical model is specified as follows:

$$HEALTH_i = b_0 + b_1 REMIT_i + b_2 CLIMATE_i + b_3 (REMIT \times CLIMATE)_i + b_4 X_i + \mu_i \quad (22)$$

where $HEALTH_i$ represents household health expenditure (H in the theoretical model), modeled as a linear function of remittances, climate vulnerability, their interaction, and a set of household controls. The primary independent variable of interest is $REMIT_i$ (R in the theoretical model), which captures the average monthly remittances received by household i, measured in local currency (Taka).

The theoretical framework predicts that remittances alleviate liquidity constraints, allowing households to invest in health expenditures, despite the potential social and psychological costs associated with migration. Empirical literature supports this hypothesis, demonstrating that remittances often enhance household spending on health-related goods and services. Consistent with this, the coefficient on $REMIT_i$ (b_1) is expected to be **positive**, reinforcing the idea that remittance inflows lead to an increase in health expenditure.

The term X_i represents a set of household-level controls that account for demographic, economic, and social characteristics that may influence health spending. These include:

- Demographic factors: Household size, number of female family members, number of working female members, number of female students above the age of 7, and number of school-going children below 7.
- Migration-related factors: Number of overseas migrants in the household and the duration of their stay abroad.
- Economic characteristics: Acres of agricultural land owned and other household assets.
- Household head attributes: Age, education level, and occupational status.

Finally, μ_i is the error term, assumed to be independently and normally distributed, capturing unobserved heterogeneity.

6.2 Climate Vulnerability and Its Moderating Role

A key objective of this study is to assess whether the effectiveness of remittances in financing health expenditures varies with climate vulnerability. To do so, I introduce an interaction term $(REMIT \times CLIMATE)_i$ in the regression model and examine the significance of its coefficient.

- A negative coefficient on b_3 would suggest that the positive impact of remittances on health expenditures weakens as households face greater climate vulnerability, as predicted by the theoretical model. This would indicate a potential reallocation of remittance income toward climate adaptation, reducing its availability for health spending.
- Conversely, a positive coefficient would imply that remittances have a stronger impact on health expenditures in more climate-vulnerable households. However, given the theoretical predictions, such a result is not expected.

The variable $CLIMATE_i$ (V in the theoretical model) quantifies the degree of climate vulnerability faced by the household. Climate vulnerability is broadly defined as the *inability to anticipate, cope with, resist, and recover from climate-related shocks* (WHO, 2002, 2009). According to the Intergovernmental Panel on Climate Change (IPCC, 2007), vulnerability is determined by three dimensions:

1. Exposure – the extent to which households experience climate-related hazards.
2. Sensitivity – the degree to which these hazards impact livelihoods and well-being.
3. Adaptive capacity – the ability of households to mitigate and recover from climate shocks.

While these three dimensions offer a comprehensive framework, this study focuses on the "exposure" dimension, as it provides a tangible and measurable indicator of vulnerability at the household level (Adger, 1999).

6.3 Measuring Climate Vulnerability

To operationalize climate vulnerability, I adopt a metric widely used in climate risk assessments: *distance to the nearest cyclone shelter*. Households located farther from cyclone shelters are more *geographically isolated* and therefore face *higher exposure* to climate-induced hazards such as cyclones and storm surges.

This choice of metric aligns with prior studies on climate vulnerability in Bangladesh (Ahsan & Warner, 2014), which have identified key indicators such as:

- Percentage of households unwilling to evacuate to cyclone shelters.
- Percentage of households without access to a cyclone shelter or nearby safe structures.
- Frequency of extreme weather events experienced over the past five years.

Given these insights, I define $CLIMATE_i$ as the *distance (in kilometers) from household i to the nearest cyclone shelter*. A greater distance signifies *higher exposure to climate risks*, increasing the likelihood that remittances are redirected toward adaptation measures rather than health expenditures.

By incorporating this measure, the empirical analysis directly tests whether *climate-induced financial pressures alter the way remittances are allocated within households*, thereby moderating the remittances-health expenditure nexus. The findings will provide new insights into whether remittances can serve as a stable source of healthcare financing in climate-vulnerable regions, or whether their benefits are attenuated by the competing demands of climate adaptation.

6.4 Endogeneity

A major challenge in estimating the causal effect of remittances on health expenditure is endogeneity bias. This arises primarily due to reverse causality and measurement error.

Regarding reverse causality, migration and remittance decisions are often driven by household poverty and limited economic opportunities, which are also correlated with health expenditures. If poorer households with lower health spending are more likely to receive remittances, this downward biases the estimated effect of remittances on health expenditures. Measurement error also poses a concern, as remittance data is often self-reported, and lower numeracy among poorer households can result in misreporting. Systematic underreporting can further attenuate the estimated coefficient, biasing the results downward.

To address these concerns, this paper employs a natural experiment that exploits plausibly exogenous variation in rainfall as an instrument for remittances.

6.5 Natural Experiment

To mitigate endogeneity, I leverage a natural experiment that links exogenous variation in rainfall across three districts in southern Bangladesh with remittance-receiving households affected by the Cyclone Roanu.

6.5.1 Instrument Justification

Two empirical regularities support the validity of this natural experiment. First, *Rainfall-Remittance Relationship*: Remittances to rural households track the variability in local rainfall, which strongly influences agricultural production. Year-to-year fluctuations in precipitation impact Aman rice yields, a staple crop heavily dependent on monsoon rainfall (Anderson and Hazell, 1987; Government of Bangladesh, 2014; Sarker et al., 2017). As income from agriculture declines due to inadequate rainfall, overseas migrants often increase remittance transfers to offset household income shocks, a pattern observed in prior studies (Yang and Choi, 2007). This identification strategy follows Yang and Choi (2007) but differs in a key aspect: rather than instrumenting for household income, it instruments directly for remittances by leveraging rainfall fluctuations in the prior sowing season.

Second, *Cyclone-Triggered Remittance Surges*: Following natural disasters, migrants frequently remit additional funds to support affected households (Bragg et al., 2017; Mahapatra et al., 2012; Clarke and Wallsten, 2004). This study captures this effect by interacting annual rainfall deviations from historical trends with household distance from the nearest weather station with an indicator variable for households who were affected by Cyclone Roanu, ensuring that remittance flows are influenced by external climate shocks rather than household-level characteristics. This approach provides an experimental measure for remittances that minimizes omitted variable bias and selection concerns. This first-stage relationship is illustrated in Figure 1.

[Insert Figure 1, here]

6.5.2 Estimation Strategy

Using this instrument, I estimate the following two-stage least squares (2SLS) model:

$$HEALTH_i = b_0 + b_1 REMIT_i + b_2 CLIMATE_i + b_3(REMIT \times CLIMATE)_i + b_4 X_i + \mu_i \tag{23}$$

$$REMIT_i = \alpha + \beta(DIST_i \times RAIN_j) + \delta' X_i + \epsilon_i \tag{24}$$

where: $HEALTH_i$ is household health expenditure; $REMIT_i$ is the average remittances received. $CLIMATE_i$ is climate vulnerability (distance to cyclone shelters).

$DIST_i \times RAIN_j$ is the instrument, capturing rainfall deviation interacted with distance to weather stations. X_i represents a set of control variables (household demographics, education, and assets).

The first stage identifies exogenous variation in remittance flows, while the second stage estimates the causal impact of remittances on health expenditures.

6.5.3 Treatment and Control Groups

By multiplying the instrument with an indicator variable for cyclone-affected households, the natural experiment assigns households to the treatment group if they received remittances and were affected by Cyclone Roanu. The control group consists of remittance-receiving households that were unaffected by the cyclone. This design ensures comparability between groups and allows for a difference-in-differences interpretation.

To further account for selection bias, I include pre-treatment household characteristics such as household size, number of children, female-headed households, household head's age, education, occupation, household assets, income, and loan access. The validity of the results hinges on ensuring that treatment and control households are comparable in pre-treatment characteristics, which is assessed through balance tests (see Table 1).

[Insert Table 1, about here]

6.5.4 Identifying Assumption

The identification assumption is that the instrument – district-level rainfall interacted with cyclone-affected household's distance to the nearest weather station – affects household health expenditures only through remittances. However, rainfall affects all households in a local area, potentially influencing health expenditures through local economic conditions, violating the exclusion restriction. Local economic conditions, such as the labor market, income from other sources, and access to credit, might independently affect health expenditures. To ensure the study's robustness, the findings account for these potential channels that could contaminate identification.

6.5.5 Data and summary statistics

The data was collected through a household survey from three coastal districts in southern Bangladesh: Bhola, Barguna, and Patuakhali. These districts are the most affected by frequent cyclones, according to the Disaster Management Bureau (DMB) of Bangladesh. From each district, an Upazila (sub-district) was selected: Monpura from Bhola, Amtoli from Barguna, and Kalapara from Patuakhali. Two unions from each Upazila were identified based on the number of affected households from Cyclone-Roanu, which made landfall on May 23, 2016. Using the "Two-Stage Sampling Methods" and simple random sampling (SRS), two villages from each union were selected for the household survey. Systematic random sampling was then used to pick at least fifty households from each village, resulting in a sample size of 610 households. The survey began in October 2016 and was completed by November 2016.

The dependent variable is household health expenditure. The key independent variable is remittances received from the overseas migrant member, measured in thousands of Taka (local Bangladeshi currency). Other independent variables include household head's characteristics (age, education, and occupation); demographic information (household size, number of female members, number of female students age seven or above, number of children below seven, and number of children below seven years of age attending school); and various socio-economic characteristics (average monthly domestic income, average monthly health expenditures, average monthly food and housing expenditures, acres of agricultural land owned, amount of outstanding loan, access to clean water and sanitation, and ownership of other short-term assets).

Table 2 presents the summary statistics for 610 households used in the empirical analysis. Migrant households are those with overseas workers in October 2016. The 105 migrant households represent 17.2 per cent of the sample of households. The table begins with presenting the summary statistics of variables used in constructing the instruments. The rainfall measure reported is the deviation of average wet-seasonal rainfall in 2015 from its long-term trend is used for instrumenting remittances. The second variable is another instrument constructed as the deviation of the average yield of Aman rice from the trend. This variable is also used to check for robustness purpose. The rest of the table summarises all variables used in the empirical analysis.

[Insert Table 2, somewhere here]

6.6 Results

6.6.1 Instrumental Variable Approach

The results are presented in Table 3, starting with the OLS model, which is estimated as a baseline regression to compare the magnitude of bias, if any, with the IV results (see; columns 1). It is recognizable that OLS underestimates the effect of remittances on health expenditure. The downward bias is neither too large nor significant at 5 per cent. The rest of the regressions take an instrumental variable approach. [Insert Table 3, somewhere here] Table 3 presents the main results from the IV regressions. The first stage is presented in the lower panel of Table 3. Looking into the main coefficients of the first-stage of the IV regressions, few things are immediately noticeable. First, the instrument – interaction of rainfall and household's distance to weather stations – demonstrates a statistically significant effect on remittances. Second, the coefficient estimate of the instrument has a negative sign which is expected and confirms the first-stage relationship illustrated in Figure 1; a decrease in the instrument (lower rainfall than the historical trend) induces a positive effect on inflowing remittances. Third, the regressions are estimated with the primary variable of interest - remittances - measured in units of Taka and its log. In the regressions where REMIT is instrumented (columns 2, 4 and 5), the table shows that the estimated F-statistics on the excluded instrument are smaller than the conservative threshold of weak instruments of 9.6 suggested by Stock, Wright, and Yogo (2002). In practice, however, there is no clear critical value for the F-statistic to test for instrument relevance because it depends on many factors (Cameron and Trivedi, 2005, 2009). Furthermore, weak instruments are usually not a problem in just-identified models provided the instrument is significant in the first-stage (Angrist and Pischke, 2008, p. 209 and Angrist and Pischke, 2009)[6]. Likewise, Asatryan et al. (2017) justified their low first-stage F-statistics than the benchmark value of 10. Reassuringly, though, the regressions where the log of REMIT is instrumented, the F-statistics on the excluded instrument well exceeds the threshold level of the weak instrument. Therefore, with a high value of F-statistics at the first stage and the lowest RMSE, the IV regressions that instrument log of REMIT give the most reliable results on which the paper's conclusion are drawn.

The second-stage estimates are presented in the upper panel of Table 3. The most important result is the positive effect of remittances on household health expenditures; see columns 2-4. The effect is not only statistically significant but also substantively meaningful: A Taka increase in remittances income

[6] According to Angrist and Pischke (2008, page 209) and Angrist and Pischke (2009), as long as the first-stage coefficient is not zero, weak instruments are usually not a problem in just-identified models as the bias on the coefficient of the endogenous variable resulting from a weak instrument is not "serious". According to Angrist and Pischke (AP), any problems with too weak instruments in just-identified models are mirrored in the standard errors of the second-stage but they do not cause the second stage to be biased. This paper indeed shows significant second-stage effects; following the argument by AP this implies that the weak instrument does not seriously bias the effect of remittances. The key message in Angrist and Pischke (2009, page 1) is: "[...] bias with a just-identified model is not usually worth worrying about because if the instruments are so weak that just-identified IV is seriously biased, then you'll easily see the cosmic weakness of your first stage in such cases by virtue of large second-stage standard errors."

corresponds to a roughly 0.16 Taka (or 16 Paisa) increase in health expenditure (column 2). A 1% increase in the income from remittances leads to an increase of 25.27 Taka in health expenditure (column 3)[7]. As a further check, in column 4, the variable remittances per migrant worker is instrumented with no substantial change to the results. The results reveal the substantially positive role overseas remittances play in migrant households' allocation of health expenditure comparable to previous studies on the same topic. Furthermore, across the IV regressions in table 3, the control variables have the expected effect on health expenditure. Age, demography, asset holdings, education and occupation, are all found significant. To explore the heterogeneous effect of remittances conditional on climate vulnerability, the primary motivation of the paper, I include an interacted term between remittance and climate vulnerability. The estimated coefficient of the interaction should be negative and significant to confirm the conditioning role of climate vulnerability. Instrumenting directly for remittances and the log of remittances and controlling for the interaction term and its other constitutive part generates a negative and significant marginal effect reported in columns 5 and 6. The significant coefficient estimate captures the heterogeneous effect of remittances on household health expenditures, i.e., the marginal effect of remittances on health expenditures decreases as the level of climate vulnerability increases. In other words, remittances and climate vulnerability are complementary with regard to the impact of health expenditure.

Figure 2 illustrates the marginal effect of remittances at low, medium, and high levels of climate vulnerability, represented by the mean distance to cyclone shelter and one standard deviation below and above the mean. The first panel shows that the average marginal effect of remittances on health expenditure decreases, with slopes of 0.16, 0.04, and -0.10 for the three values, respectively. Specifically, an additional Taka in remittances increases health expenditure by 0.24 Taka in the absence of climate vulnerability but reduces it by 0.10 Taka if the household is one standard deviation away from the average distance to a cyclone shelter. The second panel shows that the marginal effect of remittances is positive for low levels of climate vulnerability but negative for greater distances from a cyclone shelter.

[Insert Figure 2, somewhere here]

The preferred model in column (6) shows that a 1% increase in remittances raises health expenditure by 38.01 Taka. The F-statistic (12.52) on the excluded instrument exceeds the critical threshold, and its RMSE is low compared to other estimates. Only REMIT or log(REMIT) is instrumented, not the interacted term, as the primary objective is to gauge the causal impact of remittances on health expenditure. In column (7), the interaction term is also instrumented for comparison, supporting the causal interpretation that remittances cause a heterogeneous effect on health expenditure through climate vulnerability.

6.6.2 Alternative Instrument

I also check the sensitivity of the results by employing an alternative instrument. I explore the available data on crop productivity in the study area to utilize it as an alternative instrument. Conceptually, remittances respond to rainfall only because the latter generates shocks to household's income through agricultural production. Therefore, the yield variability of the major rice crop Aman provides a credibly exogenous source of variation in remittances. Utilizing the deviation of Aman's annual yield from its trend as an instrument, I estimate the IV regression presented in column 9 of Table 3. The new instrument possesses a negative sign and significantly affects remittances, and the corresponding marginal effect of remittances is positive and significant in the second stage.

Using Aman yield variability as an alternative instrument has several implications for the study.

First, credible Exogenous Variation: The yield variability of the major rice crop, Aman, provides a credibly exogenous source of variation in remittances. This is because remittances respond to rainfall only because it generates shocks to household income through agricultural production. Second, robustness of Results: By utilizing the deviation of Aman's annual yield from its trend as an instrument, the study ensures that the results are robust. The new instrument possesses a negative sign and significantly affects remittances, and the corresponding marginal effect of remittances is positive and significant in the second stage. Third, addressing Endogeneity: The use of Aman yield variability helps address the endogeneity issue by providing an alternative instrument that is not directly related to the household's health expenditure but affects remittances through agricultural income shocks. Finally, employing Aman

[7]The model in column 3 where log of remittances is instrumented is easy to interpret and its first stage F-stat exceeds 9.6 threshold

yield variability as an alternative instrument allows for a sensitivity analysis of the results. This helps in verifying the robustness of the findings and ensures that the core results do not vary with different instruments for remittances.

Overall, using Aman yield variability as an instrument strengthens the study's identification strategy and provides more reliable and robust results.

6.6.3 Alternative Indicators of Climate Vulnerability

The criteria for measuring climate vulnerability by distance to cyclone centers can be extended. The United Nations Framework Convention on Climate Change (2018) recommends identifying vulnerable groups through geographical targeting based on specific criteria, such as arid lands, mountain regions, or remote areas. While distance to cyclone centers is one criterion, others include the household's distance to the nearest vehicular road and primary school. These indicators are used as a sensitivity test for the significance of remittances and the interaction term.

Table 4 presents the sensitivity results. The modeling improves, with most first-stage F-statistics exceeding the critical threshold, and the instrument is negative and significant. The causal impact of remittances remains positive, and the interaction terms with respect to distance to vehicular road and primary school are negative, indicating a falling marginal effect of remittances with these new indicators of climate vulnerability. The results remain unchanged when using the alternative instrument of rice yield, confirming the robustness of the core findings.

[Insert Table 4, somewhere here]

6.6.4 Potential Violation of Exclusion Restrictions

A significant concern is that rainfall affects all households in a local area, potentially influencing health expenditures through local economic conditions, thus violating the exclusion restriction criteria. Rainfall might impact household health expenditure independently of remittances by affecting local economic conditions, such as income from agriculture or fishing, other household expenditures, labor market conditions, and credit demand. For instance, sources of household income stemming from production activities related to agriculture or fishing can be directly affected by rainfall and other weather conditions. Similarly, rainfall-driven conditions can also affect other household expenditures, impacting spending on health care. Additionally, rainfall could influence the household's labor supply response and affect health expenditure independently of remittances via the local labor market condition. For example, inadequate rainfall may depress local labor market conditions, causing a household member to go further away for work, reducing demand for health care. Rainfall can also affect health expenditure independently of remittances through the credit channel, as weather-related conditions might generate greater demand for credit for either smoothing consumption or for other purposes such as health care costs.

To address these concerns, control variables for domestic household income, other expenditures, working adult members, and credit amount were included. The results in Table 5 show no significant impact of these variables on health expenditures, confirming that the effects of rainfall primarily work through remittances. The marginal effect of remittances remains stable, indicating no violation of the exclusion restriction criteria. Furthermore, the main results presented in columns 1-4 in Table 5 demonstrate that none of these variables directly affect health expenditures as they are not statistically significant, thereby relieving the estimations from the worry of any identification problem. The marginal effect of the log of remittances is stable, and so is the interaction term, indicating that there is no evidence of violating exclusion restriction criteria after controlling for these alternative channels. There is hardly any substantial impact on the signs or magnitudes of the marginal effects of remittances on health expenditure. [Insert Table 5, somewhere here]

6.6.5 Potential Implications of Adaptation Expenditures

Taking log of the steady-state adaptation expenditure equation (12) and Log-linearizing it around A^* and simplifying it shows that adaptation expenditure is directly affected by remittances income received by the household.

Therefore, omitting adaptation expenditures from the model biases the estimated effect of remittances on health expenditures. This is because adaptation expenditure is influenced by remittances and affects health expenditures through substitution, according to the theoretical model. If remittances increase both health and adaptation expenditures, and adaptation expenditures reduce health expenditures due to trade-offs in household budgeting, excluding adaptation expenditure leads to a downward bias in estimating the true effect of remittances on health. Moreover, since remittances are instrumented using rainfall-driven external shocks, and the instrument affects adaptation expenditure via remittance, the exclusion restriction is violated. Including adaptation expenditures controls for this indirect pathway, ensuring consistent estimation and preserving the validity of the instrumental variable strategy.

To address this, adaptation expenditure such as rebuilding and renovating damaged property in the aftermath of Cyclone Roanu is collected from the survey. Subsequently, I control for the amount (in thousands of local currency) of household's explicit expenditures on home improvement, including rebuilding work related to the house and the homestead area. The analysis finds no direct effect of post-Roanu adaptation expenditure on health expenditure. Additionally, there is no noticeable change in the estimated marginal effect of remittances (see column 5 in Table 5) and the interaction term. This alleviates concerns about omitted variable bias and exclusion restriction violations due to post-Roanu adaptation expenditures.

7 Conclusion

Previous studies have shown that while the effect of remittances on a household's health outcome, such as infant mortality, is ambiguous, the impact on health expenditure is positive and less equivocal. In this paper, I revisit the health expenditure and remittances nexus in light of the adverse impact of climate vulnerability.

This study offers the first integrated empirical and theoretical analysis of how remittances influence household health expenditures in the context of climate vulnerability. By leveraging a natural experiment based on rainfall variation and cyclone exposure in southern Bangladesh, the paper establishes a robust identification strategy to isolate the causal effect of remittances on health spending. The results confirm that remittances positively impact household health expenditures; however, the magnitude of this effect is significantly moderated by a household's exposure to climate risks. In particular, while remittances increase health spending by 0.24 Taka per Taka received in the absence of environmental stressors, this marginal effect declines by 0.10 Taka when climate vulnerability rises by one standard deviation, highlighting a non-linear and conditional relationship.

The findings are theoretically grounded in a model of resource allocation under climate stress and are robust across multiple specifications, instruments, and alternative measures of climate vulnerability. Importantly, the exclusion restrictions of the instrumental variable framework remain valid after accounting for competing channels such as changes in domestic income, labor market participation, and access to credit. These results demonstrate that the remittance-health expenditure link is contingent upon environmental conditions that affect household budgeting decisions—particularly in rural and hazard-prone areas where adaptation needs compete with health-related spending. In omitting adaptation expenditures, earlier studies may have overstated the welfare-enhancing role of remittances in such contexts.

The policy implications are urgent and multi-dimensional. Remittances play a vital but conditional role in financing healthcare in vulnerable economies like Bangladesh. Climate-related stress can distort this role, redirecting remittance flows toward coping and resilience-building measures at the expense of long-term health investment. Policymakers must, therefore, adopt a more integrated approach to climate and migration policy by promoting remittance-supported health insurance, improving physical access to healthcare in high-risk regions, and offering incentives for climate-resilient health investments. Without such interventions, the developmental promise of remittances could be partially undone by escalating climate pressures, particularly for the poorest and most exposed households.

Appendix: Tables

Table 1: Group Differences in Pre-treatment Household Characteristics (Treatment vs. Control)

VARIABLES	Treatment (Mean)	Control (Mean)	Difference in Mean (t-statistic)
Age	39.29	45.02	5.73 (1.90*)
Number of persons living in the house	5.89	7.00	1.11 (2.40**)
Number of female students	0.66	0.70	0.04 (0.26)
Number of females	0.53	3.40	2.74 (2.42**)
Number of children below 7	0.58	0.77	0.19 (1.29)
Number of children going to school below 7	0.34	0.42	0.08 (0.74)
House located near forest	1.65	1.74	0.10 (1.07)
Primary education	0.53	0.42	-0.11 (-1.14)
Secondary education	0.13	0.26	0.13 (1.67)
Higher secondary education	0.11	0.12	0.00 (0.05)
Religious school education	0.10	0.21	0.11 (1.63)
Farmer occupation	0.26	0.09	-0.17 (-2.14**)
Timber business	0.11	0.14	0.03 (0.40)
General business	0.15	0.21	0.06 (0.85)
Salaried job	0.13	0.07	-0.06 (-0.97)
Professional	0.00	0.02	0.02 (1.20)
Number of overseas migrants	1.16	1.09	-0.07 (-0.93)
Years living abroad	4.89	3.26	-1.63 (-3.17***)
Overseas remittances income	23266.13	29186.05	5919.92 (1.56)
Domestic income	31475.81	39813.95	8338.15 (1.76*)
Outstanding loans	6427.42	13255.81	6828.40 (1.74*)
Orchard owned	0.60	0.65	0.05 (0.56)
Agricultural land	252.83	336.95	84.12 (1.13)
Livestock owned	2.00	3.09	1.09 (1.74*)
Short-term assets (boat/vehicle/van)	1.08	0.28	-0.80 (-5.00***)

Table 2: Table 2 — Summary Statistics

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min – Max**
WEATHER				
Rainfall	3	275.518	16.715	251.82 – 288.37
Yield of Aman rice	3	0.584	1.331	-1.2 – 1.94
HOUSEHOLD HEAD (HH) CHARACTERISTICS				
Age	610	41.485	13.975	14 – 95
Age-squared	610	1916.016	1246.358	196 – 9025
HH EDUCATION				
Primary	610	0.441	0.497	0 – 1
Secondary	610	0.154	0.361	0 – 1
Higher Secondary	610	0.070	0.256	0 – 1
Madarasa	610	0.051	0.220	0 – 1
HH OCCUPATION				
Farming and Fishing	610	0.330	0.470	0 – 1
Wage earners	610	0.216	0.412	0 – 1
Shrimp farmer	610	0.305	0.461	0 – 1
Business	610	0.057	0.233	0 – 1
HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS				
Total members	610	5.761	2.290	1 – 18
Total female members	610	2.777	1.457	0 – 12
Working male members	610	1.713	0.886	0 – 7
Working female members	610	0.163	0.431	0 – 3
Children below 7 years	610	0.718	0.787	0 – 6
Children ¡7 attending school	610	0.338	0.556	0 – 3
Female children ¿= 7 attending school	610	0.675	0.804	0 – 7
MIGRATION AND REMITTANCES				
Overseas migrants	105	1.133	0.369	1 – 3
Years migrant abroad	105	4.219	2.703	0 – 15
Remittances per month	105	25690.48	19285.60	1000 – 150000
Log of remittances	105	9.906	0.768	6.907 – 11.918
Remittances per migrant	105	24273.02	19634.71	1000 – 150000
HOUSEHOLD FINANCIAL CHARACTERISTICS				

Table 2 — Summary Statistics (continued)

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min – Max**
Domestic income/month	610	16894.75	14656.47	0 – 150000
Food expenditure/month	610	6646.89	4137.53	700 – 45000
Housing expenditure/month	610	410.98	640.83	0 – 5000
Health expenditure/month	610	1648.77	1318.40	0 – 10000
Education expenditure/month	610	1922.95	2196.35	0 – 20000
Credit from NGO	610	22096.91	70034.37	0 – 1000000
HOUSEHOLD ASSETS				
Agriculture land	610	98.72	248.55	0 – 2660
Orchard	610	0.792	0.406	0 – 1
Poultry	610	0.543	0.499	0 – 1
Mechanised vehicle	610	0.226	0.419	0 – 1
Mechanised boat	610	0.382	0.486	0 – 1

Table 3: Remittances, Health Expenditure and Climate Vulnerability – I

Instrumented Variables	**(1) OLS**	**(2) 2SLS-IV**	**(3) 2SLS-IV**	**(4) 2SLS-IV**	**(5) 2SLS-IV**	**(6) 2SLS-IV**	**(7) 2SLS-IV**	**(8) 2SLS-IV**
REMIT	0.013 (0.007)*	0.164 (0.067)**			0.236 (0.092)***			
Log (REMIT)			2526.89 (856.14)***			3801.80 (1240.87)***		6067.85 (2304.74)***
REMIT per migrant				0.168 (0.069)**				
Log(REMIT) × CLIMATE							-4616.34 (2284.49)**	
Control Variables								
REMIT × CLIMATE					-0.151 (0.078)*			
Log(REMIT) × CLIMATE						-2337.71 (1006.34)**	-3961.85 (1640.57)**	
Log(REMIT)							4945.90 (2055.79)**	
CLIMATE					3472.46 (1783.64)*	23120.97 (9956.43)**	45385.21 (22580.15)**	39217.83 (16370.15)**
Constant	-850.84 (1494.80)	-3003.32 (1603.79)*	-23581.47 (7571.38)***	-4780.03 (1619.47)***	-6791.23 (2942.66)**	-37793.28 (12248.38)	-50236.21 (20983.81)**	-59977.13 (22764.66)***
No. of observations	105	104	104	104	104	104	104	104
Overall F (p-value)	267.48 (0.00)***	44.02 (0.00)***	44.29 (0.00)***	13.02 (0.00)***	166.09 (0.00)***	111.40 (0.00)***	170.87 (0.00)**	97.00 (0.00)***
Root MSE	1481.2	1916	1592	1894	1730	1503	1971	2026
FIRST-STAGE REGRESSION								
Rainfall × distance		-0.635 (0.281)**	-0.00004 (0.00001)***	-0.620 (0.279)**	-0.421 (0.162)**	-0.00003 (7.29e-06)***	0.00001 (9.28e-06)**	
Rice_yield × distance								-0.0036 (0.002)**
F-statistic on instrument		5.12	11.01	4.92	6.69	12.52	3.97	5.40

Note: Two-stage least square (2SLS-IV) regressions. Dependent variable is household's average monthly health expenditure in Taka. Robust standard errors clustered by village in parentheses. * Significant at 10%; ** at 5%; *** at 1%. All regressions include household controls: household size, female family members, working females, female students aged 7+, children under 7 in school, number of migrants, years abroad, agricultural land, short-term assets, and household head's age, education, and occupation. All regressions except column (8) use rainfall-driven instruments; column (8) uses rice-yield-based instrument.

Table 4: Remittances, Health Expenditure and Climate Vulnerability – II

Instrumented Variables	**(1) 2SLS-IV**	**(2) 2SLS-IV**	**(3) 2SLS-IV**	**(4) 2SLS-IV**	**(5) 2SLS-IV**	**(6) 2SLS-IV**
REMIT	0.133 (0.039)***	0.269 (0.123)**				
Log(REMIT)			2257.01 (683.45)***	4322.91 (1642.15)***	2946.82 (954.04)***	7087.53 (3136.33)**
Control Variables						
REMIT × Distance to Vehicular Road	-0.043 (0.020)**					
Distance to Vehicular Road	965.419 (2.06)**					
REMIT × Distance to School		-0.193 (0.108)*				
Distance to School		4101.91 (2365.65)*				
Log(REMIT) × Distance to Vehicular Road			-612.58 (389.44)		-899.899 (508.22)*	
Distance to Vehicular Road			5906.20 (3844.77)		8708.30 (5077.48)*	
Log(REMIT) × Distance to School				-3018.83 (1357.24)**		-5213.79 (2489.12)**
Distance to School				29585.67 (13420.87)**		51240.69 (24607.99)**
Constant	-3161.78 (1452.82)**	-7940.55 (3916.82)***	-21173.98 (6302.97)***	-43300.66 (16344.52)***	-27357.98 (8875.27)***	-70799.08 (31098.24)**
No. of observations	104	104	104	104	104	104
Overall F (p-value)	1397.61 (0.00)***	758.34 (0.00)***	127.23 (0.00)***	103.46 (0.00)***	85.94 (0.00)***	35.11 (0.00)***
Root MSE	1451	1857	1440	1554	1644	2182
FIRST-STAGE REGRESSION						

Note: Two-stage least square (2SLS-IV) regressions. Dependent variable is household's average monthly health expenditure in Taka. Robust standard errors clustered by village in parentheses. * Significant at 10%; ** at 5%; *** at 1%. All regressions include household controls: household size, female family members, working females, female students aged 7+, children under 7 in school, number of migrants, years abroad, agricultural land, short-term assets, and household head's age, education, and occupation. All regressions except (5) and (6) use rainfall-driven instruments; (5) and (6) use rice-yield-based instrument.

Table 4 - Remittances, Health Expenditure and Climate Vulnerability – II

Instrumented Variables	(1) 2SLS-IV	(2) 2SLS-IV	(3) 2SLS-IV	(4) 2SLS-IV	(5) 2SLS-IV	(6) 2SLS-IV
Rainfall × distance	-0.857 (0.203)***	-0.357 (0.139)**	-0.00005 (0.00001)***	-0.00002 (6.45e-06)***		
Rice yield × distance					-0.009 (0.002)	-0.003 (0.001)**
F-statistic on instrument	17.77	6.56	16.63	11.61	14.55	4.50

Note: Two-stage least square (2SLS-IV) regressions. Dependent variable is household's average monthly health expenditure in Taka. Robust standard errors clustered by village in parentheses. * Significant at 10%; ** at 5%; *** at 1%. All regressions include household controls: household size, female family members, working females, female students aged 7+, children under 7 in school, number of migrants, years abroad, agricultural land, short-term assets, and household head's age, education, and occupation. All regressions except (5) and (6) use rainfall-driven instruments; (5) and (6) use rice-yield-based instrument.

Table 5: Tests of the Exclusion Restrictions

Instrumented Variables	**(1) OLS**	**(2) 2SLS-IV**	**(3) 2SLS-IV**	**(4) 2SLS-IV**	**(5) 2SLS-IV**
Log (REMIT)	4374.02 (1439.75)***	3073.11 (1487.68)**	3811.85 (1247.13)***	3691.93 (1188.02)***	3828.88 (1472.04)***
Control Variables					
Log (REMIT) $\times$ CLIMATE	-2405.38 (983.88)**	-1952.73 (1084.54)*	-2343.41 (1006.25)**	-2249.51 (948.82)**	-2357.22 (1111.18)**
CLIMATE	23761.70 (9712.16)**	19373.84 (10653.13)*	23184.57 (9957.60)**	22251.51 (9395.24)	23311.82 (10973.80)**
Domestic Income	-0.033 (0.021)				
Other expenditure		0.128 (0.115)			
Working members in household			-49.162 (291.51)		
Credit from microfinance institutions				0.004 (0.008)	
Post cyclone-Roanu home improvement expenditure					0.001 (0.017)
Constant	-42891.12 (13927.88)***	-31149.62 (14507.50)**	-37961.39 (12381.23)***	-36795.56 (11818.99)***	
Number of observations	104	104	104	104	104
Overall F (p-value)	94.12 (0.00)***	746.42 (0.00)***	149.67 (0.00)***	759.28 (0.00)***	555.53 (0.00)***
Root MSE	1531	1351	1505	1481	1509

Note: Two-stage least square (2SLS-IV) regressions. Dependent variable is household's average monthly health expenditure in Taka. Robust standard errors clustered by village in parentheses. * Significant at 10%; ** at 5%; *** at 1%. All regressions include household controls: household size, female family members, working females, female students aged 7+, children under 7 in school, number of migrants, years abroad, agricultural land, short-term assets, and household head's age, education, and occupation. All regressions except column (5) use rainfall-driven instruments; column (5) uses rice-yield-based instrument.

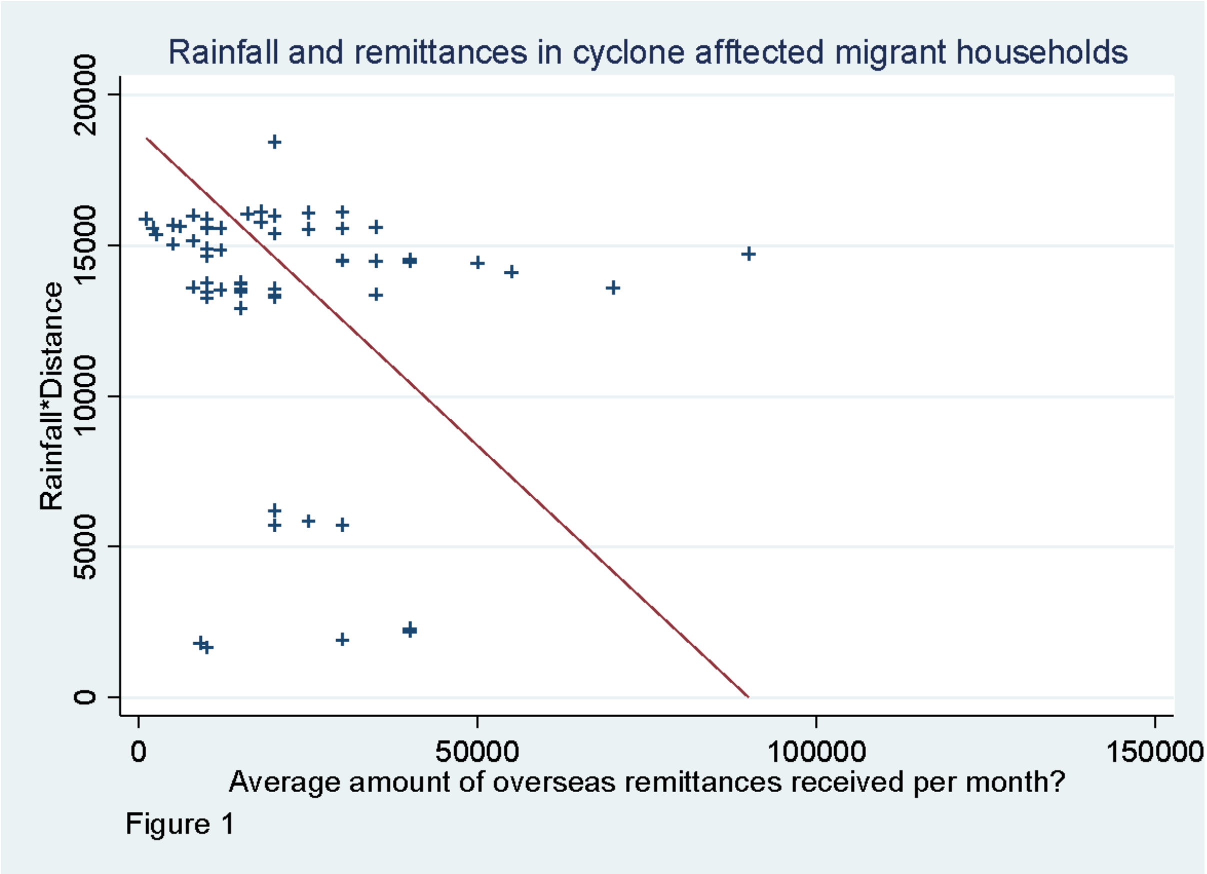

Figure 1: Rainfall and Remittances

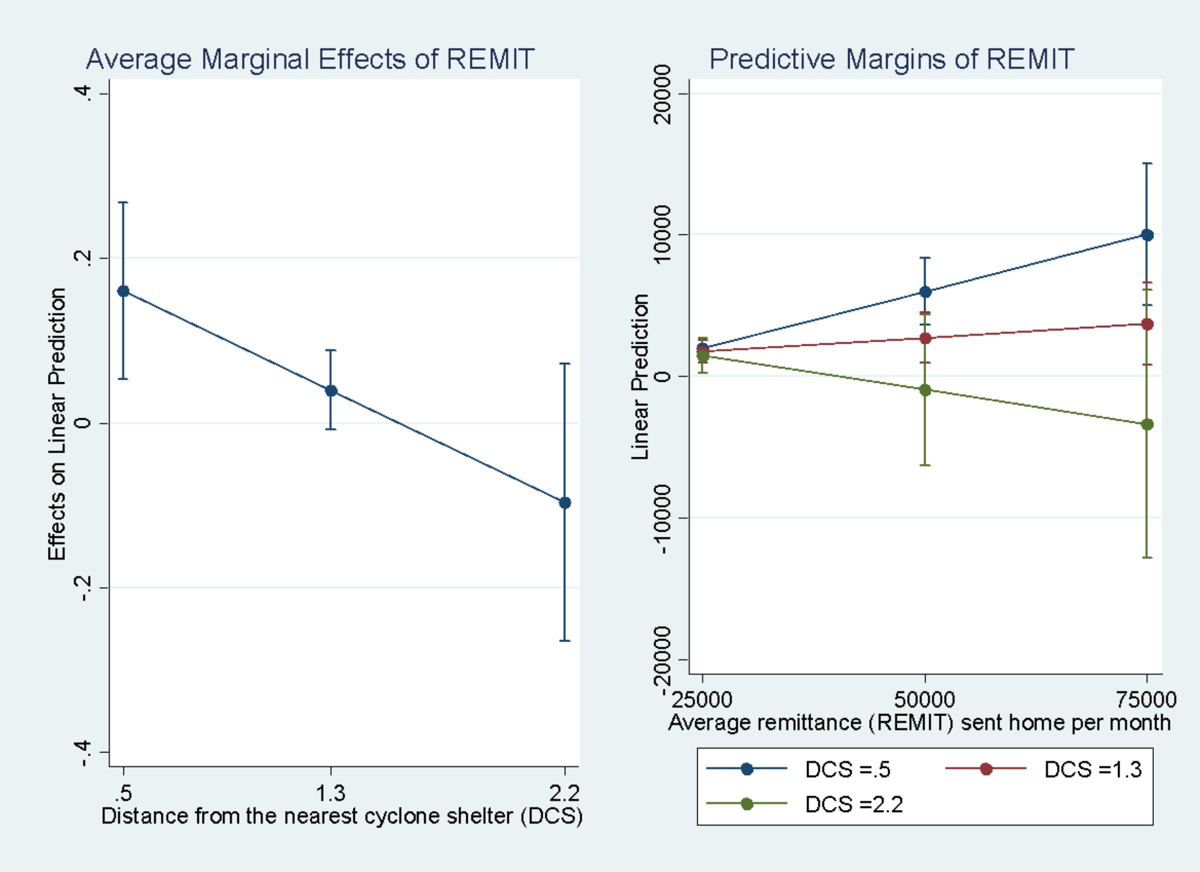

Figure 2: Marginal Effects of Remittances

Declarations

Ethical Approval: Survey design was approved by an ethics committee

Funding: Not Applicable

Availability of Data and Materials: Data has been collected from primary sources using a survey design. The questionnaire, data file and associated codes to replicate the results can be accessed from the corresponding author by emailing at `gazi.hassan@gmail.com`.

References

[1] Acosta, P., Fajnzylber, P., Calderon, C., Lopez, H. (2008). Do Remittances Lower Poverty Levels in Latin America? In P. Fajnzylber, H. Lopez, In Remittances and Development: Lessons from Latin America (pp. C4: 87-132). Washington, D.C.: World Bank.

[2] Adams Jr, R. H. (1998). Remittances, investment, and rural asset accumulation in Pakistan. Economic Development and Cultural Change, 47: 155-173.

[3] Adams Jr, R. H., Cuecuecha, A. (2013). The impact of remittances on investment and poverty in Ghana. World Development, 50: 24–40.

[4] Adams Jr, R., Cuecuecha, A. (2010). Remittances, household expenditure and investment in Guatemala. World Development, 38: 1626–1641.

[5] Adams Jr, R., Page, J. (2005). Do international migration and remittances reduce poverty in developing countries? World development, 33:1645-1669.

[6] Adger, W. (1999). Social vulnerability to climate change and extremes in coastal Vietnam. World Devevelopment, . World Devevelopment, 27:249–69.

[7] Alcaraz , C., Chiquiar , D., Salcedo, A. (2012). Remittances, schooling, and child labor in Mexico. Journal of Development Economics, 97, 156-165.

[8] Alderman, H. (1996). Saving and economic shocks in rural Pakistan. . Journal of Development Economics, 51: 343-365.

[9] Ambler, K., Aycinena, D., Yang , D. (2015). Channeling remittances to education: a field experiment among migrants from El Salvador. American Economic Journal: Applied Economics,, 7: 207-232.

[10] Ambrosius, C., Cuecuecha, A. (2013). Are remittances a substitute for credit? Carrying the financial burden of health shocks in national and transnational households. World Development, 46: 143–152.

[11] Amuedo-Dorantes, C., Pozo, S. (2011). Pozo, S. New evidence on the role of remittances on health care expenditures by Mexican households. Review of Economics of the Household, 9, 69–98.

[12] Anderson , J., Hazell, P., Evans, L. (1987). Variability of cereal yields: Sources of change and implications for agricultural research and policy. Food Policy, 12: 199-212.

[13] Angrist, J. D., Pischke, J. S. (2009). A note on bias in just identified IV with weak instruments. London: London School of Economics.

[14] Angrist, J., Pischke, J. (2008). Mostly harmless econometrics: An empiricist's companion. Princeton: NJ: Princeton University Press.

[15] Asatryan, Z., Bittschi, B., Doerrenberg, P. (2017). Remittances and public finances: Evidence from oil-price shocks. Journal of Public Economics,, 155: 122-137.

[16] Azizi, S. (2018). Azizi S (2018) The impacts of workers' remittances on human capital and labor supply in developing countries. Economic Modelling, 75:377–396.

[17] Bangladesh, Government of. (2009). Global Climate Change: Health Impacts on Bangladesh. Pocket Book 2009. Dhaka: Ministry of Health and Family Welfare .

[18] Bangladesh, Government of . (2014). Bangladesh Economic Review. Dhaka: Ministry of Finance, Bangladesh.

[19] Bendandi, B., Pauw, P. (2016). Remittances for Adaptation: An 'Alternative Source'. In A. Milan , B. Schraven , K. Warner, N. Cascone, Migration, risk management and climate change: evidence and policy responses (Global Migration Issues (pp. 195-211). Berlin: Heidelberg: Springer.

[20] Bragg , C., Gibson , G., King , H., Lefler, A. (2018). Remittances as aid following major sudden-onset natural disasters. . Disasters, , 42: 3-18.

[21] Cameron, A. C., Trivedi, P. (2005). Microeconometrics: methods and applications. New York: Cambridge University Press.

[22] Cameron, A., Trivedi, P. (2009). Microeconometrics Using Stata . College Station, Texas: STATA Press.

[23] Chiodi, V., Jaimovich, E., Montes-Rojas, G. (2012). Migration, remittances and capital accumulation: Evidence from rural Mexico. Journal of Development Studies, 48:1139-1155.

[24] Clarke, G., Wallsten, S. (2004). Do remittances protect households in developing countries against shocks? Evidence from a natural disaster in Jamaica. Washington D.C: World Bank.

[25] Confalonieri, U. e. (2007). Human health. In M. e. Parry, Climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. (pp. 391–431.). Cambridge: Cambridge University Press.

[26] Eckstein, D., Hutfils, M., Winges, M. (2018). Global Climate Risk Index 2019: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017. Bonn: Germanwatch Nord-Süd Initiative eV.

[27] Edwards, A., Ureta, M. (2003). International migration, remittances, and schooling: evidence from El Salvador. Journal of Development Economics, 72: 429-461.

[28] Frank, R., Hummer, R. (2002). The other side of the paradox: The risk of low birth weight among infants of migrant and nonmigrant households within Mexico. International Migration Review, 36:746-765.

[29] Global Burden of Disease Health Financing Collaborator, N. (2019). Past, present, and future of global health financing: a review of development assistance, government, out-of-pocket, and other private spending on health for 195 countries, 1995–2050. The Lancet, 393: 2233-2260.

[30] GCRC, G. C. (2019). Who suffers Most from Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017. Bonn: Germanwatch e.V.

[31] Gupta, S., Pattillo, C., Wagh, S. (n.d.). Effect of remittances on poverty and financial development in Sub-Saharan Africa. World Development, 37: 104-115.

[32] Haines , A., Patz, J. (2004). Health effects of climate change. JAMA, 29:99-103.

[33] Hassan, G., Faria, J. (2015). Do Remittances Diminish Social Violence? The Journal of Development Studies, 51:1309-1325.

[34] Hildebrandt, N., McKenzie , D. (2005). "The Effects of Migration on Child Health in Mexico." ., World Bank Policy Research Working Paper No. 3573. Washington, D.C.: World Bank.

[35] IPCC. (2007). Working group I contribution to the fourth assessment report of the Intergovernmental Panel on Climate Change: Climate change 2007 – the physical science basis. Summary for policymakers. Geneva: Intergovernmental Panel on Climate Change Secretariat.

[36] IPCC. (2014). "Summary for policymakers", in Climate Change 2014: impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,. Cambridge,: Cambridge University Press.

[37] Kanaiaupuni, S., Donato, K. (1999). Migradollars and Mortality: The effects of migration on infant survival in Mexico. Demography, 36: 339.

[38] Kovats , S., Haines A , A. (1995). The potential health impacts of climate change: an overview. Medicine and War,, 11:168–178.

[39] Lopez-Cordova, E. (2006). Globalization, Migration and Development: the Role of the Mexican Migrant Remittances. Buenos Aires: INTAL-ITD.: Working Paper No. 20, Institute for the Integration of Latin America and the Caribbean, Inter-American Development Bank,.

[40] Maclellan, N., Mead, S. (2016). After Paris: Climate finance in the Pacific islands. Auckland: OXFAM New Zealand.

[41] Maddala, G. S. (1986). Limited-dependent and qualitative variables in econometrics. New York: Cambridge University Press.

[42] Mahmud, S., Hassan, G. (2018). Are remittances a source of finance for private adaptation strategy? Evidence from a natural experiment in the Cyclone Sidr hit regions of southern Bangladesh, CAMA Working Papers 61. Canbera: Crawford School of Public Policy, Australian National University.

[43] McIntyre , D., Thiede , M., Dahlgren , G., Whitehead, M. (2006). What are the economic consequences for households of illness and of paying for health care in low- and middle-income country contexts?. Social Science and Medicine, 62: 858-65.

[44] McKenzi, D., Sasin, M. (2007). Migration, Remittances, Poverty, and Human Capital: Conceptual and Empirical Challenges, World Bank Policy Research Working Paper No. 4272. Washington DC: World Bank.

[45] McMichael, A. (2003). Climate change and human health: Risks and responses. ,. Geneva: World Health Organization.

[46] Mohapatra, S., Joseph , G., Ratha, D. (2009). emittances and natural disasters: ex-post response and contribution to ex-ante preparedness. Washington: D.C.: The World Bank.

[47] O'Donnell, O., Doorslaer , E., Rannan-Eliya, R., Somanathan, A., Adhikari, S., Akkazieva, B., , .., Zhao , Y. (2008). Who pays for health care in Asia? . Joural of Health Economics, 27: 460-475.

[48] Ponce, J., Olivié, I., Onofa, M. (n.d.). The Role of International Remittances in Health Outcomes in Ecuador: Prevention and Response to Shocks. The International Migration Review, 45:727-745.

[49] Sarker, M. A., Alam, K., Gow, J. (2017). Performance of rain-fed Aman rice yield in Bangladesh in the presence of climate change. Renewable Agriculture and Food Systems,, 1-9.

[50] Stock, J., Wright, J., Yogo, M. (2002). A survey of weak instruments and weak identification in generalised method of moments. Journal of Business Economic Statistics, 20: 518-529.

[51] Taylor, J., Lopez-Feldman, A. (2010). Does migration make rural households more productive? Evidence from Mexico. The Journal of Development Studies, 46: 68-90.

[52] Valero-Gil, J. (2009). Remittances and the household's expenditures on health. MPRA Paper 9572,. Munich: University Library of Munich, Germany.

[53] WHO. (2002). The world health report . Geneva: World Health Organization.

[54] WHO. (2009). Protecting health from climate change: Connecting science, policy and people. Geneva: World Health Organization.

[55] Yang, D. (2005). International migration, human capital, and entrepreneurship: evidence from Philippine migrants' exchange rate shocks. World Bank Research Working Paper 3578. Washington: DC: The World Bank.

[56] Yang, D., Choi, H. (2007). Yang, D., Choi, H. (2007). Are remittances insurance? Evidence from rainfall shocks in the Philippines. The World Bank Economic Review, 21: 219-248.

[57] Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy*, *80*(2), 223–255.

[58] Dasgupta, S., Laplante, B., Meisner, C. M., Wheeler, D., Yan, J. (2009). The impact of sea-level rise on developing countries: A comparative analysis. *Climatic Change*, *93*(3–4), 379–388.

[59] Lucas, R. E. B., Stark, O. (1985). Motivations to remit: Evidence from Botswana. *Journal of Political Economy*, *93*(5), 901–918.

[60] Hoddinott, J. (2006). Shocks and their consequences across and within households in rural Zimbabwe. *Journal of Development Studies*, *42*(2), 301–321.

[61] Jha, S., Martinez, A., Quising, P. (2018). Natural disasters and remittances: Exploring the linkages in Asia and the Pacific. *Asian Development Review*, *35*(1), 1–24.

[62] Black, R., Bennett, S. R. G., Thomas, S. M., Beddington, J. R. (2011). Climate change: Migration as adaptation. *Nature*, *478*(7370), 447–449.

[63] Dercon, S. (2004). *Insurance against poverty*. Oxford University Press.