THE EFFECT OF CLIMATE UNPREDICTABILITY AND NATURAL DISASTERS DUE TO TEMPERATURE RISE ON LABOR MOBILITY IN BANGLADESH

By

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Abstract

The unpredictability of climate and natural disasters is a concern in Bangladesh because this forces laborers in Bangladesh to leave their birthplace. This thesis is about measuring the effect of temperature, which is a proxy of climate and natural disasters, on labor mobility in Bangladesh by using Labor Force Survey (LFS) data from 2013 and mean temperature data from 2005-2015. The empirical analysis has used the econometric method and has found a positive influence of temperature on labor mobility. This thesis also has suggested policies to tackle the labor mobility crisis due to temperature-induced climate unpredictability and natural disasters.

Keywords: Climate; Natural Disasters; Temperature; Proxy; Econometric Method

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TABLE OF CONTENTS

1. Introduction

The long-period statistics of weather are defined as climate (Berlemann & Steinhardt, 2017). Temperature, precipitation, humidity, atmospheric pressure, and wind are the important factors that are defining the weather. Weather is the statistics of temperature, precipitation, humidity, atmospheric pressure, and wind for a short period. For example: one week, ten days, one month, one year. The most used proxies for climate are temperature and/or precipitation.

The climate is changing and the increment of temperature is one of the main indicators. Because of the use of fossil fuel, carbon dioxide, deforestation, coal smoke, and brick kilns, greenhouse gas is forming outside of the earth, preventing sunlight from getting out of the earth and this is leading to the increment of the earth's temperature. Since the temperature is increasing, our earth is getting warmer and the ice of the polar region is melting, leading to sea level rise and ultimately to flooding. Moreover, rising temperature increases the risk of cyclones because the temperature is one of the main elements to form cyclones in the ocean. In addition, due to global warming, the mean temperature for a calendar year is increasing. The increment in temperature is increasing the risk of temperature-induced climate unpredictability and temperature-induced natural disasters. Many countries are becoming vulnerable due to temperature-induced climate unpredictability and temperature-induced natural disasters and Bangladesh is one of them. In general, the country is acknowledged as unusually in jeopardy of climate change because of the greatly inconsistent environment (Yu, 2010).

The consequences of climate unpredictability and natural disasters in various ways on laborers are studied by the literature. According to the literature, the most vulnerable people are the agricultural workers because it reduces crop yields in the agricultural sector and people are trying to find strategies. The most adaptation strategy to cope with climate change and climate-induced natural disasters is migration (Reid, 2014). According to Colmer (2021), the reallocation of workers is necessary to mitigate economic loss. To compensate for income loss, agricultural workers may move to the non-agricultural sector and this leads to a reduction in wages for non-agricultural workers (Jayachandran, 2006; Bastos et al., 2013; Jessoe et al., 2016; Aragon et al., 2021). Migration is growing as an adaptation strategy in Bangladesh (Martin et al., 2013). In addition, there is also an argument about which people are likely to migrate. According to Bernzen

et al. (2019), educated people are likely to migrate because it is mobile and therefore, it might encourage mobility.

The effect of climate unpredictability and natural disasters as a reason for labor mobility by the literature. The reason is that it hampers productivity in agriculture and forces people in the agricultural sector to migrate. Precipitation data and temperature data are used as a proxy for climate. When the temperature is used, it is only used during temperature deviation from its actual long-term averages such as the duration of heat waves and cold waves and it is the average of a certain period (Berlemann & Steinhardt, 2017). But mean temperature data of a specific time scale without counting heat waves or cold waves is never used. This thesis will use the mean temperature data of the ten years as a proxy for climate and natural disasters to find labor mobility in Bangladesh.

This thesis is arranged as follows: Section 2 is about the Literature Review; Section 3 is about the Model and Methodology; Section 4 is about the Result, Discussion, and Robustness Test; Section 5 is about the Conclusion.

2. Literature Review

2.1. Temperature and Precipitation Data Usage Pattern

The data on temperature and precipitation are used in different ways to estimate climate or climate change. Temperature enters estimation in absolute terms and it is the average of a certain period. The temperature deviation from its actual long-term average is used. The temperature deviation is used at the time of disasters which is related to climate, the temperature deviation is used. For example: at the time of heat waves and cold waves (Berlemann & Steinhardt, 2017).

2.2. Global Warming Effect on Ecology

Global warming is severely affecting the ecology of Earth. According to Seneviratne et al. (2012), since the middle of the 20th century, the frequency of heat wave length has increased. According to Bhattacharya & Lichtman (2016), there were several circles of glacial period and retreat period in the past 6,50,000 years. The beginning of the modern climate era was begun 11,000-12,000 years ago when the last ice age was ended. In the last 50 years, the increment of average near-surface temperature is extraordinary and it is not entirely due to the result of natural

processes. According to Menzel & Estrella (2001), ecology is affected in several ways due to global warming. For example: earlier flowering and leaf opening. In addition, Beebee (1995) states another example: animal breeding. Moreover, Crick et al. (1997) state another example: spring migration. Furthermore, higher altitude advancement of trees (Wardle & Coleman, 1992). However, the ice of the Arctic and Antarctic Peninsula will continue to melt which will lead to sea level rise (Cazenave & Nerem 2004).

2.3. Changes in Living Conditions and Population Distribution

According to Berlemann & Steinhardt (2017), many major factors are determining the growth and distribution of the world population. Climate and geography are one of them. From the early 20th century, especially from the late 1970s, the average surface temperature has changed and will continue to change. Temperature and precipitation differ enormously in regional changes, average annual temperature fluctuates slightly. The likelihood of natural hazards and/or their magnitude is influenced by global warming and these have very different regional patterns. So, it causes changes in living conditions much quicker than expected in some parts of the world.

2.4. Adaptation Strategy to Cope Up

Many authors are talking about what is the most extreme adaptation strategy to cope with climate unpredictability. According to Reid (2014), migration is considered the most extreme adaptation strategy to cope with climate change and climate-induced natural disasters. Moving to other places may be a suitable option when other adaptation strategies are unavailable, costly, and ineffective. Human displacement in response to environmental shock is not a new phenomenon (Jha et al., 2017). Furthermore, according to Scheffran et al. (2012), human migration is an adaptive response to the change in climate. The major consequences of climate change are rising sea levels and environmental degradation. These lead to short or long-run migration. According to the result of Ibanez et al. (2021), it shows that the push factors are temperature shocks in El Salvador. To respond to these shocks, rural area households migrate abroad as a strategy to mitigate the negative income shock.

2.5. Response of Affected Ones in Agriculture Due to Unpredictability in Weather

People in the agricultural sector are the most vulnerable due to climate unpredictability and many authors are talking about how they respond. According to Colmer (2021), productivity in agriculture is affected due to vagaries in weather and the increment of temperature causes a decrement in agricultural production. The known is less about how those affected ones respond. The reallocation of workers is one potentially important margin of adjustment. If workers in the agricultural sector can find other kinds of work, the economic depletion can be lessened. However, the livelihoods of the individuals will be dependent upon nature if the reallocation of workers is hampered. Furthermore, Colmer (2021) adds that in India, the more important driver is temperature rather than rainfall. Also, in the short run, to respond to temperature-driven changes in agricultural productivity, workers can move across sectors. Colmer (2021) estimates an offsetting movement of workers into the both manufacturing sector and the service sector.

According to Nordas & Gleditsch, (2007); Laczko & Aghazarm, (2009); Tacoli, (2009); Scheffran et al., (2012), the most climate-centric economic activity is agriculture and it faces the greatest risk and uncertainties associated with the loss of livelihood. According to Jha et al. (2017), due to the impact of unpredictable weather consequences, farmers decide to migrate in search of alternative livelihoods under the risk of crop failure or low yield. According to Warner, (2010); Renaud et al., (2007); Conisbee & Simms, (2003); Adamo, (2010), there is a baseline assumption in the literature and the assumption is that since individuals fail to adapt effectively, they migrate to other locations.

According to Huntley (1999); and Tyson et al. (2002), the connection between climate change and prehistoric human settlement and migration is supported by a broad spectrum of the literature. In rural areas, the effect of climate change on human migration is noticeable. Jha et al. (2017) found four cognitive conditions of the farmers' decision were considered: (i) perceive climate changes and migrate; (ii) perceive changes in climate but do not migrate; (iii) do not perceive climate changes and therefore do not migrate; and (iv) do not perceive climate changes yet choose to migrate. Their study found that the experiences and perceptions about climate variability and climate extremes of farmers are the determinants of whether this migration is temporary or permanent. The more vulnerable farmers are more likely to migrate permanently. But

the farmers who are only affected due to seasonal climate variation, their migration is temporary. According to Feng et al., (2010); Cai et al., (2016); and Thiede et al., (2016), migration which is driven by weather is higher in countries that are more reliant on agriculture.

2.6. Effects of Natural Disasters and Weather Unpredictability on Migration

Goldbach (2017) used a binary logit regression approach to study the effects of floods, coastal erosion, and storms on outmigration in Ghana and Indonesia and he found that only subsidence has an effect on Indonesia and only storm risk has an effect on Ghana for outmigration. Bohra-Mishra et al., (2014) fail to find a systematic effect in Indonesia for earthquakes, volcanic eruptions, or floods. There are some systemic outmigration effects only for landslides. The result of Beine & Parsons (2015) is mainly about international migration but internal migration is also there with some results. Berlemann & Steinhardt (2017) state that migration is induced by natural disasters such as floods, but evidence of international migration is not found in many recent macro-level studies. A positive impact on internal migration has been found for temperature. For the short-term internal migration effect, natural disasters have some influence. Furthermore, Ibanez et al. (2021), add that migration is a coping strategy and it is turning out as a regular event more and more as weather becomes more unpredictable in some regions of the world.

2.7. Effect on Income due to Temperature Shock

Reduction of crop yield occurs due to negative temperature shock and inputs are adjusted by the farmers accordingly when risk-coping mechanisms are absent such as credits or insurance (Aragon et al., 2021; Hornbeck, 2012). According to Jayachandran, (2006); Bastos et al., (2013); Jessoe et al., (2016); Aragon et al., (2021) to compensate for income loss, laid-off agricultural workers' movement to the non-agricultural sector may occur. If a large amount of labor supply occurs in the non-agricultural sector or, a reduction of non-agricultural sector wage can occur and this may affect non-agricultural workers. According to Kleemans, (2015); Kubik & Maurel, (2016); Cattaneo & Peri, (2016); and Mahajan & Yang, (2020), the opportunity costs of the landowners are larger than the agricultural wage workers and landowners are better able to cope with the negative income shocks because their risk coping mechanism is wider. One additional week of temperature shock causes the increment of international migration for agricultural households and the impact is 26.5% evaluated at the mean of the shock. One point explaining the

cause of migration is the effect of temperature shock. Temperature shock decreases total agricultural production by 2.8% and the value of corn production per hectare by 5.4%.

2.8. Climate Change Context in Bangladesh

According to Huq (2001), Huq & Ayers (2008), in the context of climate change, Bangladesh has been identified as one of the most vulnerable countries. According to Martin et al. (2013), in the Bangladesh context, migration is growing as an acknowledgment of adaptation strategy as an outcome of climatic stresses and shocks. According to McLeman & Smit (2006), Barnett & Webber (2010), Tacoli (2009), Foresight (2011), and ADB (2012), the impacts of environmental shocks and stresses can be mutated by migration which is posited as an effective adaptation strategy. In addition, Martin et al. (2013) state that migration could be affected due to climate change in a range of ways. According to Rahman et al. (2007), in Bangladesh, more intense disasters like cyclones and extreme rain events could lead to the destruction of habitats, livelihoods, and infrastructure. Moreover, according to Zaman (1989), migration related to disasters involves short distance and short term. It can be described with an example: in Bangladesh, 88% of migrant agricultural people were found to remain within two miles of their previous residence after land erosion and home loss due to flooding. On cyclone response, similar responses are found. According to Sward and Codjoe (2012); and Gemenne (2011), climate change-inspired movement is more likely to be short-term and short distance. A viable effective strategy to diversify risk or escape untenable conditions is migration (Mahajan & Yang, 2020).

2.9. Effect of Environmentally Related Disasters in Bangladesh

According to IOM (2010), Bangladesh is widely considered a hotspot for the processes of climate variability and environmentally induced migration. According to Banerjee, (2007); Del Ninno et al., (2001); Khandker, (2007); and Mueller & Quisumbing, (2011), the population is highly exposed to environmentally related disasters and harms population well-being. According to Findlay & Geddes, (2011); Kartiki, (2011); Mallick et al., (2017); Mallick & Vogt, (2014); Paul, (2005); Paul & Routray, (2010); Penning-Rowsell et al., (2013); Rahman et al., (2015), mobility related to flooding and the coastal storm has been witnessed but they were short term and temporary.

2.10. Factors for Migration

According to Black et al. (2013), for migration, environmental stressors can be both a cause and an obstacle. Push factors (threats of violence, family problems, natural disasters, and economic hardship) and pull factors (perceived economic opportunities and positive views of city living) are the influencers of the decision to migrate and 10% of these migrations are related to natural disasters. Azam & Falk (2017) state that climate change is not a factor in migration. Rather, the economically induced land use change. Due to crop loss and damage linked to flooding and drought, about 5% migrated after the completion of two rural sending communities in northern Bangladesh (Swain, 1996).

2.11. The Demographics of People Who are Likely to Migrate

The question is whether the migrants are rich and poor because both arguments exist about whether the poor are more exposed to hazards and thereby more likely to be displaced or those with more individual resources are more likely to move (Bernzen et al., 2019). Education and English skills are human capital and mobile and they might encourage mobility. According to Ishtiaque & Ullah (2013), migration might be enabled if they have non-agricultural jobs and the ties to the local rural community are weaker. According to Mallick & Vogt (2012), migration is encouraged by higher income but it is discouraged due to owning farmland and local elite ties. Akter & Bauer (2014) state that larger firms owning households are less likely to migrate. Despite being more exposed to environmental hazards, poor people are less likely to migrate (Gray & Mueller 2012; Chen et al. 2017). Those whose primary occupation is agriculture or aquaculture are much less likely to migrate than those whose primary occupation is non-agriculture/aquaculture jobs. Joardar & Miller (2013) found from a study that households who had lost assets due to environmental hazards were likely to migrate permanently and those who lost livestock and crops were more likely to move temporarily.

This thesis will use temperature as a proxy for both climate and natural disasters. The pieces of literature only studied climate and natural disasters as a reason for mobility. But above them, temperature is one of the main reasons for climate unpredictability and natural disasters. Berlemann & Steinhardt (2017) stated that the temperature is only used when there is a temperature shock. For example: during heat waves and cold waves. But this thesis will use mean temperature for ten years' time scale which means it will not take the duration of heat waves or cold waves.

3. Data, Model, and Methodology

3.1. Data:

The data is collected from the Labour Force Survey (LFS) data 2013 which was conducted by the Bangladesh Bureau of Statistics (BBS). For this research, only the data of sex, rural, house type, the main activity of the household, income, and education are cleaned. The data on temperature are collected from the internet. The temperature data is the calculation of the mean temperature of 2005-2015. The value of temperature is the mean temperature of 2005-2015.

Table 1: Summary Statistics

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Temperature[a]	156987	26.338	0.662	25	27
Gross Income[b]	156987	1940.852	6020.823	0	900000

[a]Temperature data source: https://www.timeanddate.com/weather/bangladesh

[b]Gross Income data source: Labour Force Survey (LFS) Data of 2013

Table 2: Descriptive Statistics[a]

Variable	Value	Frequency	Net Frequency	Percentage	Net Percentage
Sex	Female	79,128	1,56,987	50.40%	100%
	Male	77,859		49.60%	
Main activity of the household	Agriculture	50,058	1,56,987	31.89%	100%
	Manufacture	6,912		4.40%	
	Others	14,250		9.08%	
	Service	85,767		54.63%	
Rural	Rural	118,163	1,56,987	75.27%	100%
	Urban	38,824		24.73%	
House type	Katcha	85,860	1,56,987	54.69%	100%
	Pucca	26,982		17.19%	
	Semi-pucca	44,145		28.12%	
Education	11	895	41,626	2.15%	100%
	99	1,028		2.47%	
	Bachelor degree	3,345		8.04%	
	Class 1	4,829		11.60%	
	Class 10	2,039		4.90%	
	Class 2	3,863		9.28%	
	Class 3	3,506		8.42%	
	Class 4	3,576		8.59%	
	Class 5	2,876		6.91%	
	Class 6	2,325		5.59%	
	Class 7	2,212		5.31%	
	Class 8	2,533		6.09%	
	Class 9	1,772		4.26%	
	Diploma	954		2.29%	
	Don’t know	15		0.04%	
	HSC	3,446		8.28%	
	Masters’ degree	1,154		2.77%	
	PhD	78		0.19%	
	Pre-school	1,180		2.83%	

[a]Descriptive Statistics Data Source: Labour Force Survey (LFS) Data of 2013

3.2. Model and Methodology:

A model is specified to get the result of labor mobility. According to Bernzen et al. (2019), human capital are education and English skill. They are mobile and mobility might be encouraged. So, the 'Education' variable is selected. Bernzen et al. (2019) also state that agriculture or aquaculture occupation households are less likely to migrate. So, 'Main activity of the household' is selected. According to Mallick & Vogt (2012), higher income encourages migration but it is discouraged due to owning farmland. So, to measure it, the 'Gross income in last one month' variable is selected. In addition, there is a positive influence of temperature on mobility (Berlemann & Steinhardt, 2017). So, the 'Temperature' variable is selected.

$$(Labor\ Mobility)_i = \beta_0 + \beta_1(Sex)_i + \beta_2(Temperature)_i + \beta_3(Rural)_i + \beta_4(House\ type)_i + \beta_5(Main\ activity\ of\ the\ household)_i + \beta_6(Gross\ income\ in\ last\ one\ month)_i + \beta_7(Education)_i + \varepsilon_i \quad (1)$$

There are two types of gross income: earnings in cash or earnings in kind. Earnings in cash are earnings paid in cash or by check or direct bank deposit. On the other hand, earnings in kind included the regular supply of food, clothing, housing, water, electricity, fuel, transport, etc. on a free or subsidized basis.

The variable 'Sex' is treated as a dummy variable. The expression of the dummy variable 'Sex' is expressed below.

$$Sex = \begin{cases} 1 \text{ if (Sex = "Female")} \\ 0 \text{ otherwise} \end{cases}$$

The variable 'Rural' is treated as a dummy variable. The expression of the dummy variable 'Rural' is expressed below.

$$Rural = \begin{cases} 1 \text{ if (Rural = "Rural")} \\ 0 \text{ otherwise} \end{cases}$$

The variable 'House type' is treated as a dummy variable. The expression of the dummy variable 'House type' is expressed below.

$$House\ type = \begin{cases} 1 \text{ if (House type = "Katcha")} \\ 0 \text{ otherwise} \end{cases}$$

The ‘Education’ variable is converted from string to numeric. ‘Temperature’ is also a numerical variable.

The ‘Main activity of the household’ variable is treated as a dummy variable. The expression of the dummy variable ‘Main activity of the household’ is expressed below.

$$Main\ activity\ of\ the\ household = \begin{cases} 1 \text{ if (Main activity of the household} = \text{"Agriculture"}) \\ 0 \text{ otherwise} \end{cases}$$

The left-hand side variable which is the ‘Regressand’ is generated from the variable names ‘Left their birthplace’ and ‘Cause of leaving.’ The answer to ‘Left their birthplace’ is ‘Yes’ and the answer to ‘Cause of leaving’ is ‘Natural disaster.’

OLS estimate, Logit estimate, Probit estimate, and Two Stage Least Square (2SLS) estimate are used to analyze data. Logit and Probit are likelihood models. Both models interpret the sign of the coefficient but not the magnitude. Logit is about both regressors and regressand to be binary outcomes: 0 and 1 and expresses the result in percentage. Logit also considers the natural logarithm value of the odds ratio of laborers leaving their birthplace due to temperature-induced climate unpredictability and temperature-induced natural disasters versus the odds of it not being so: that is,

$$\log\left(\frac{P(Labor\ Mobility)}{1-P(Labor\ Mobility)}\right)_i$$

So, the Equation (1) stands as:

$$log\left(\frac{P(Labor\ Mobility)}{1-P(Labor\ Mobility)}\right)_i = \beta_0 + \beta_1(Sex)_i + \beta_2(Temperature)_i + \beta_3(Rural)_i + \beta_4(House\ type)_i + \beta_5(Main\ activity\ of\ the\ household)_i + \beta_6(Gross\ income\ in\ last\ one\ month)_i + \beta_7(Education)_i + \varepsilon_i \quad (2)$$

Like Logit, Probit is also about regressors and regressand to be the binary outcome: 0 and 1. However, unlike Logit, Probit does not express the result in percentage. But in both cases, the result of both Logit and Probit is between 0 and 1.

Two Stage Least Square (2SLS) estimate is done for the Endogeneity test. The Endogeneity test is performed on three occasions. (a) When any of the independent variables are correlated with

the error term (b) When there is measurement error in independent variables and (c) When there is reverse causality that means the dependent variable also causes changes in the independent variable. For the 2SLS test, the Instrumental Variable technique is used. This instrumental variable (i) Cannot be omitted variable (ii) The Instrumental Variable must be correlated with the endogenous variable and (iii) The Instrumental Variable cannot be correlated with the omitted variable.

Before doing these estimates, the Breusch-Pagan/Cook-Weisberg test is conducted to see whether the Heteroskedastic problem exists or not. The information on sex, temperature, the main activity of the household, education, gross income, house type, and rural are used in these estimates. Since the Heteroskedastic problem is found, Heteroskedastic robust standard errors are used in these estimates. The marginal effect at the Logit and Probit estimates is used to see how the increment of one unit of the regressors affects the regressand. At the 2SLS estimate, the 'Gross income in last one month' variable is treated as an endogenous variable. This endogenous variable is instrumented by the instrumental variable 'Type of work' at the First Stage Regression. There are two answers to 'Type of work,' "Full-time" and "Part-time." The expression of the dummy variable 'Type of work' is expressed below.

$$Type\ of\ work = \begin{cases} 1 \text{ if (Type of work} = \text{"Full-time")} \\ 0 \text{ otherwise} \end{cases}$$

To check the endogeneity and validity of the instrument, endogeneity, and first-stage regression summary statistics tests were used to check whether the selected variable for this thesis is an endogenous variable or not and whether the selected instrument is valid or not.

To check the validity of the result, robustness tests are used by changing the value of the temperature variable. To check robustness, four months of mean temperature data (January, February, March, May, and June) of the years 2005-2015 are used separately by using the same estimates (OLS, Logit, Probit, and Two Stage Least Square).

4. Empirical Estimation Results, Discussions, and Robustness Test

4.1. Results and Discussions:

4.1.1. OLS Estimate: Table 3 presents the labor mobility model with an OLS estimate. Table 3 looks at the coefficients of the variables of temperature, the main activity of the household, gross income, and education.

Table 3: Labor Mobility Model, OLS Estimate

Regressor	Regressand: Labor Mobility
Sex	0.000
	(0.0003)
Temperature(ºC)	0.001***
	(0.0002)
Rural	0.000
	(0.0004)
House type	-0.000
	(0.0003)
Main activity of the household	-0.002***
	(0.0003)
Gross income in last one month	5.38×10^{-8}*
	(2.33×10^{-8})
Education	0.0002***
	(0.00004)
Constant	-0.026***
	(0.006)
Number of observations	1,56,987

Note: Heteroskedastic Robust Standard Errors in parentheses.

*, **, & *** denote statistical significance at 10, 5, & 1 percent levels of significance.

Those households whose main activity is agriculture do not migrate because it is negatively correlated with the regressand 'Labor Mobility' and it is significant at a 1 percent level. So, the coefficient of 'Main activity of the household' is -0.002. The coefficient of the 'Gross income in last one month' variable is very small and this variable is also positively correlated and significant at a 10 percent level with the regressand. The 'Education' variable is also positively correlated with the regressand.

There is a positive correlation between the main independent variable 'Temperature' and the regressand 'Labor Mobility.' The coefficient of the 'Temperature' variable is 0.001 and this correlation is significant at a 1 percent level. The increment of temperature changes ecology.

Moreover, the increment of temperature triggers temperature-induced climate unpredictability and temperature-induced natural disasters and this forces laborers to migrate. The frequency of heat wave length has increased since the middle of the 20th century (Seneviratne et al. (2012). In addition, because of global warming, our ecology is being affected in several ways (Menzel & Estrella, 2001). Moreover, according to Cazenave & Nerem, (2004), the Arctic ice and Antarctic peninsula ice will continue to melt which ultimately leads to the rising of sea level. Also, in some regions of the world, since weather is becoming more unpredictable in some regions of the world, migration is becoming increasingly frequent (Ibanez et al., 2021). Furthermore, according to Berlemann & Steinhardt (2017), temperature has a positive influence on labor mobility.

4.1.2. Logit and Probit Estimates: Table 4 is about Logit and Probit estimates. These estimates are the model of likelihood. The increment of temperature increases the likelihood of labor mobility. If the main activity of the household is agriculture, then that household is less likely to migrate. Bernzen et al. (2019) state that people who have non-agricultural jobs are more likely to migrate than those who have agricultural jobs. However, education increases the likelihood of labor mobility. Bernzen et al. (2019) add that education and English skills are mobile and they have a lower likelihood to encourage labor mobility.

Table 4: Labor Mobility Model, Logit and Probit Estimates

Regressor	Regressand: Labor Mobility (Logit Estimate)	Regressand: Labor Mobility (Probit Estimate)
Sex	0.009	0.006
	(0.092)	(0.030)
Temperature(ºC)	0.399***	0.120***
	(0.092)	(0.028)
Rural	0.013	0.005
	(0.115)	(0.0379)
House type	-0.130	-0.039
	(0.105)	(0.0339)
Main activity of the household	-0.764***	-0.242***
	(0.126)	(0.0395)
Gross income in last one month	4.60×10^{-6}***	2.37×10^{-6}**
	(1.37×10^{-6})	(8.78×10^{-7})
Education	0.0399***	0.014***
	(0.008)	(0.003)
Constant	-16.24***	-5.878***
	(2.415)	(0.748)
Marginal Effect (Temperature)	0.001***	0.001***
	(0.0003)	(0.0003)
Marginal Effect (Main activity of the household)	-0.002***	-0.002***
	(0.0004)	(0.0004)
Marginal Effect (Gross income in last one month)	1.39×10^{-8}***	2.16×10^{-8}**
	(4.21×10^{-9})	(8.10×10^{-9})
Marginal Effect (Education)	0.0001***	0.0001***
	(0.00003)	(0.00003)
Number of observations	1,56,987	1,56,987

Note: Heteroskedastic Robust Standard Errors in parentheses.

*, **, & *** denote statistical significance at 10, 5, & 1 percent levels of significance.

Table 4 also calculates the marginal effect of Logit and Probit. From the marginal effect of temperature at Logit and Probit estimates, if the temperature increases by 1ºC, laborers are 0.1% more likely to migrate. Furthermore, if income increases by 1 Taka, it increases the likelihood of labor mobility.

4.1.3. 2SLS Estimate: Table 5 presents the Two Stage Least Square (2SLS) estimate and First Stage Regression. The temperature variable which is the main independent variable is positively correlated with the regressand 'Labor Mobility.' This correlation is similar to the

Ordinary Least Square (OLS) estimate of Table 3. The value of it is 0.001 at Table 5 and it is also significant at a 1 percent level.

Table 5: Labor Mobility Model, Two Stage Least Square (2SLS) Estimate and First Stage Regression

Regressor	Regressand: Labor Mobility
Sex	0.0006
	(0.0003)
Temperature(ºC)	0.001***
	(0.0002)
Rural	0.000
	(0.0004)
House type	-0.000
	(0.0003)
Main activity of the household	-0.002***
	(0.0003)
Gross income in last one month ^	2.93×10^{-7}***
	(6.45×10^{-8})
Education	0.0002***
	(0.00004)
Constant	-0.026***
	(0.006)
Number of Observations	1,56,987
First Stage Regression	
Regressor	Regressand: Gross income in last one month
Type of work	5190.353***
	(38.04534)
Controls	Yes
Number of Observations	1,56,987

Note: Heteroskedastic Robust Standard Errors in parentheses.

*, **, & *** denote statistical significance at 10, 5, & 1 percent levels of significance.

Agriculture is defined as the 'Main activity of the household' and the coefficient of the variable is negatively correlated with the regressand 'Labor Mobility' similar to the OLS estimate of Table 3. That means those households whose main activity is agriculture do not migrate. The coefficient of the variable 'Gross income in last one month' is small but positively correlated with the regressand 'Labor Mobility' and this correlation is statistically significant. It indicates people with higher incomes migrate because they are equipped with resources to cope with the new place. Higher income encourages migration but it is discouraged due to farmland ownership and local elite ties (Mallick & Vogt, 2012).

Table 5 also looks at the First Stage Regression of the 2SLS estimate. At the First Stage Regression of the 2SLS estimate, the 'Gross income in last one month' variable is treated as a 'Regressand' and the 'Type of work' variable, which is treated as an instrument at 2SLS estimate, is treated as a 'Regressor' along with the other variables Sex, Rural, House Type, Main activity of the household, and Education. They are treated as 'Controls.'

The 'Type of work' variable is selected as an instrumental variable for the 2SLS estimate and the 'Gross income' variable is selected as an endogenous variable. The answer to the variable 'Type of work' is "Part-time" and "Full-time" for those who work. A "Full-time" worker is always committed to giving his or her whole time and effort at his or her office. In addition, a full-time worker is sometimes assigned to more tasks than his or her office duty. In contrast, a "Part-time" worker is not committed to giving his or her whole time and effort at the office. Rather, he or she is only assigned to a duty for which that individual is hired and for this, his or her office time is also limited for that task only. So, a full-time worker earns more than a part-time worker. It can be illustrated by an example. Suppose, a university hired a visiting Professor to take classes for undergraduate and postgraduate programs. In that case, the office hours for that visiting professor will be restricted to only class time. So, he or she is a part-time faculty. A few days later, the same university appointed a Professor on a full-time basis. In that case, the Professor is committed to giving his or her full time and effort to the university. If the university asks, then that faculty will need to step up as department chair and may need to take more courses outside of his or her assigned courses. If the university assigns him or her only for postgraduate courses, then he or she will take postgraduate classes only. If the university assigns him or her to both undergraduate and postgraduate classes, then he or she will need to take classes in both undergraduate and postgraduate programs. So, a full-time appointed Professor will earn more than one who is appointed on a part-time basis because a full-time Professor is committed fully and ready to do more work rather than only taking classes if necessary. In contrast, a part-time Professor will only take classes during office time and he or she will not be asked to take more classes, he or she will not be asked to take classes in another program. So, a visiting Professor will earn less than a full-time Professor.

Table 6: Endogeneity and Instrumental Validity Test

	Test Statistic	**p-value**
Panel A: Tests of Endogeneity[a]		
Robust Score $\chi^2(1)$	16.0242***	0.0001
Robust Regression F (1,156978)	16.365***	0.0001
Panel B: First Stage Regression Summary Statistics[b]		
Variable	Gross income in last one month	
R-square	0.1839	
Adjusted R-square	0.1839	
Partial R-square	0.1402	
Robust F (1, 156979)	18611.9***	
p-value	0.0000	

[a] Tests of Endogeneity. H_0: Variables are exogenous.

[b] First Stage Regression Summary Statistics. It suggests the validity of the instrument.

Panel A of Table 6 is about the endogeneity test. This test is conducted to check whether the selected variable for this thesis is endogenous or not. The values of the Robust Score $\chi^2(1)$, the other name of it is Wooldridge's Score, and the Robust Regression are 16.0242 and 16.365 respectively and their associated p-values are 0.0001. So, this thesis should reject the null hypothesis that variables are exogenous and this thesis is correct in treating 'Gross income in last one month' as an endogenous variable.

Panel B of Table 7 is about first stage regression summary statistics. The values of the Partial R-square and its' Robust F-statistic are 0.1402 and 18611.9 respectively. The value of Robust F-statistic is large enough and the associated p-value of Robust F-statistic is 0.0000 which suggests that the instrument 'Type of work' is valid.

4.2. Diagnostic Test:

Table 7: Diagnostic Test: Test for Heteroskedasticity[a]

	F (7, 156979)	**p-value**
Breusch-Pagan/Cook-Weisberg Test	15.81***	0.0000

[a] Test for Heteroskedasticity in OLS estimates. Test conducted using OLS regression without robust standard errors. H_0: Constant variance

Table 7 is about the diagnostic test for Heteroskedasticity. This test is conducted to check whether the problem of Heteroskedasticity exists or not. The value of the F-statistic is 15.81 and its' associated p-value is 0.0000. So, this thesis can strongly reject the null that those

coefficients are 0 and this thesis does have predictability in that error variance and this thesis does have evidence of Heteroskedasticity.

4.3. Robustness Test

To check the validity of section 4.1, only the temperature data was changed and the rest of the data were kept the same. The temperature data is changed by taking the mean temperature of January, March, May, and June of the year 2005-2015. From all the estimates, the positive correlation between temperature and labor mobility exists just like the original result. The diagnostic test, endogeneity test, and instrument validity test of the robustness test section are attached in the 'Appendix' section.

4.3.1. January Mean Temperature:

To check robustness, OLS, Logit, Probit, and Two Stage Least Square (2SLS) estimates are used by using the January mean temperature of the year 2005-2015.

Table 8: Robustness check of Labor Mobility model with mean temperature data of January

Regressor	Regressand: Labor Mobility (OLS Estimate)	Regressand: Labor Mobility (Logit Estimate)	Regressand: Labor Mobility (Probit Estimate)	Regressand: Labor Mobility (Two Stage Least Square Estimate)
Temperature(ºC)	0.0002*	0.0775*	0.0257*	0.0002*
	(0.0001)	(0.035)	(0.0121)	(0.0001)
Controls	Yes	Yes	Yes	Yes

Note: Heteroskedastic Robust Standard Errors in parentheses.

*, **, & *** denote statistical significance at 10, 5, & 1 percent levels of significance.

From the January mean temperature, this thesis can see a positive correlation between the 'Temperature' variable and labor mobility from all the estimates. So, from the mean temperature of January, this thesis can say that the result from Section 4.1 is valid.

4.3.2. March Mean Temperature:

To check robustness, OLS, Logit, Probit, and Two Stage Least Square (2SLS) estimates are used by using the March mean temperature of the year 2005-2015.

Table 9: Robustness check of Labor Mobility model with mean temperature data of March

Regressor	Regressand: Labor Mobility (OLS Estimate)	Regressand: Labor Mobility (Logit Estimate)	Regressand: Labor Mobility (Probit Estimate)	Regressand: Labor Mobility (Two Stage Least Square Estimate)
Temperature(ºC)	0.001***	0.403***	0.121***	0.001***
	(0.0002)	(0.0919)	(0.0284)	(0.0002)
Controls	Yes	Yes	Yes	Yes

Note: Heteroskedastic Robust Standard Errors in parentheses.

*, **, & *** denote statistical significance at 10, 5, & 1 percent levels of significance.

From the March mean temperature, this thesis can see a positive correlation between the 'Temperature' variable and labor mobility from all the estimates. So, from the mean temperature of March, this thesis can say that the results from Section 4.1 are valid.

4.3.3. May Mean Temperature:

To check robustness, OLS, Logit, Probit, and Two Stage Least Square (2SLS) estimates are used by using the May mean temperature of the year 2005-2015.

Table 10: Robustness check of Labor Mobility model with mean temperature data of May

Regressor	Regressand: Labor Mobility (OLS Estimate)	Regressand: Labor Mobility (Logit Estimate)	Regressand: Labor Mobility (Probit Estimate)	Regressand: Labor Mobility (Two Stage Least Square Estimate)
Temperature(ºC)	0.0007***	0.232***	0.075***	0.0007***
	(0.0001)	(0.0469)	(0.016)	(0.0001)
Controls	Yes	Yes	Yes	Yes

Note: Heteroskedastic Robust Standard Errors in parentheses.

*, **, & *** denote statistical significance at 10, 5, & 1 percent levels of significance.

From the May mean temperature, this thesis can see a positive correlation between the 'Temperature' variable and labor mobility from all the estimates. So, from the mean temperature of May, this thesis can say that the result from Section 4.1 is valid.

4.3.4. June Mean Temperature:

To check robustness, OLS estimate, Logit, Probit, and Two Stage Least Square (2SLS) estimates are used by using the June mean temperature of the year 2005-2015.

Table 11: Robustness check of Labor Mobility model with mean temperature data of June

Regressor	Regressand: Labor Mobility (OLS Estimate)	Regressand: Labor Mobility (Logit Estimate)	Regressand: Labor Mobility (Probit Estimate)	Regressand: Labor Mobility (Two Stage Least Square Estimate)
Temperature(ºC)	0.0007***	0.234***	0.0755***	0.0007***
	(0.0002)	(0.0645)	(0.022)	(0.0002)
Controls	Yes	Yes	Yes	Yes

Note: Heteroskedastic Robust Standard Errors in parentheses.

*, **, & *** denote statistical significance at 10, 5, & 1 percent levels of significance.

From the June mean temperature, this thesis can see a positive correlation between the 'Temperature' variable and labor mobility from all the estimates. So, from the mean temperature of June, this thesis can say that the result from Section 4.1 is valid.

To conclude the robustness test section, this thesis can say that this test is conducted to check the validity of the correlation between the main independent variable temperature and the dependent variable labor mobility. From robustness tests, this thesis can see the same correlation between the main independent variable temperature variable and the dependent variable labor mobility. All correlations are positive and statistically significant.

5. Conclusion

This thesis has discussed the effect of temperature, which is used as a proxy for both climate and natural disasters on labor mobility. This thesis has found a positive influence of temperature on labor mobility. The influence is not only positive but also significant. Laborers are forced to leave their birthplace because of temperature-induced climate unpredictability and temperature-induced natural disasters. This thesis also found that those households whose income is not high enough do not leave their birthplace because they know that if they leave their birthplace, they will not have enough resources to cope with the new environment. Moreover, those who are not enough educated do not leave their birthplace because they do not have enough capability to cope in the new place. Furthermore, agriculture-occupant households do not leave their birthplace despite they face loss because this is the only occupation they can do and they are doing this occupation from their ancestor. As a result, they do not want to leave their ancestral land.

To tackle mobility related to temperature-induced climate unpredictability and temperature-induced natural disasters, one important thing we can do is to reduce temperature rise. Since temperature is rising due to greenhouse gases, many countries are becoming vulnerable to temperature-induced climate unpredictability and temperature-induced natural disasters and Bangladesh is one of them. So, it is our responsibility to create a green earth that will be free of fossil fuel and zero carbon emissions and this will bring a positive impact on a long-term scale because this will lead to the reduction of greenhouse gas and the temperature will reduce in the long term. Moreover, reducing temperature will reduce the risk of forming cyclones in the ocean because temperature is one of the main elements to form cyclones. The goal of 'The Paris Agreement,' which was agreed at the COP21 conference, is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels." However, by the end of this century, the need to limit global warming to 1.5ºC is stressed by world leaders. Without the Paris Agreement, our earth was destined above 3ºC by 2100 (Rahman, 2016). If countries can implement this agreement, temperature-induced climate unpredictability and natural disasters will be reduced in the long term and as a result, the laborers in Bangladesh will not be forced to leave their birthplace.

Another important thing we can do is to improve five types of capital which will lead to resilience against any type of disaster. According to UNDP (2017), the five types of capital are (i) Human Capital (ii) Social Capital (iii) Natural Capital (iv) Physical Capital (v) Financial Capital. Firstly, human capital is encompassed by having abilities, experience, and work experience. Human capital is a factor at the household level and this is the determinant of the quantity and quality of the available workforce. It is developed by education and training. Secondly, social capital refers to the social resources and individuals rely on it to achieve objectives which is related to their livelihood. Networks and connections are included in social capital. Networks may be vertical (hierarchical) or horizontal (between individuals with common interests). Participation in more formal groups is also included and this tends to imply adherence to certain rules, relationships of trust, and exchanges that facilitate cooperation. In addition, natural capital refers to stocks of natural resources. A lot of resources fall under this capital. For example: land and soil, food production, woods, marine and forest resources, water, air quality, protection from erosion, waste disposal, storm protection, and water supply. Moreover, physical capital is composed of basic

infrastructure and producer goods for livelihood. For sustainable livelihood, there is a need to access roads and transport, housing and safe buildings, access to water and sanitation, clean and affordable energy, and access to information (communication). Finally, financial capital refers to financial resources which people use to achieve livelihood objectives. There are two main sources of financial capital: available stocks and regular inflows of money. Bangladesh already has enough natural capital and can improve the other four capitals. If the government can introduce a sustainable policy that will improve the other four capitals, then livelihood will improve and most importantly, community resilience will grow among people. According to Marasco et al. (2022), community and infrastructure resilience is the key to the well-being of modern societies and to tackling environmental hazards. If community resilience grows among people due to the improvements five capitals which are mentioned before, temperature-induced climate unpredictability and temperature-induced natural disasters will not touch people because people are already resilient, and due to resilience, they do not need to leave their birthplace due to climate unpredictability and natural disasters because they can overcome the effect of temperature-induced climate unpredictability and temperature-induced natural disasters now.

References

ADB (2012). Addressing Climate Change and Migration in Asia and the Pacific. Mandaluyong City, Philippines: Asian Development Bank.

Adamo, S. B. (2010). Environmental migration and cities in the context of global environmental change. *Current Opinion in Environmental Sustainability*, *2*(3), 161–165. doi: 10.1016/j.cosust.2010.06.005

Azam, M., & Falk, G. C. (2013, January). Governance of climate induced migration in the coastal regions of Bangladesh: New transformation required. In *Proceedings of the Earth System Governance Tokyo Conference, Tokyo, Japan* (pp. 28-31).

Banerjee, L. (2007). Effect of Flood on Agricultural Wages in Bangladesh: An Empirical Analysis. *World Development*, *35*(11), 1989–2009. doi: 10.1016/j.worlddev.2006.11.010

Bangladesh Bureau of Statistics (2013). Labour Force Survey. International Labour Organization.

Barnett, J. R., & Webber, M. (2010). Accommodating migration to promote adaptation to climate change. *World Bank Policy Research Working Paper*, (5270). doi:10.1596/1813-9450-5270

Beebee, J.C. (1995). Amphibian breeding and climate. *Nature*, 374, 219–220.

Beine, M., & Parsons, C. (2015). Climatic factors as determinants of international migration. *The Scandinavian Journal of Economics*, *117*(2), 723-767.

Berlemann, M., & Steinhardt, M. F. (2017). Climate Change, Natural Disasters, and Migration—a Survey of the Empirical Evidence. *CESifo Economic Studies*, 353–385. doi:10.1093/cesifo/ifx019

Bernzen, A., Jenkins, J. C., & Braun, B. (2019). Climate Change-Induced Migration in Coastal Bangladesh? A Critical Assessment of Migration Drivers in Rural Households under Economic and Environmental Stress. *Geosciences*. doi:10.3390/geosciences9010051

Bhattacharya, A. B., & Lichtman, J. M. (2016). *Solar Planetary Systems Stardust to Terrestrial and Extraterrestrial Planetary Sciences*. Boca Raton: Taylor & Francis.

Black, R., Arnell, N. W., Adger, W. N., Thomas, D., & Geddes, A. (2013). Migration, immobility and displacement outcomes following extreme events. *Environmental Science & Policy*, *27*, S32–S43. doi:10.1016/j.envsci.2012.09.001

Bohra-Mishra, P., Oppenheimer, M., & Hsiang, S. M. (2014). Nonlinear permanent migration response to climatic variations but minimal response to disasters. *Proceedings of the National Academy of Sciences*, *111*(27), 9780-9785.

Cai, R., Feng, S., & Oppenheimer, M. (2016). Climate Variability and International Migration: The Importance of the Agricultural Linkage. *Journal of Environmental Economics and Management*, *79*(586). doi:10.1016/j.jeem.2016.06.005

Cazenave, A., & Nerem, R. S. (2004). Present-day sea level change: Observations and causes. *Reviews of Geophysics*, *42*(3). doi:10.1029/2003RG000139

Chen, J. J., Mueller, V., Jia, Y., & Tseng, S. K.-H. (2017). Validating Migration Responses to Flooding Using Satellite and Vital Registration Data. *American Economic Review, 107*(5), pp.441–445. doi:10.1257/aer.p20171052

Colmer, J. (2021). Temperature, Labor Reallocation, and Industrial Production: Evidence from India, IZA Discussion Papers, No. 14604, Institute of Labor Economics (IZA), Bonn

Crick, H. Q., Dudley, C., Glue, D. E., & Thomson, D. L. (1997). UK birds are laying eggs earlier. *Nature*, *388*(6642), 526-526.

Feng, S., Krueger, A. B., & Oppenheimer, M. (2010). Linkages among climate change, crop yields and Mexico-US cross-border migration. *Proceedings of the National Academy of Sciences*, *107*(32), 14257–14262.

Findlay, A., & Geddes, A. (2011). Critical views on the relationship between climate change and migration: some insights from the experience of Bangladesh. In *Migration and climate change* (pp. 138-159). UNESCO/Cambridge University Press.

Gemenne, F. (2011). Why the numbers don't add up: A review of estimates and predictions of people displaced by environmental changes. *Global Environmental Change-Human and Policy Dimensions*. doi: 10.1016/J.GLOENVCHA.2011.09.005

Goldbach, C. (2017). Out-migration from coastal areas in Ghana and Indonesia—The role of Environmental factors. *CESifo Economic Studies*, *63*(4), 529-559.

Gray, C. L., & Mueller, V. (2012). Natural disasters and population mobility in Bangladesh. *Proceedings of the National Academy of Sciences of the United States of America*. doi:10.1073/pnas.1115944109

Huntley, B. (1999). Climatic change and reconstruction. *Journal of Quaternary Science: Published for the Quaternary Research Association*, *14*(6), 513-520.

Huq, S. (2001). Climate change and Bangladesh. *Science*, *294*(5547), 1617-1617.

Huq, S., & Ayers, J. (2008). Taking steps: mainstreaming national adaptation. International Institute for Environment and Development

Ibánez, A. M., Romero, J., & Velásquez, A. (2021). Temperature Shocks, Labor Markets and Migratory Decisions in El Salvador. *Unpublished paper. World Bank, Washington, DC*.

Jha, C. K., Gupta, V., Chattopadhyay, U., & Sreeraman, B. A. (2017). Migration as adaptation strategy to cope with climate change: A study of farmers' migration in rural India. *International Journal of Climate Change Strategies and Management*, *10*(1), 121–141. doi:10.1108/IJCCSM-03-2017-0059

Kartiki, K. (2011). Climate change and migration: a case study from rural Bangladesh. *Gender & Development*, *19*(1), 23-38.

Khandker, S. R. (2007). Coping with flood: role of institutions in Bangladesh. *Agricultural Economics.* doi:10.1111/j.1574-0862.2007. 00196.x

Laczko, F. and Aghazarm, C. (Eds) (2009), *Migration, Environment and Climate Change: Assessing the Evidence*, International Organization for Migration, Geneva, pp. 7-40.

Mahajan, P., & Yang, D. (2020). Taken by storm: Hurricanes, migrant networks, and US immigration. *American Economic Journal: Applied Economics*, *12*(2), 250-277.

Mallick, B., & Vogt, J. (2012). Cyclone, coastal society and migration: empirical evidence from Bangladesh. *International Development Planning Review*, *34*(3), 217-240.

Mallick, B., & Vogt, J. (2014). Population displacement after cyclone and its consequences: empirical evidence from coastal Bangladesh. *Natural hazards*, *73*, 191-212.

Mallick, B., Ahmed, B., & Vogt, J. (2017). Living with the risks of cyclone disasters in the south-western coastal region of Bangladesh. *Environments*, *4*(1), 13.

Marasco, S., Kammouh, O., & Cimellaro, G. P. (2022). Disaster resilience quantification of communities: A risk-based approach. *International Journal of Disaster Risk Reduction*, *70*, 102778. doi: 10.1016/j.ijdrr.2021.102778

Martin, M., Kang, Y. H., Billah, M., Siddiqui, T., Black, R., & Kniveton, D. (2013). Policy analysis: Climate change and migration Bangladesh. *Dhaka, Bangladesh: Refugee and Migratory Movements Research Unit (RMMRU)*.

McLeman, R., & Smit, B. (2006). Migration as an Adaptation to Climate Change. *Climatic Change,* 76, 31–53.doi: 10.1007/s10584-005-9000-7

Mueller, V., & Quisumbing, A. (2011). How Resilient are Labour Markets to Natural Disasters? The Case of the 1998 Bangladesh Flood. *The Journal of Development Studies, 47*(12), 1954–1971. doi:10.1080/00220388.2011.579113

Ninno, C. del, Dorosh, P. A., Smith, L. C., & Roy, D. K. (2001). *The 1998 floods in Bangladesh: disaster impacts, household coping strategies, and response*. Washington, D.C.: International Food Policy Research Institute.

Nordås, R., & Gleditsch, N. P. (2007). Climate change and conflict. *Political Geography*, *26*(6), 627–638. doi: 10.1016/j.polgeo.2007.06.003

Paul, B. K. (2005). Evidence against disaster-induced migration: the 2004 tornado in north-central Bangladesh. Disasters, 29(4), 370-385.

Paul, S. K., & Routray, J. K. (2010). Flood proneness and coping strategies: the experiences of two villages in Bangladesh. Disasters, 34(2), 489-508.

Penning-Rowsell, E. C., Sultana, P., & Thompson, P. M. (2013). The 'last resort'? Population movement in response to climate-related hazards in Bangladesh. Environmental science & policy, 27, S44-S59.

Rahman, M. K., Paul, B. K., Curtis, A., & Schmidlin, T. W. (2015). Linking coastal disasters and migration: A case study of Kutubdia Island, Bangladesh. The Professional Geographer, 67(2), 218-228.

Rahman, A. A., Alam, M., Alam, S. S., Uzzaman, M. R., Rashid, M., & Rabbani, G. (2008). *Risks, Vulnerability and Adaptation in Bangladesh*. United Nations Development Programme.

Rahman, A. A. (2016, January 1). Paris Agreement and the Bangladesh Perspective. *The Daily Star*. Retrieved from https://www.thedailystar.net/supplements/new-year-special-2016/paris-agreement-and-the-bangladesh-perspective-195028

Reid, H. (2014). *Climate change and human development*. Bloomsbury Publishing.

Renaud, F. G., Bogardi, J. J., Dun, O., & Warner, K. (2007). *Control, adapt or flee: How to face environmental migration?*. UNU-EHS.

Scheffran, J., Marmer, E., & Sow, P. (2012). Migration as a contribution to resilience and innovation in climate adaptation: Social networks and co-development in Northwest Africa. *Applied Geography*, 119–127. doi: 10.1016/j.apgeog.2011.10.002

Seneviratne, S., Nicholls, N., Easterling, D., Goodes, C., Kanae, S., Kossin, J., … Zwiers, F. W. (2012). Changes in Climate Extremes and their Impacts on the Natural Physical Environment. In *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. Cambridge University Press. doi: 10.7916/d8-6nbt-s431

Simms, A., & Conisbee, M. (2003). Environmental Refugees: The case for recognition. Retrieved from https://neweconomics.org/2003/09/environmental-refugees

Swain, A. (1996). Displacing the Conflict: Environmental Destruction in Bangladesh and Ethnic Conflict in India. *Journal of Peace Research*, *33*(2). doi:10.1177/0022343396033002005

Sward, J., & Codjoe, S. (2012). Human mobility and climate change adaptation policy: A review of migration in National Adaptation Programmes of Action (NAPAs). *Migrating out of Poverty RPC Working Paper*, *6*.

Tacoli, C. (2009). Crisis or adaptation? Migration and climate change in a context of high mobility. *Environment & Urbanization*, *21*(2). doi:10.1177/0956247809342182

The Government Office for Science (2011). Migration and Global Environmental Change: Future Challenges and Opportunities. London

The Paris Agreement. What is the Paris Agreement? (n.d.). Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement

Thiede, B., Grey, C., & Mueller, V. (2016). Climate variability and inter-provincial migration in South America, 1970–2011. *Global Environmental Change*. doi:10.1016/j.gloenvcha.2016.10.005

Tyson, P. D., Lee-Thorp, J., Holmgren, K., & Thackeray, J. F. (2002). Changing Gradients of Climate Change in Southern Africa during the Past Millennium: Implications for Population Movements. *Climatic Change*, 52, 129–135.doi:10.1023/A:1013099104598

UNDP (2017). Application of the Sustainable Livelihoods Framework in Development Projects. Panama City, Panama.

Walther, G. R., Burga, C. A., & Edwards, P. J. (Eds.). (2001). *"Fingerprints" of Climate Change: Adapted Behaviour and Shifting Species Ranges;[proceedings of the International Conference" Fingerprints" for Climate Change: Adapted Behaviour and Shifting Species Ranges, Held February 23-25, 2001, at Ascona, Switzerland]*. Springer Science & Business Media.

Walsham, M. (2010). *Assessing the Evidence: Environment, Climate Change and Migration in Bangladesh*. IOM.

Wardle, P., & Coleman, M. C. (1992). Evidence for rising upper limits of four native New Zealand forest trees. *New Zealand Journal of Botany*, 303–314. doi:10.1080/0028825X.1992.10412909

Warner, K. (2010). Global environmental change and migration: Governance challenges. *Global Environmental Change*, *20*(3), 402–413. doi: 10.1016/j.gloenvcha.2009.12.001

Weather in Bangladesh. (n.d.). Retrieved from https://www.timeanddate.com/weather/bangladesh

Yu, W., Alam, M., Hassan, A., Khan, A. S., Ruane, A., Rosenzweig, C., ... & Thurlow, J. (2010). *Climate change risks and food security in Bangladesh*. Routledge.

Zaman, M. Q. (1989). The Social and Political Context of Adjustment to Riverbank Erosion Hazard and Population Resettlement in Bangladesh. *Human Organization*, *48*(3). Retrieved from https://www.jstor.org/stable/44126428

Appendix:

In this section, the diagnostics test of the Heteroskedasticity Test, Endogeneity Test, and Instrumental Validity Tests of the Robustness Section (Section 4.3), which has used the mean temperature data of January, March, May, and June of the year 2005-2015, are attached.

January: Mean Temperature data of January of the year 2005-2015.

Table I: Diagnostic Test, Endogeneity Test, and Instrumental Validity Test: (Temperature measured in January)

	F (7, 156979)	**p-value**
Panel A: Test for Heteroskedasticity[a]		
Breusch-Pagan/Cook-Weisberg test	12.39***	0.0000
	Test Statistic	**p-value**
Panel B: Tests of Endogeneity[b]		
Robust Score $\chi^2(1)$	16.0867***	0.0001
Robust Regression F (1, 156978)	16.4304***	0.0001
Panel C: First Stage Regression Summary Statistics[c]		
Variable	Gross income in last one month	
R-square	0.1839	
Adjusted R-square	0.1838	
Partial R-square	0.1402	
Robust F (1, 156979)	18561.1***	
p-value	0.0000	

[a] Test for Heteroskedasticity in OLS estimates. Test conducted using OLS regression without robust standard errors. H_0: Constant variance.

[b] Tests of Endogeneity. H_0: Variables are exogenous.

[c] First Stage Regression Summary Statistics. It suggests the validity of the instrument.

Panel A of Table I is about diagnostic test for Heteroskedasticity. This test is conducted to check whether the problem of Heteroskedasticity exists or not. The value of the F-statistic is 12.39 and its' associated p-value is 0.0000. So, this thesis can strongly reject the null that those coefficients are 0 and this thesis does have predictability in that error variance and this thesis does have evidence of Heteroskedasticity.

Panel B of Table I is about the endogeneity test. This test is conducted to check whether the selected variable for this thesis is endogenous or not. The values of the Robust Score $\chi^2(1)$, the other name of it is Wooldridge's Score, and the Robust Regression are 16.0867 and 16.4304

respectively and their associated p-values are 0.0001. So, this thesis should reject the null hypothesis that variables are exogenous and this thesis is correct in treating 'Gross income in last one month' as an endogenous variable.

Panel C of Table I is about the test of first-stage regression summary statistics. The endogenous variable is 'Gross income in last one month.' The values of R-square, Adjusted R-square, Partial R-square, and Robust F (1, 156979) are 0.1839, 0.1838, 0.1402, and 18561.1 respectively. The value of Robust F (1, 156979) is large enough and the associated p-value of Robust F-statistic is 0.0000 which suggests that the instrument 'Type of work' is valid.

March: Mean Temperature data of March of the year 2005-2015.

Table II: Diagnostic Test, Endogeneity Test, and Instrumental Validity Test: (Temperature measured in March)

	F (7, 156979)	**p-value**
Panel A: Test for Heteroskedasticity[a]		
Breusch-Pagan/Cook-Weisberg test	15.88***	0.0000
	Test Statistic	**p-value**
Panel B: Tests of Endogeneity[b]		
Robust Score $\chi^2(1)$	15.9976***	0.0001
Robust Regression F (1, 156978)	16.3378***	0.0001
Panel C: First Stage Regression Summary Statistics[c]		
Variable	Gross income in last one month	
R-square	0.1839	
Adjusted R-square	0.1839	
Partial R-square	0.1402	
Robust F (1, 156979)	18617.7***	
p-value	0.0000	

[a] Test for Heteroskedasticity in OLS estimates. Test conducted using OLS regression without robust standard errors. H_0: Constant variance.

[b] Tests of endogeneity. H_0: Variables are exogenous.

[c] First Stage Regression Summary Statistics. It suggests the validity of the instrument.

Panel A of Table II is about the diagnostic test for Heteroskedasticity. This test is conducted to check whether the problem of Heteroskedasticity exists or not. The value of the F-statistic is 15.88 and its' associated p-value is 0.0000. So, this thesis can strongly reject the null that those coefficients are 0 and we do have predictability in that error variance and this thesis does have evidence of Heteroskedasticity.

Panel B of Table II is about the endogeneity test. This test is conducted to check whether the selected variable for this thesis is endogenous or not. The values of the Robust Score $\chi^2(1)$, the other name of it is Wooldridge's Score, and the Robust Regression are 15.9976 and 16.3378 respectively and their associated p-values are 0.0001. So, this thesis should reject the null hypothesis that variables are exogenous and this thesis is correct in treating the 'Gross income in last one month' variable as an endogenous variable.

Panel C of Table II is about First-stage regression summary statistics. The endogenous variable is 'Gross income in last one month.' The values of R-square, Adjusted R-square, Partial R-square, and Robust F (1, 156979) are 0.1839, 0.1839, 0.1402, and 18617.7 respectively. The value of Robust F (1, 156979) is large enough and the associated p-value of Robust F-statistic is 0.0000 which suggests that the instrument 'Type of work' is valid.

May: Mean Temperature data of May of the year 2005-2015.

Table III: Diagnostic Test, Endogeneity Test, and Instrumental Validity Test: (Temperature measured in May)

	F (7, 156979)	**p-value**
Panel A: Test for Heteroskedasticity[a]		
Breusch-Pagan/Cook-Weisberg test	14.94***	0.0000
	Test Statistic	**p-value**
Panel B: Tests of Endogeneity[b]		
Robust Score $\chi^2(1)$	15.8093***	0.0001
Panel C: First Stage Regression Summary Statistics[c]		
Variable	Gross income in last one month	
R-square	0.1840	
Adjusted R-square	0.1839	
Partial R-square	0.1402	
Robust F (1, 156979)	18639.6***	
p-value	0.0000	

[a] Test for Heteroskedasticity in OLS estimates. Test conducted using OLS regression without robust standard errors. H_0: Constant variance.

[b] Tests of endogeneity. H_0: Variables are exogenous.

[c] First Stage Regression Summary Statistics. It suggests the validity of the instrument.

Panel A of Table III is about diagnostic tests for Heteroskedasticity. This test is conducted to check whether the problem of Heteroskedasticity exists or not. The value of the F-statistic is 14.94 and its' associated p-value is 0.0000. So, this thesis can strongly reject the null that those coefficients are 0 and this thesis has predictability in that error variance and this thesis does have evidence of Heteroskedasticity.

Panel B of Table III is about the endogeneity test. This test is conducted to check whether the selected variable for this thesis is endogenous or not. The values of the Robust Score $\chi^2(1)$, the other name of it is Wooldridge's Score, and the Robust Regression are 15.8093 and 16.1373 respectively and their associated p-values are 0.0001. So, this thesis should reject the null hypothesis that variables are exogenous and this thesis is correct in treating 'Gross income in last one month' as an endogenous variable.

Panel C of Table III is about First-stage regression summary statistics. The endogenous variable is 'Gross income in last one month.' The values of R-square, Adjusted R-square, Partial

R-square, and Robust F (1, 156979) are 0.1837, 0.1837, 0.1399, and 18605.4 respectively. The value of Robust F (1, 156979) is large enough and the associated p-value of Robust F-statistic is 0.0000 which suggests that the instrument 'Type of work' is valid.

June: Mean Temperature data of June of the year 2005-2015.

Table IV: Diagnostic Test, Endogeneity Test, and Instrumental Validity Test: (Temperature measured in June)

	F (7, 156979)	**p-value**
Panel A: Test for Heteroskedasticity[a]		
Breusch-Pagan/Cook-Weisberg test	13.50***	0.0000
	Test Statistic	**p-value**
Panel B: Tests of Endogeneity[b]		
Robust Score $\chi^2(1)$	16.0821***	0.0001
Robust Regression F (1, 156978)	16.4248***	0.0001
Panel C: First Stage Regression Summary Statistics[c]		
Variable	Gross income in last one month	
R-square	0.1839	
Adjusted R-square	0.1839	
Partial R-square	0.1402	
Robust F (1, 156979)	18566.6***	
p-value	0.0000	

[a] Test for Heteroskedasticity in OLS estimates. Test conducted using OLS regression without robust standard errors. H_0: Constant variance.

[b] Tests of endogeneity. H_0: Variables are exogenous.

[c] First Stage Regression Summary Statistics. It suggests the validity of the instrument.

Panel A of Table IV is about diagnostic test for Heteroskedasticity. This test is conducted to check whether the problem of Heteroskedasticity exists or not. The value of the F-statistic is 13.50 and its' associated p-value is 0.0000. So, this thesis can strongly reject the null that those coefficients are 0 and this thesis has predictability in that error variance and this thesis does have evidence of Heteroskedasticity.

Panel B of Table IV is about the instrument validity test. This test is conducted to check whether the instruments are valid or not. The values of the Robust Score $\chi^2(1)$, the other name of it is Wooldridge's Score, and the Robust Regression are 16.0821 and 16.4248 respectively and their associated p-values are 0.0001. So, this thesis should reject the null hypothesis that variables

are exogenous and this thesis is correct in treating ‘Gross income in last one month’ as an endogenous variable.

Panel C of Table IV is about First-stage regression summary statistics. The endogenous variable is ‘Gross income in last one month.’ The values of R-square, Adjusted R-square, Partial R-square, and Robust F (1, 156979) are 0.1839, 0.1839, 0.1402, and 18566.6 respectively. The value of Robust F (1, 156979) is large enough and the associated p-value of Robust F-statistic is 0.0000 which suggests that the instrument ‘Type of work’ is valid.