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CONTENTS

List of Tables and Figures

Page No.

Tables

Figures

ACRONYMS

AEZ	Agro-Ecological Zones
BBS	Bangladesh Bureau of Statistics
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BDT	Bangladesh Taka
COP	Conference of Parties
CCKPI	Climate Change Knowledge Perception Index
CCIPI	Climate Change Impact Perception Index
DDMKPI	Disaster and Disaster Management Knowledge Perception Index
DRR	Disaster Risk Reduction
DPI	Disaster Preparedness Index
EPI	Evacuation Preparedness Index
GOB	Government of Bangladesh
IPI	Infrastructure Preparedness Index
ICCHL	Impact of Climate Change on Human Life
INDC	Intended Nationally Determined Contributions
PKCC	Perceived Knowledge of Climate Change
PPI	Preservation Preparedness Index
NPDM	National Plan for Disaster Management
NGO	Non-Government Organization
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goals
SOD	Standing Orders on Disaster
UNDP	United Nations Development Programme
UNISDR	United Nations Office for Disaster Risk Reduction (Now UNDRR)
UNFCCC	United Nations Framework Convention on Climate Change

FOREWORD

This study by Dr. Azreen Karim explores disaster preparedness at the household level in terms of the role of human capital. The study argues that while most studies focus on the supply side, namely the role of government in managing disasters, there is a clear area on the demand side that requires to be addressed.

The study is interesting in that it uses a large data base, examines the role of education and knowledge acquired through both formal and informal channels, and comes to the important conclusion that specific, short-duration training material on what households should do under alternative disaster scenarios hold out the greatest promise.

The study directly addresses the core issues and has managed to indicate clear policy measures that should be of interest to the relevant agencies – both in government and outside government who are working on issues related to climate change impact.

I congratulate the author for undertaking this important study which will contribute to the growing literature on climate resilience and climate-development.

December 2020

K. A. S. Murshid
Director General

Executive Summary

Recent literatures have widely portrayed natural disaster impacts on welfare and livelihoods. This literature largely focuses on loss of physical capital (e.g. asset, livestock, and crop), household income–earning opportunities, coping strategies (including migration) and health outcomes. The aspects that are extremely less understood are the role of human capital (i.e., direct and indirect effects of education) and its impact on disaster risk reduction policies through adoption of disaster preparedness measures in lower and middle-income countries with high climatic risks. This study aims to add to the growing "climate-development" literature by investigating the possible determinants of household disaster preparedness behaviour particularly focusing on knowledge and perception and prior damage and employment channels of disaster experience utilizing the BBS 2015 Impact of Climate Change on Human Life (ICCHL) survey, which is a unique and comprehensive large scale big data in Bangladesh.

The supply side focus of the government policies, e.g., cyclone shelter, embankment construction, etc. has been appreciated both nationally and internationally, especially with respect to mortality reduction and minimising loss and damages. However, there are extremely limited discussions on the effectiveness of the demand-side policies of the GoB, i.e., disaster preparedness demonstrating their impacts on disaster risk reduction in the short- to medium-longer term at the household level. Hence, there exists a strong need to scrutinize the existing short- to medium-longer term disaster risk reduction policies of the Bangladesh government for efficient domestic and international investments for successful implementation of the Climate Action Plan, i.e., SDG 13.

In the light of our strategic focus on the longer-term solutions to reduce climate and disaster risk at the micro/household level, our research questions have been established to look at the effectiveness of the key policy interventions of the Bangladesh government in DRR through knowledge, perception, education, social capital, infrastructure, and household loss mitigation. We looked at three policy interventions of the government: existing early warning system, public awareness for preparedness and government disaster financial support and attempted to answer two research questions. We first identify the determinants of household disaster preparedness behaviour including justifying the role of climate change and disaster knowledge and perception, human and social capital, disaster displacement, remittance, income, wealth and labour market outcomes. We then attempt to look at the effectiveness of the key government policies and responses in mitigating household loss and damages to sustain economic development at the household level. To incorporate the respective policy responses, our methodological approach has been primarily index creation targeting the policy relevant questions in various modules of the ICCHL survey and thereby include in our empirical specifications for estimation purpose. For example, we initially develop three preparedness indices, i.e., evacuation preparedness index (to clarify the extent of the existing early warning policies influencing household evacuation preparedness

measures), preservation preparedness index (to clarify the extent of households' adoption of preservation preparedness measures due to public awareness adhering to the global 72-hour emergency supplies rule) and infrastructure preparedness index (to clarify the extent of government's disaster financial support, e.g., government loan support influencing households' infrastructure preparedness measures).

This study provides strong context-specific empirical evidence on the possible determinants of household disaster preparedness behaviour utilizing a unique and comprehensive big data in Bangladesh. Our results show that, in Bangladesh, disaster risk perception explains around 1.5 per cent of formal education with nearly 7.4 per cent of female education compared to the mean. Similarly, climate change perception accounts for around 1.5 per cent of formal education, whereas education levels of female household heads explain almost 7.68 per cent compared to the mean, indicating the overwhelming importance of enhanced disaster education (formal and non-formal) for women in climate and disaster risk reduction policies in Bangladesh. We argue that mainstreaming disaster education across education, climate change and disaster risk reduction policies could significantly enhance responsiveness to our disaster preparedness behaviour and thereby increase household resilience.

We also found that household responses to adoption of numerous forms of preparedness measures ranges between 2 and 3.6 per cent due to increase in remittances while ranging between 1.4 and 2.4 per cent increase due to percentage increase in residing in better housing (i.e., resilient infrastructure). Access to safe drinking water, electricity and sanitation also influences preparedness behaviour significantly. Our findings show that social capital is a robust determinant of adoption of preparedness measures. We identify disaster displacement as an important determinant of disaster preparedness behaviour of households. Our positive and significant result of disaster displacement variable indicates that displaced people are found to be better prepared due to their past disaster experience and actively respond to the government interventions and policies. Our results represent that wealth and salaried income are positively and significantly associated with disaster preparedness compared to net per capita income and daily wages. Per capita income (net) is found to have a negative relationship (but insignificant) along with daily wages, which is also not found to be strongly correlated with disaster preparedness behaviour.

Our contribution to the "climate-development" literature is three-fold: first, we argue that in the absence of a globally agreed loss and damage framework, this study conceptualizes disaster preparedness as a risk reduction pathway towards sustainable development. Second, we provide strong empirical evidence to what extent disaster preparedness could reduce household loss and damage arising from 12 types of natural disasters among 143,980 households across 64 disaster affected regions (including agro-ecological zones) of Bangladesh using big data for the first time in this study. Third, we strongly argue that integration of development and disaster risk reduction policies could further reduce the amount of losses arising from climate-induced natural disasters,

implying integrated impacts across various SDG targets at the micro-household level. Our findings suggest that disaster preparedness is almost 76 per cent effective in mitigating net income loss (per capita) and nearly 81 per cent effective in mitigating salaried income loss (annual) arise via unemployment channel (i.e., loss of employment days due to climate disasters) at the household level.

To conclude, despite widespread policy successes at the local and international contexts, it has been evident that non-adherence to some of the government policies still remains, which translates to their ineffectiveness at various contexts. For example, vulnerable people are often found reluctant to leave their homes and assets due to the lack of security despite early warning or they often look for high lands nearby their houses or take shelter on the embankments rather than flood shelters. A recent high-level consultation meeting delineated that public awareness interventions might not be fully effective without high perception and knowledge level regarding climate change and disaster risk impacts in the short- to medium-longer term. This again reiterates the fact that households' responses (demand-side) and government's actions (supply-side) complement one another in most cases, and efficacy of household responses could deliberately depend on other public interventions and responses as well. In some cases, effectiveness of the demand-side policies in terms of the uptake of preparedness measures might depend on the behavioural responses of the households. We assume that uptake of preparedness measures due to policy intervention of early warning information might depend on the timing of disaster occurrences, i.e., deliberation of the "what to do list" in formal education (via textbooks) might not lead to full effectiveness of these policies in many cases; rather, informal education and short-term skill based designated education programmes might address several of these issues including enhanced resilience gained through knowledge and perception. We therefore recommend short-term and disaster-specific "72-hour early warning-based preparedness education programme" and/or "3-5 day flood forecasting model-based preparedness education programme" as potential solutions that requires further research.

CHAPTER 1

INTRODUCTION

Disasters are not an "equal opportunity menace", and the unavoidable changing climatic environment has become a development concern with the likelihood of rolling back years of development gains and aggravating inequality (e.g., Karim and Noy, 2016a; Karim, 2018). This is primarily due to the inherent vulnerabilities which imply the fact that all human beings are not created equal. Literatures have explicitly shown these differences by age, gender, education, level of income, location, and many other factors (see Hoffmann and Muttarak, 2017; Muttarak and Lutz, 2014). Economic researches, in recent years, further provided evidences of varying loss and damages due to poverty and inequality.[1] In an attempt to critically understand the multidimensional nature of vulnerability and making this a development priority, it is perhaps important to highlight issues which are interdisciplinary in nature.[2] To fully operationalize these development priorities, the national governments are adhering to the targeted goals of the global agendas i.e., the sustainable development goals (SDGs). From a development policy perspective, it is also of immense importance that we identify targeted areas through which disaster damages could be mitigated through risk reduction activities. In recent "climate-development" literature, the strand that is significantly getting more importance is the synergies between adaptation and development due to the quite unavoidable burden of climate change impacts on the developing world for which adaptation becoming the prominent mode of building resilience in the medium to longer-term (Karim and Noy, 2016a,b). Another strand that consistently got more attention in the last few years in "disaster-development" literature is *ex ante* disaster risk reduction, i.e., disaster preparedness (World Bank, 2010; Karim, 2018). Recent literatures have widely portrayed natural disaster impacts on welfare and livelihoods. This literature largely focuses on loss of physical capital (e.g., asset, livestock, and crop), household income–earning opportunities, coping strategies (including migration), and health outcomes. The aspects that are extremely less understood are the role of human capital (i.e., direct and indirect effects of education) and its impact on disaster risk reduction policies through adoption of disaster preparedness measures in lower and middle-income countries with high climatic risks. This study aims to add to the growing "climate-disaster-development" literature by investigating the possible determinants of household disaster preparedness behaviour, particularly focusing on knowledge and perception and prior damage and employment channels of disaster experience utilizing a comprehensive and large scale big data in Bangladesh.

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[1]Karim and Noy (2016a) have done a comprehensive survey of the empirical literature on the differential impacts of natural disasters, specifically on poverty and inequality.

[2] See also Karim (2018), p.41.

It is increasingly been understood that climate disasters are a development concern with the likelihood of rolling back years of development gains and exacerbate inequality (e.g., Karim, 2018). Therefore, increased attention has been provided by policymakers towards disaster risk reduction to develop disaster resilience compared to the focus on relief and recovery persisted at early stages of disaster research. The recently concluded UN Climate Change COP negotiations put forth in place the "Paris Rulebook" significantly boosting support for adaptation and resilience recognizing mounting climate change impacts on lives and livelihoods, especially in the poorest countries' with high climatic risks. Bangladesh has strongly emphasized disaster preparedness measures as adaptation priorities in its Intended Nationally Determined Contributions (INDCs) submitted to the UNFCCC. Hence, there exists a strong need to scrutinize the existing short- to medium-longer term disaster risk reduction policies of the Bangladesh government for efficient domestic and international investments for successful implementation of the Climate Action Plan, i.e., SDG 13.[3] One implementing framework to create a climate-resilient pathway is to understand the mechanism for integration among various targets, e.g., the role of direct and indirect effects of education (i.e., SDG 4) in implementing risk reduction policies, which is one of the central highlights of this study.

Besides supply-side focus in disaster management and response, the demand-side aspects, disaster preparedness in particular, has also been highlighted in both the National Plan for Disaster Management (NPDM) and Standing Orders on Disaster (SOD) documents of the Bangladesh Government. The supply side focus of the government policies, e.g., cyclone shelter, embankment construction, etc. has been appreciated both nationally and internationally, especially with respect to mortality reduction and minimising loss and damages. However, there are extremely limited discussions on the effectiveness of the demand-side policies of the GoB, i.e., disaster preparedness demonstrating their impacts on disaster risk reduction in the short- to medium-longer term at the household level.

Our findings have broader policy implications in both cross-country and domestic contexts. This is the first study that justifies DRR policies as a development pathway through loss and mitigation response mechanism. In the absence of a global loss and damage framework for international negotiations for climate change investment allocation, the study identifies the robust determinants and demonstrates substantive results via development channels exhibiting DRR as the risk reduction pathway towards sustainable development. We strongly argue that the preparedness-development mechanism will contribute quite precisely in designing country-based loss and damage (L & D) framework in order to articulate a longer-term strategy towards global negotiations and could be replicated for other developing countries as well. Policy wise, in the domestic contexts, the study provides empirical evidence of the effectiveness of the demand-side public policies in disaster risk reduction and quantifies the integrated development responses of such policies in the case of Bangladesh.

[3] See Karim and Noy (2020).

1.1. Research Question(s)

In the light of the strategic focus on the longer-term solutions to reduce climate and disaster risk at the micro/household level, the research questions' have been established to look at the effectiveness of the key policy interventions of the Bangladesh government in Disaster Risk Reduction through knowledge, perception, education, social capital and household loss mitigation. The research question(s) along with the key policy interventions are outlined in Table 1.1.

Table 1.1

Research Question(s) for Bangladesh

Research Question(s)	Policy Intervention(s)
• What are the determinants of household disaster preparedness behaviour in Bangladesh? • Does disaster preparedness be a response mechanism for household loss mitigation in Bangladesh?	To clarify the extent of the existing early warning policies influencing household evacuation preparedness measures. To clarify the extent of households' adoption of preservation preparedness measures due to public awareness adhering to the global 72-hour emergency supplies rule. To clarify the extent of government's disaster financial support, e.g., government loan support influencing households' infrastructure preparedness measures.

Source: Author's elaborations.

1.2 Study Objective

The overall goal of the study is to identify the directly observable determinants' of household disaster preparedness behaviour in Bangladesh. The objective of the study is to primarily examine the role of climate change and disaster knowledge and perception, education, prior disaster experience (via disaster damage and labour market outcomes), and other potential determinants (e.g., income, wealth, location, disaster displacement, remittance, social capital, financial inclusion, etc.). The study will further analyze households' loss mitigation mechanism through adoption of household preparedness measures and effectiveness of key government policies on 143,980 households affected by 12 types of natural disasters during 2009-'14 across 64 districts of Bangladesh.

Recent literatures have shown the role of education and prior disaster experience on household preparedness behaviour at various contexts with the underlying mechanisms being highly context-specific (Hoffmann and Muttarak, 2017; Onuma, Shin and Managi, 2017). Therefore, this study contributes the following to the "climate-disaster-development" literature: first, it provides strong context-specific empirical evidence on

the possible determinants of household disaster preparedness behaviour utilizing a unique self-reported big data in Bangladesh; second, it shows the impacts of sudden and slow on-set natural disasters on household loss and damage (including agricultural, land and homestead damage); third, it justifies the role of disaster preparedness and the effectiveness of government policies in mitigating household loss and damage. The novelty in this study is the identification of the possible determinants of household disaster preparedness behaviour including the role of climate change and disaster knowledge and perception, human and social capital, income, wealth, labour market outcomes along with the effectiveness of government policies and responses in mitigating household loss and damage to sustain economic development.

1.3 Organization of the Report

The report has been organized as follows: Chapter 2 describes the conceptual framework outlining the determinants of disaster preparedness and the pathway to household loss mitigation and reviews the empirical evidences of the determinants. Chapter 3 explains the methods and approaches of index creation and provides details on the construction of disaster and climate indexes, while Chapter 4 describes the data, provides detailed breakdown of the methodological framework, explains the identification strategy and identifies the key variables with added descriptive statistics. Chapter 5 presents and analyzes the estimation results comparing with previous literature and Chapter 6 presents robustness checks. Few limitations have been outlined in Chapter 7. Chapter 8 analyzes the effectiveness of existing government policies and provides policy recommendations. Finally, Chapter 9 concludes with implications of our findings to the government key policy documents and also some insight for further advancements.

CHAPTER 2

LITERATURE REVIEW

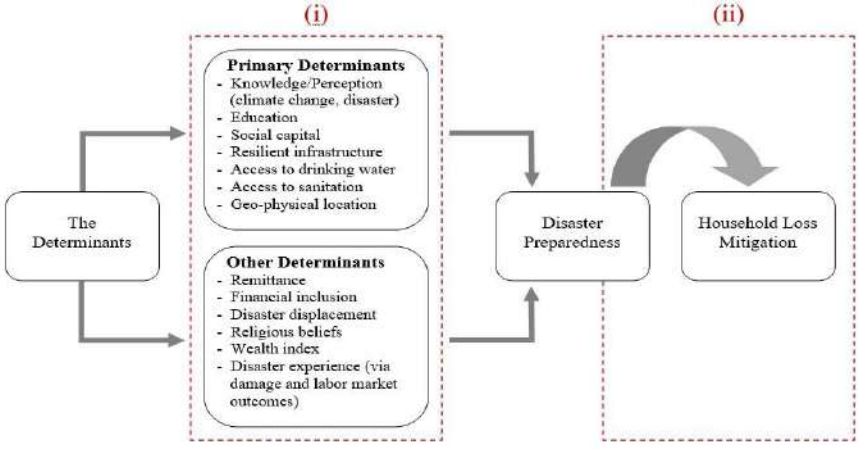
2.1 Disaster Preparedness: Definition and its Types

Preparedness is a concept used by researchers and practitioners to refer to a series of activities which directly or indirectly should mitigate the loss of life and property in a disaster (see Faupel, Kelley and Petee, 1992). According to UNISDR (2009), preparedness may be defined as the knowledge, capabilities and actions of governments, organizations, community groups, and individuals to effectively anticipate, respond to, and recover from the impacts of likely, imminent or current hazard events or conditions. Preparedness is not static in nature, but dynamic, requiring revisions and modifications as social contexts change (Perry and Lindell, 2003). Emergency preparedness involves knowing the risks particular to a community, developing an emergency plan, and having an emergency kit in the home containing food, water, and medical supplies to shelter in place for 72 hours (e.g., Public Safety Canada, 2012). The American Red Cross (2004) suggests that in addition to having an emergency plan, preparedness also involves practicing the plan with family members, and learning about emergency shelters and community response evacuation plans and the need for its continuity throughout all phases of a disaster, i.e., mitigation, preparedness, response and recovery.

2.2 Conceptual Framework

Figure 2.1 displays the breakdown of our conceptualization of disaster preparedness behaviour and the response mechanism towards household loss mitigation. Our conceptual framework has two components. These components portray the premise of the research questions that have been asked in this study.

Figure 2.1: **The Determinants of Disaster Preparedness Behaviour and its Influence Towards Household Loss Mitigation**



Source: Author's elaborations.

The first component has been conceptualized based on the intuition of Hoffmann and Muttarak (2017) that examined the relationship among the pathways through which education, knowledge, perception and/or disaster experience affect household disaster preparedness behaviour. Vulnerability reduction programmes reduce susceptibility and increase resilience.[1] Susceptibility to disasters is largely reduced by prevention and mitigation of emergencies. Emergency preparedness and response and recovery activities—including those that address climate change—increase disaster resilience (e.g., Keim, 2008). Education can increase preparedness behaviour through direct and indirect channels. Evidence suggests that formal schooling is a primary way through which individuals acquire knowledge, skills, and competencies that influence their preparatory efforts. Schooling helps individuals adopt preparatory measures by improving their knowledge of the causal mechanisms between preparedness and disaster risk reduction. Moreover, educated individuals may have better understanding of specific preparedness measures and timing of adoption. Level of education is not only highly correlated with access to weather forecasts and warnings but highly educated individuals are also able to better understand more complex environmental issues, e.g., climate change and disaster impacts. Our conceptualization slightly differs and adds to the justification of formal education to be the primary channel of gaining knowledge and perception regarding climate change and disaster risk. We argue that informal education and community-based training could also play a strong role in this mechanism as evident in the literature.[2] Besides education, prior disaster experience is another key factor determining preparedness behaviour. Theoretically, previous disaster experience may influence preparedness behaviour through channels similar to education. Hazard awareness and risk perception are closely related to prior disaster experience which in turn increases preparedness behaviour. Our study adds development dimensions to this conceptualization through portrayal of disaster experience via two channels: unemployment and production. Therefore, based on this conceptualization, we first identify the determinants of household disaster preparedness behaviour and second, we show to what extent disaster preparedness could be a response mechanism in household loss mitigation exhibiting a risk reduction pathway towards sustainable development.

2.3 The Determinants of Disaster Preparedness: Empirical Evidences

In recent years, studies have attempted to understand the relationship between disaster preparedness and the factors that promote the adoption of preventive measures.[3] Human capital particularly education could create effective long-term defense against the dangers of climate change and can directly influence risk perception, skills, knowledge, disaster preparedness and indirectly reduce poverty, improve health and promote access to information and resources (Muttarak and Lutz, 2017; Zhang *et al.*, 2017; Muttarak and

[1] See SDC (2010); Keim (2008); Toufique and Yunus (2013).
[2] See UNDP (2015); Sharma *et al*., (2013).
[3] See Appendix Table 3 for a review of the literature.

Pothisiri, 2017). Focusing on the determinants of personal disaster preparedness, Hoffmann and Muttarak (2017) find that the effect of education on disaster preparedness is mainly mediated through social capital and disaster risk perception in Thailand; in particular, disaster risk perception explains 11.1 per cent, perception of the impacts of climate change explains 11 per cent and social capital clarifies 23.3 per cent of the education effects on disaster preparedness. However, there is no evidence that education is mediated through observable channels in the Philippines even after the inclusion of the additional factors in this exercise. In one particular study, Onuma, Shin and Managi (2017) analyzes the impact of disaster experience on household preparation of emergency supplies for natural disasters using originally collected Japanese data and show that experience with disaster damage increases preparedness, but the magnitude of the impact varies among the item categories. Damage experience increases the level of preparedness in all categories, but evacuation experience affects only the Basic Preparedness (BP) and Evacuation Preparedness (EP) categories and has no statistically significant impact on the Energy/Heat Preparedness. However, in both of these cases, the underlying mechanisms are highly context-specific. In a project on Andhra Pradesh, India, Sharma *et al.* (2009) argued that evacuation behaviour is also significantly related to prior warning experience, perception of safety during evacuation and perception of quality of stay at the relief camps and the number of channels through which a person receives the message. This evidence is re-emphasized by Dash and Gladwin (2007) pointing out to warning the crucial factor of risk perception in the decision-making process between the transition from hearing warnings to evacuation decisions. Furthermore, whether decisions about evacuation would be taken at the community level or at household level is significantly determined by occupation homogeneity and the size of the village as well.[4] Interestingly, compared to men, women are more likely to prepare emergency kits and/or have an emergency plan and have a greater intention to migrate (e.g., Witvorapong *et al.,* 2015). However, this finding contrasts with the findings of Mohammad-pajooh and Aziz (2014) where men were found to be more prepared than women with higher levels of income and education in the Malaysian context. The striking conclusion in Hoffmann and Muttarak (2017) is education raises disaster preparedness only for those households that have not experienced a disaster in the past.

Social capital is also an identifiable determinant to exhibit positive externalities to strengthen resilience (Cummings *et al.,* 2018; Witvorapong *et al*., 2015; Sadeka *et al.,* 2015; Muttarak and Lutz, 2017). Witvorapong et al. (2015) found that individuals who participate in village-based activities are 5.2 per cent more likely to undertake all identified risk reduction actions compared to those not engaging in community activities encouraging participation in community activities which could have positive externalities in disaster mitigation. Social capital also allows individuals to undertake disaster preparation, receive warnings, help find out shelter and supplies, and help obtain

[4] See Sharma *et al.* (2009).

immediate aid and initial recovery assistance.[5] However, the implications of social capital are found to differ based on its definition and types in particular, on different modes of knowledge creation and tangibility (Cummings *et al.,* 2019). Despite income and education are found to be strongly correlated with preparedness; race was not found to affect preparedness in the Malaysian case (Mohammad-pajooh and Aziz, 2014). Intriguingly, in an investigation from a developed country setting in three counties in Texas (U.S.), Reininger *et al.* (2013) revealed that a higher level of preparedness has been prevalent in individuals who reported the highest perception of fairness. A cross-sectional study to assess the risk perceptions, attitudes, knowledge, and behaviours related to typhoon among rural residents in Zhejiang province of China found gap between residents' cognition or knowledge and behaviour in rural areas (Zhang *et al.,* 2017). Existing gender inequality is believed to be heightened as a result of weather events and Flato *et al.* (2017) show that female-headed households in South Africa are differentially affected by relatively modest levels of variation in rainfall that households experience on a year-to-year basis. However, living in a community with a higher proportion of women who have at least a secondary education increases the likelihood of disaster preparedness (Muttarak and Pothisiri, 2017; Lutz, Muttarak and Striessnig, 2014). In a similar context, Witvorapong *et al.* (2015) further added that the probability of engaging in community activities and carrying out disaster risk reduction measures increase in communities with a higher proportion of women with tertiary education.

Studies have articulated the importance and the roles of various forms of education, i.e., formal and informal, levels of education on behavioural changes associated with emergency management and environmental change. The role of formal education has been characterized to look at the impacts on preparedness actions, and studies are found to exhibit evidences in interdisciplinary contexts. In a study on global warming in Thailand, Chankrajang and Muttarak (2017) show that formal education encourages pro environmental behaviour significantly. However, the authors found no statistically significant relationship between years of schooling and concern about global warming and between education and willingness to pay for environmental tax. Another Thai case study on earthquakes also identified formal education to be positively associated with preparedness actions at the individual, household and village levels (Muttarak and Pothisiri, 2013). These authors further concluded that individual disaster preparedness differs by demographic and educational composition of the village. Interestingly, the role of formal education is also been found in positively significantly reducing vulnerability at both micro and macro levels after controlling for income and/or wealth in low- and middle-income countries for natural disasters in general (Muttarak and Lutz, 2014). This is particularly found evident when economic vulnerability has been portrayed along with vulnerability of loss of life in the context of Bangladesh where projections of flood risk exposure has been found dynamic (Mechlar and Bouwer, 2015). This has also been observed in Bangladesh where several issues like vulnerability, hazards and disaster risk

[5] See Sadeka *et al.* (2015).

reduction measures are placed in text books starting from elementary to Masters level (Islam, 2010).[6] However, past studies have shown that although participation in disaster education is significantly related to preparedness measures, this effect is not important for response or planning compared to previous disaster experience.[7] This has further been elaborated through robust impact of damage experience been associated with preparation of emergency items (Onuma *et al.,* 2017).

One group of projects on India attempted to identify geographic vulnerability due to cyclonic hazard (Mohapatra *et al.,* 2012; Sharma and Patwardhan, 2008). These projects particularly identified coastal districts vulnerable to cyclones. This evidence is critical for the government policymakers to design large scale evacuation measures compared to north-eastern Indian districts which are mostly affected by depressions and floods and therefore not subject to large-scale evacuation related public spending. Some literature further identified relationship between coastal distance and evacuation departure time (e.g. Wu *et al.,* 2012). In a case study on hurricane in North Carolina, USA; Wu *et al.* (2012) revealed that those who evacuated longer distances experienced greater evacuation travel time and additional travel time, longer evacuation duration and greater cost for lodging, food and transportation. Interestingly, in the socio-economic vulnerability literature, the cyclonic event case study in the coastal zones of India by Sharma *et al.* (2013) demonstrates that the relationship between formal education and evacuation is not as strong as expected and it completely disappears when definition of appropriate response is made stricter. This finding is further revealed by Najafi *et al.* (2015) in the Iranian case study on earthquakes where past disaster experience, monthly income level, residential district and occupation matters more compared to education and other socio-demographic controls in justifying disaster preparedness behaviour. The earlier literature, however, shows that there exists positive and significant correlation between education and income.

Despite formal education provides greater access to income earning opportunities and enhance welfare in general, the hazard-specific knowledge and understanding gained from non-formal sources play a greater role in responding appropriately to hazard risk (Sharma *et al.,* 2013). Recent literatures portrayed the aspects of risk perception from informal education, in particular disaster and early warning education in reducing vulnerability. These literatures also emphasized the importance of disaster education in implementing government policy measures through effective response. In a study in the Chinese province of Zhejiang on typhoons, Zhang *et al.* (2017) depicts that residents who has clear understanding of typhoon signals were more likely to adopt measures than others, and television was the main way to get information before typhoon. The study provide evidence of insufficient risk perception of health damage and life threat compared to property damage which in many cases contrasts with the national

[6] However, Mechlar and Bouwer (2015) concluded that reduction in vulnerability can be due to autonomous or exogenous adaptive behaviour.
[7] See Faupel *et al.* (1992).

governments policy prioritization measures in disaster responses towards vulnerable communities. Evidence from India from an UNDP project, 2015 reiterated the strong need for training to provide quick response to emergency situation to successfully manage the disasters' aftermath. It has been revealed that the trainings helped people understood the warnings that were issued and the action that needed to be taken. What is crucial here is that this policy recommendation reflected people's voice at the community and village level in the Indian context for floods and tropical cyclones where more people felt that training in search and rescue or first aid should be organized more frequently. Intriguingly, evidence from North Carolina displayed by Whitehead *et al.* (2000) emphasized on placing a mandatory order rather than a voluntary one in implementing evacuation decisions. But households are found to differ in their perceived risk based on hazard indicators, e.g., storm intensity in making evacuation decisions from their location (Whitehead *et al.*, 2000).

One group of projects attempted to analyze the gendered aspects of evacuation behaviour in various contexts. In a study on hurricane preparedness in North Carolina, USA; Bateman and Edwards (2002) revealed that it is more likely for women to evacuate during hurricanes because of underlying gender differences in care giving roles, evacuation preparation, their greater exposure to certain risks and their greater understanding of subjective risk. But for hydro-meteorological hazards, Lutz *et al.* (2014) argue that female education can reduce disaster fatalities. However, the authors argued that indicators of socioeconomic status do not predict evacuation and mediate the effect of sex on evacuation. In particular, per capita income is not found to be a significant determinant of reducing mortality risk from disaster.[8] This finding has also been confirmed by Masterton and Horney (2013) which further depicted that knowing about an evacuation order does not make a significant difference in a family's decision to leave their home in preparation for hurricane. Intriguingly, for sudden on-set events like hurricane, risks are particularly identified by the ethnic minorities in the re-entry process in Texas, USA (Siebeneck *et al.*, 2012). The authors identified that socio-demographic groups particularly ethnic minorities and individuals with lower levels of education had greater expectations of looting in the evacuation zone. This finding could perhaps be crucial in the comparative policy designation in similar contexts in lower and middle-income countries in terms of asset protection during the advent of a major disaster. However, types and levels of concerns seem to vary positively with the re-entry timing among the returnees.[9]

[8] See Lutz *et al.* (2014).
[9] See Siebeneck *et al.* (2012).

CHAPTER 3

METHODS AND APPROACHES: INDEX CREATION

Index Creation is an important component in this analysis. We employ big data reduction method and develop several indexes in the climate-disaster-development space. In this study we utilize the 2015 "Impacts of Climate Change on Human Life (ICCHL)" Survey of the Bangladesh Bureau of Statistics (BBS) and employ multi-faceted approaches to develop the following indices:

3.1 Disaster and Climate Change Indexes

a) Disaster Preparedness Index (DPI)

   i) Evacuation Preparedness Index (EPI)

   ii) Preservation Preparedness Index (PPI)

   iii) Infrastructure Preparedness Index (IPI)

b) Disaster Risk Management Index

   iv) Disaster and Disaster Management Knowledge Perception Index (DDMKPI)

c) Climate Change Knowledge Perception Index (CCKPI)

d) Climate Change Impact Perception Index (CCIPI)

Development Index

e) Wealth Index

3.2 Choice and Selection of Questions for Index Construction

The details regarding the construction of each of these indices are explained below:

Disaster Preparedness Index (DPI)

We construct three types of disaster preparedness indexes based upon the types of questions' been asked to the respondents which are recorded for each of twelve types of natural disasters been already defined. They are as follows:

Evacuation Preparedness Index (EPI)

We identify the following questions that measure the evacuation preparedness behaviour of households:

i) Did you send your school-going children to safe place?

ii) Did you move cattle to safe place?

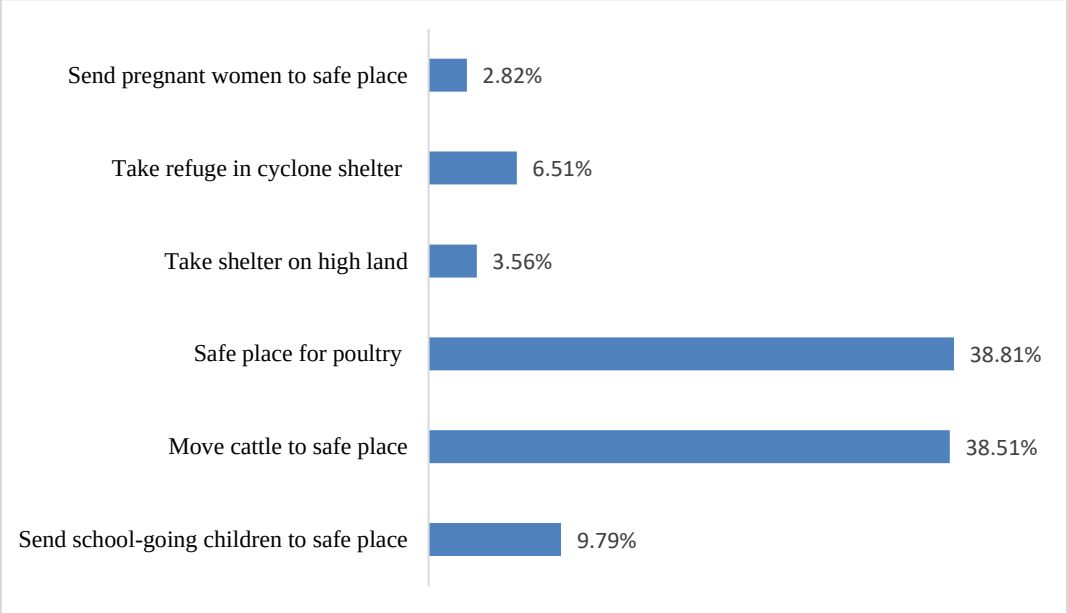
iii) Do you have safe place for poultry?

iv) Did you take shelter on high land/embankment?

v) Did you take refuge in cyclone shelter?

vi) Did you send pregnant women to safe place?

Figure 3.1: **Evacuation Preparedness Measures by Respondents (%)**



Source: Author's calculations.

Preservation Preparedness Index (PPI)

We identify the following questions that measure the preservation preparedness behaviour of households:

i) Did you increase security measures of family food storage area?

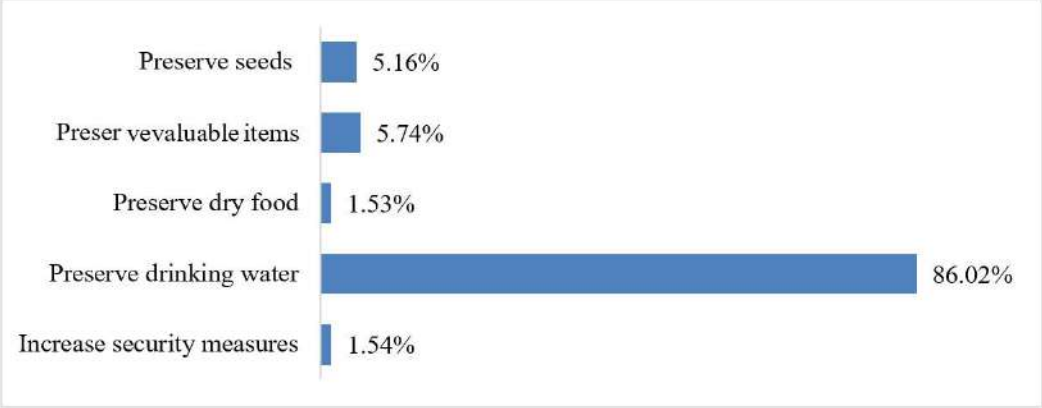
ii) Did you preserve drinking water?

iii) Did you preserve dry food?

iv) Did you preserve valuable items?

v) Did you preserve seeds?

Figure 3.2: **Preservation Preparedness Measures by Respondents (%)**



Source: Author's calculations.

Infrastructure Preparedness Index (IPI)

We identify the following questions that measure the infrastructure preparedness behaviour of households:

i) Do you have brick built house?

ii) Do you have semi-brick built house?

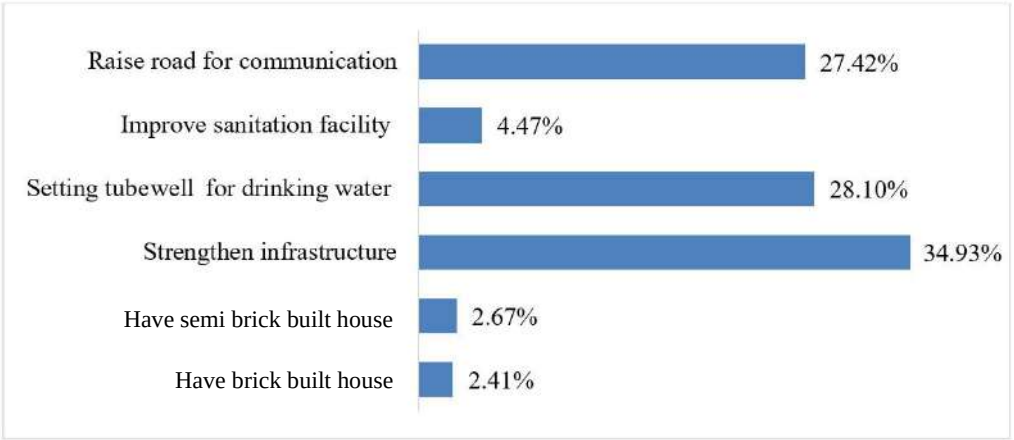
iii) Did you strengthen infrastructure?

iv) Did you set tube well on high ground for drinking water?

v) Do you have improved sanitation facility?

vi) Did you raise road for communication?

Figure 3.3: **Infrastructure Preparedness Measures by Respondents (%)**



Source: Author's calculations.

Disaster Risk Management Index

Disaster and Disaster Management Knowledge Perception Index (DDMKPI)

We develop a Disaster and Disaster Management Knowledge Perception Index (DMKPI) based on the following questions:

i) What do you understand on your perception about disaster?

The index has been developed based on five perceptions about disaster rated by the respondents. They are:

- Disaster is a critical situation created by nature or human induced
- Disaster is a usual process that occurs from time to time
- Disaster happens without any reason
- If others (specify)
- Do not know

ii) What is your knowledge and perception about disaster management?

The index has been developed based on five perceptions about disaster management rated by the respondents. They are as follows:

- Activities or initiatives aimed to reduce pre-disaster, during disaster and post-disaster loss in a systematic manner is disaster management
- Assist only affected people during disaster is disaster management
- To stand beside the affected people only is disaster management
- If others (specify)
- Do not know

Climate Change Knowledge Perception Index (CCKPI)

We develop the Climate Change Knowledge Perception Index (CCKPI) based on the following question:

- ***What do you know or your perception about Climate Change?***

The index has been developed based on five perceptions about climate change rated by the respondents. They are:

- Climate change is long-term changes of climatic conditions, due to variation in natural processes or due to human activities
- Climate change is regional variation in temperature and rainfall
- Climate change is extreme events that cause colossal and sudden loss of human life and infrastructure
- If others (specify)
- Do not know

Climate Change Impact Perception Index (CCIPI)

We develop the Climate Change Knowledge Perception Index (CCKPI) based on the following question:

- ***What are the possible impacts/effects of climate change?***

The respondents identified the possible effects from the following:

- Sea level rise
- Drought/Dryness
- Flood/Water logging
- Salinity
- Storm/Tornado/Hailstorm
- Tidal Surge/Cyclone/Hurricane
- If Others (Specify)

It needs to be noted here that the respondents answered this question on a priority basis, i.e., they have ranked their top three choices of possible impacts/effects of climate change. Therefore, we use the Principal Component Analysis (PCA) approach to construct the CCIPI index.

Perceived Knowledge of Climate Change Index (PKCCI)

Our final measure of climate change perception index is as follows:

Perceived knowledge of climate change (pkcc) =
*Climate change knowledge perception index (cckpi) * Climate change impact perception index (ccipi)*

The perceived knowledge of climate change is the interplay between climate change knowledge perception index and climate change impact perception index. The ICCHL survey is a self-reported dataset with households reporting both their perception on climate change knowledge and impacts. As the dataset reports information between 2009 and 2014, we assume that the perceived knowledge of climate change would be more concisely reflected with the interplay between knowledge and climate-induced disaster impacts due to its self-reported nature of longer-term phenomena.

Table 3.1 documents the particular questions that are used to construct the aforementioned indexes.

Table 3.1

Questions Used to Construct the Indexes

No.	Indexes	Questions used to construct the indexes
1	Evacuation Preparedness Index (EPI)	• Did you send your school-going children to safe place? • Did you move cattle to safe place? • Do you have safe place for poultry? • Did you take shelter on high land/embankment? • Did you take refuge in Cyclone shelter? • Did you send pregnant women to safe place?
2	Preservation Preparedness Index (PPI)	• Did you increase security measures of family food storage area? • Did you preserve drinking water? • Did you preserve dry food? • Did you preserve valuable items? • Did you preserve seeds?
3	Infrastructure Preparedness Index (IPI)	• Do you have brick built house? • Do you have semi-brick built house? • Did you strengthen infrastructure? • Did you set tube well on high ground for drinking water? • Do you have improved sanitation facility? • Did you raise road for communication?
4	Disaster and Disaster Management Knowledge Perception Index (DDMKPI)	*What do you understand on your perception about disaster?* • Disaster is a critical situation created by nature or human induced • Disaster is a usual process that occurs from time to time • Disaster happens without any reason • If others (specify) • Do not know *What is your knowledge and perception about disaster management?* • Activities or initiatives aimed to reduce pre-disaster, during disaster and post-disaster loss in a systematic manner is disaster management • Assist only affected people during disaster is disaster management • To stand beside the affected people only is disaster management • If others (specify) • Do not know
5	Climate Change Knowledge Perception Index (CCKPI)	*What do you know or your perception about Climate Change?* • Climate change is long-term changes of climatic conditions, due to variation in natural processes or due to human activities • Climate change is regional variation in temperature and rainfall • Climate change is extreme events that cause colossal and sudden loss of human life and infrastructure • If others (specify) • Do not know

No.	Indexes	Questions used to construct the indexes
6	Climate Change Impact Perception Index (CCIPI)	*What are the possible impacts/effects of climate change?* • Sea level rise • Drought/Dryness • Flood/Water logging • Salinity • Storm/Tornado/Hailstorm • Tidal Surge/Cyclone/Hurricane • If Others (Specify)

Source: Author's elaborations.

Wealth Index

To develop the wealth index, we use the following question:

- *Does your household own or have owned any of the following items?*

To answer this question, the respondents need to mention whether their household owned any of the 20 different listed items in the year 2014. The items are mostly household durable assets including infrastructure and transportation.

3.3 Construction of the Disaster and Climate Indexes

The primary approach to construct an index is to apply the data aggregation technique based upon the format of the data been collated. A total of seven disaster and climate change indexes had been constructed based upon various types of questions been asked at different modules in the ICCHL survey. To construct these seven indices, we mostly apply Multiple Correspondence Analysis (MCA) technique. MCA is an extension of Correspondence Analysis (CA) which allows one to analyze the pattern of relationships of several categorical dependent variables (e.g., Abdi and Valentin, 2007). It can also be seen as a generalization of Principal Component Analysis (PCA) when the variables to be analyzed are categorical instead of quantitative, i.e., the variable has been coded in 0 and 1 format.

We, therefore, generalize the construction of the disaster and climate change indexes using the following step-by-step method:

Step 1: Choice of Unit. The unit is the most commonly used unit in survey analysis i.e. household.

Step 2: Identification of Domain and Indicators. The domain is the area of research focus based upon which survey questions have been designed under various modules. For example, disaster preparedness measures, disaster and disaster management knowledge perception and perceived knowledge of climate change. Our focus in this study is the role of disaster risk and climate change knowledge and perception on households' disaster preparedness behaviour, its drivers and the role of government policies and preparedness in households' loss mitigation. Therefore, several indexes are

constructed aggregating singular dimensional attributes of similar domain to utilize as indicators in the estimation model(s).

Step 3: Big Data Aggregation Method. We mostly apply big data aggregation method using MCA and PCA techniques on a contextual basis in this study. The ICCHL is a self-reported cross sectional dataset of 143,980 disaster affected people and encompasses data on their livelihood activities in relation to the direct and indirect impacts of climate change and natural disasters.

Step 4: Weights/Aggregation Strategy. The application of weights in index analyzes using MCA technique depends on the type of input data - unit records or summarized aggregates. Use of frequency weights is applicable in most cases ruling out any issue (i.e., equal and/or specific weights, cut-off points, etc.) as in the case of sampling or analytic weights.

Step 5: Check for Correlation and Robustness. Tables 3.2 and 3.3 display the correlations among the climate change and disaster knowledge and perception indexes and their robustness.

Table 3.2

Correlation among the Indexes

	dpi	**epi**	**ppi**	**ipi**	**ddmkpi**	**cckpi**	**ccipi**	**pkcc**
dpi	1							
epi	0.8654	1						
ppi	0.8493	0.7913	1					
ipi	0.8847	0.6114	0.5954	1				
ddmkpi	0.0216	0.0176	0.0175	0.0206	1			
cckpi	0.0023	-0.0015	0.0003	0.0034	0.1443	1		
ccipi	-0.0085	-0.0062	-0.0105	-0.0067	0.0239	0.0215	1	
pkcc	0.01	0.0113	0.0092	0.0065	-0.0124	0.0075	-0.0385	1

Source: Author's calculations.

Table 3.3

Robustness among the Indexes

Variables	(1)	(2)	(3)	(4)
	dpi	epi	ppi	ipi
ddmkpi	0.0220***	0.0184***	0.0182***	0.0208***
	(0.00267)	(0.00272)	(0.00265)	(0.00267)
cckpi	-0.000723	-0.00408	-0.00214	0.000471
	(0.00268)	(0.00269)	(0.00267)	(0.00268)
ccipi	-0.00960**	-0.00686	-0.0118***	-0.00777**
	(0.00412)	(0.00423)	(0.00440)	(0.00394)
pkcc	0.0111***	0.0127***	0.0102**	0.00727*
	(0.00405)	(0.00416)	(0.00437)	(0.00389)
Constant	-0.000214	-0.000245	-0.000195	-0.000140
	(0.00264)	(0.00265)	(0.00264)	(0.00264)
Observations	143,980	143,980	143,980	143,980

Source: Author's calculations.

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

3.4 Construction of the Wealth Index

We apply the Principal Component Analysis (PCA) to construct the wealth index for the following reasons:

i) The respondents listed their ownership of 20 selected durable assets. The range of items includes both household durable, infrastructure and transportation items. The PCA method has been applied here because it captures the variance of the principal components (in this case, the most common household items/assets) and transforms into a singular index.

ii) The weight is also captured based upon the variation of the principal components, i.e., widely owned household items that show the maximum variation among the household item categories.

CHAPTER 4

DATA AND METHODOLOGY

4.1 Data Description

The study employs the 2015 "IMPACTS OF CLIMATE CHANGE ON HUMAN LIFE (ICCHL) SURVEY" cross-sectional self-reported nationally representative climate change and disaster-related big data conducted by the Bangladesh Bureau of Statistics (BBS) and Ministry of Planning, Government of Bangladesh (GOB) covering 143,980 households of disaster-affected regions across 64 districts of Bangladesh. This is a unique self-reported cross-sectional dataset providing the baseline household information including disaster preparedness and prevention information of the impacts of twelve natural disasters due to climate change over various stages (i.e., pre-disaster, during disaster and post-disaster) on the lives and livelihoods of vulnerable communities in the entire country. The data reveals that population by male and female in the households indicates 51.97 per cent and 48.0 per cent respectively where Dhaka division is found to be mostly affected (with 25 per cent damage and loss), followed by Barisal division (20.1 per cent), Khulna division (15.9 per cent), Rajshahi division (11.8 per cent), Chittagong division (10.3 per cent), Sylhet division (8.5 per cent) and Rangpur division (8.5 per cent) respectively. Among them, 24.4 per cent households are affected by floods, 15.1 per cent are cyclone-affected households, 10.6 per cent are affected by thunderstorm, 10.5 per cent are affected by drought, 9.8 per cent are affected by water logging, 8.4 per cent are affected by hailstorm and 6.1 per cent households are affected due to storm/tidal surge consecutively (ICCHL, 2015). The fourteen survey modules encompass information on basic household and population characteristics (including women, children and persons with disability), impacts on livelihood (including disaster-type wise number of non-working days), agricultural (i.e., crop and non-crop) and operational land loss and damage, education, health, sanitation, data on disaster preparedness, experience (2009-'14), knowledge and perception on climate change, impacts of climate change, disaster and disaster management.

Table 4.1

Descriptive Statistics A – The Indexes

Variables	Obs.	Mean	Std. Dev.	Min	Max
dpi	143,980	-8.39E-10	1.000003	-24.4041	0.099028
epi	143,980	1.97E-10	1.000003	-44.4017	0.076942
ppi	143,980	2.02E-09	1.000003	-24.9207	0.081269
ipi	143,980	-1.53E-09	1.000003	-21.0391	0.099168
ddmkpi	143,980	-1.03E-08	1.000003	-1.21381	1.402492
cckpi	143,980	1.62E-08	1.000003	-0.91014	1.168668
ccipi	143,980	-1.48E-09	0.893447	-0.94458	3.978929
pkcc	143,980	0.019241	0.893056	-3.62136	4.650046
Wealth Index	143,980	-4.97E-09	1	-0.74557	1.341239

Source: Author's calculations.

Table 4.1 exhibits the descriptive statistics of the indexes that have been constructed in the context of disaster preparedness, disaster and climate change knowledge perception and wealth ownership. It needs to be noted here that Disaster Preparedness Index (DPI) is the accumulated version of three separate preparedness measures: evacuation, preservation and infrastructure. The perceived knowledge of climate change is the interplay between climate change knowledge perception and the impacts of climate change. The wealth index demonstrates that the disaster affected households owns a maximum of more than one item among 20 tangible listed items.

Table 4.2

Descriptive Statistics B – Determinants and Variables

Variables	Obs.	Mean	Std. Dev.	Min	Max
Total damage	143,980	37318.93	171578.2	0	2.00E+07
Agricultural loss	143,980	18798.01	40664.47	0	2071890
Crop loss	143,980	15264.81	32271.19	0	2070390
Non-crop loss	143,980	3533.198	21750.93	0	1300000
Land damage	143,980	9313.299	160471.4	0	2.00E+07
Homestead property damage	143,980	9207.628	34179.61	0	6110000
Per capita income (net)	143,980	46111.44	71885.02	-440920	9013600
Day labour income_non-agri (annual)	143,980	28809.22	45501.69	0	1080000
Salaried income_non-agri (annual)	143,980	21714.82	86775.46	0	6000000
Loss of employment days due to disasters	143,980	0.941527	4.89978	0	99
Female headed household	143,980	0.0593555	0.2362896	0	1
Rural	143,980	0.9403945	0.2367553	0	1
Dependent member	143,980	1.92931	1.339227	0	16
House ownership	143,980	0.9516252	0.2145576	0	1
Landownership_2014	143,980	0.9790249	0.1433015	0	1
Landownership_2009	143,980	0.9868593	0.1138777	0	1
Proportion of formal education	143,980	0.6151331	0.2722509	0	1
Education level of female household head	143,980	0.1215448	0.8908178	0	16
Access to safe drinking water	143,980	0.9639117	0.1865106	0	1
Access to electricity	143,980	0.6325531	0.4821113	0	1
Access to sanitation	143,980	0.4958744	0.4999847	0	1
Non-birth residence	143,980	0.0357202	0.1855924	0	1
Disaster displacement	143,980	0.0057786	0.0757973	0	1
Internet users	143,980	0.023795	0.1524104	0	1
Social media users	143,980	0.0174608	0.1309809	0	1
Resilient infrastructure (residence)	143,980	0.3071329	0.4613066	0	1
Remittance	143,980	0.0760731	0.2651159	0	1
Social capital	143,980	0.1070774	0.3092127	0	1
Financial inclusion	143,980	0.1564106	0.3632454	0	1
Muslim*Islamic religious institutions	143,980	53829.41	72891.36	0	686350
Hindu*Temple	143,980	11.31427	40.36106	0	380
Christian*Church	143,980	0.0741978	1.624764	0	107
Buddhist*Pagoda	143,980	0.5133491	5.483397	0	74
Hydro-meteorological disasters	143,980	0.56528	0.495722	0	1
Geo-climatological disasters	143,980	0.29843	0.457571	0	1
Emerging disasters	143,980	0.37242	0.483451	0	1
Plain land	143,980	0.4456869	0.4970431	0	1
Char land	143,980	0.0731004	0.2603022	0	1
Coastal	143,980	0.286519	0.4521363	0	1
Beel	143,980	0.0874566	0.282504	0	1
Barind tract	143,980	0.0572371	0.2322959	0	1
Madhupur	143,980	0.0108348	0.1035255	0	1

Source: Author's calculations.

Table 4.2 displays the descriptive statistics of the determinants and variables as constructed.[1] The average (mean) damage amount is BDT 37,318.93 between 2009 and 2014 irrespective of being affected by any of 12 types of disasters. It needs to be noted here that this amount includes the damage cost of households affected by disasters multiple times. Total loss and damage also includes all kinds of agricultural (crop and non-crop), non-agricultural and other losses along with land and homestead property damages due to natural disasters. The descriptive statistics (mean) of these indicators show that, on average, agricultural loss, particularly crop loss (approx. BDT 15,264.81), holds for the major share of losses, while non-crop (BDT 3533.198), land (BDT 9313.299) and homestead property damages (BDT 9207.628) account for the remaining shares. According to a 2014 valuation, on average, net per capita income was BDT 46111.44. It needs to be noted here that some reported values are as low as BDT 44,0920 (minimum negative value) due to production cost being higher than annual income generated through sales from agricultural sector. We assume that this price shock might accommodate other shocks in addition to climate-induced natural hazards.

Among other primary determinants, more than 60 per cent of the household members receive any form of formal education (e.g., primary, secondary and/or tertiary and others). We do note here that the mean of education level of female–headed households (0.1215448) exhibits the coverage of education level of the female household heads. Around 96 per cent of the households have access to safe drinking water, whereas around 63 per cent and 49 per cent of the households reported to have access to electricity and sanitation respectively. It is interesting to note that households who have reported to live in place other than their birthplace, nearly 20 per cent (i.e., 832) of the migrated households are forcibly displaced due to natural disasters. Around 30 per cent of the households live in concrete and half-concrete residence (i.e., resilient infrastructure) with nearly 7.6 per cent reportedly received remittance. Around 10.7 per cent of the affected households have access to network-based social capital[2] while nearly 15.6 per cent households represent financial inclusion i.e., access to any forms of loan in the post-disaster period. Among the types of natural events, during 2009 and 2014, households were mostly affected by hydro-meteorological disasters (56.5 per cent), followed by geo-climatological disasters (29.8 per cent) and emerging disasters (37.2 per cent). The ICCHL survey records 12 types of natural hazards being reported by 143,980 disaster-affected households across 64 districts of Bangladesh. We define these 12 types into 3 groups, namely hydro-meteorological disasters (i.e., flood, storm/tidal surge, cyclone, tornado, landslide and river/coast erosion), geo-climatological disasters (i.e., drought, salinity and water logging) and emerging disasters (i.e., thunderstorm, hailstorm and

[1] See Appendix Table 1 for a description of the variables and their sources.

[2] We define social capital as social network-based financial support available during or after disaster in the years 2009–2014 from any government/non-government organization depicting the strength of social networks in the community. Our assumption on social capital here is households who are more engaged in community activities and have better access to information; expertise and material resources through their social networks (See also Hoffmann and Muttarak, 2017).

others). The disaster-affected households are reported to have located at six agro-ecological zones (AEZs)[3] of Bangladesh due to their proximity with climate-induced natural disasters. We identify these affected households in six locations, namely, Plain land (44.5 per cent), Coastal zone (28.6 per cent), Beel (8.7 per cent), Char land (7.3 per cent), Barind tract (5.7 per cent) and Madhupur AEZ (1.08 per cent).

4.2 Identification Strategy

Our objective in this study is twofold: first, to identify the determinants of the households' disaster preparedness behaviour among 143,980 disaster-affected households across 64 districts in Bangladesh; second, to understand the channels of households' loss mitigation response mechanism and the effectiveness of relevant policies. As our primary focus is on households preparedness behaviour, our identification strategy is basically to identify the disaster-affected households who have adopted any forms of preparedness measures as listed in the ICCHL survey. The 2015 ICCHL survey has got two modules, i.e., modules 11 and 12 which had asked households questions' particularly on their adoption of disaster preparedness measures. The module initially ask households to self-report whether any member of the household took measures for natural disaster preparedness during 2009-'14? If the response turns out to be 'YES', then households were given listed choices of numerous preparedness measures to respond if they have taken any of those measures based upon being affected by any of 12 types of natural disasters. Despite both modules 11 and 12, have listed a range of selected preparedness measures, the adoption response may have differed based on various stages of disasters. The preparedness measures in module 11 have been based on lessons from previous disasters whereas module 12 showcased preparedness measures which households had adopted during the time of the natural disasters till the situation gets normal. Overall, the range of preparedness measures encompasses all three stages of natural disasters: pre-disaster, during disaster and post-disaster.

4.3 Model Specification

The econometric models have been developed based upon the research questions been asked earlier. Therefore, two models have been generated for estimation purposes which are as follows:

MODEL 1:

Research Question 1: *What are the determinants of household disaster preparedness behaviour in Bangladesh?*

[3] The agro-ecological zones (AEZs) of Bangladesh have been identified on the basis of four elements such as physiography, soils, land levels in relation to flooding and agro-climatology (See Banglapedia, 2014).

To identify the determinants, we first estimate the following econometric specification:

$$DPI_{ijk} = \alpha + \beta X_{ij} + \lambda_1 DDMKPI_{ij} + \lambda_2 PKCC_{ij} + \theta_d + \varepsilon_{ij} \quad (1)$$

where DPI indicates disaster preparedness indices for household i in sub-district j for categories k (i.e., infrastructure-based, preservation-based and evacuation-based preparedness measures); X indicates various socio-economic controls (e.g., per capita household income, social network-based financial support, location – coastal, hilly or plain, various age cohorts, rural, sex of household head, average age, dependent, house ownership, land ownership, access to safe drinking water, sanitation facilities and electricity); DDMKPI denote disaster and disaster management knowledge and perception index; and PKCC indicates the perceived knowledge of climate change (which is the interaction between climate change knowledge perception and climate change impact). β indicates the coefficients for various determinants of household preparedness, while λ1 and λ2 denotes the coefficients for disaster and disaster management knowledge perception and perceived knowledge of climate change consecutively. Here, in this functional form, θ represents disaster fixed effect and ε captures the error term. The study uses robust standard errors for the hypothesis tests.

MODEL 2:

To address the second research question, we then estimate the following econometric specification:

Research Question 2: *Does disaster preparedness be a response mechanism for household loss mitigation in Bangladesh?*

$$LD_{ij} = \alpha + \beta X_{ij} + \lambda DPI_{ij} + \theta_d + \varepsilon_{ij} \quad (2)$$

where LD represents loss and damage for household i in sub-district j, X indicates various socio-economic controls (e.g., per capita household income, social network-based financial support, location – coastal, hilly or plain, various age cohorts, rural, sex of household head, average age, dependent, house ownership, land ownership, access to safe drinking water, sanitation facilities and electricity) and DPI indicates disaster preparedness index for household i in sub-district j. β indicates the coefficients for various determinants of household preparedness while λ denotes the coefficient for disaster preparedness index. Similar to the earlier functional form, θ represents disaster fixed effect and ε captures the error term. The study uses robust standard errors for the hypothesis tests.

Indicators from three stages of disaster preparedness have been analyzed e.g., pre-disaster, during disaster and post-disaster during 2009-'14. Three categories of disaster preparedness measures were analyzed, i.e., Infrastructure Preparedness (IP), Preservation Preparedness (PP) and Evacuation Preparedness (EP) measures. The ICCHL survey recorded self-reported information on adopting infrastructure-based measures such as brick built house, semi brick built house, strengthen infrastructure, setting tube well on

high ground for drinking water, improve sanitation facility, raise road for communication and raise bed/cot/plinth. Preservation-based preparedness measures, e.g., increase security measures of family food storage area, preserve drinking water, preserve dry food, preserve valuable items and preserve seeds are also been recorded. The households further responded to evacuation-based preparedness measure questions such as sending school going children to safe place, moving cattle to safe place, safe place for poultry, taking shelter on high land/embankment, taking refuge in cyclone shelter and sending pregnant women to safe place. The preparedness questions have been aggregated into Disaster Preparedness Indices (DPI) using Multiple Correspondence Analysis (MCA) methodology as the responses had been binary (0, 1).

The independent variables primarily includes education (i.e., levels – primary, secondary, tertiary; number of years' of formal schooling; father's and mother's education), Climate Change and Disaster Management Knowledge and Perception Index (CCDMKPI), per capita income, various age cohorts, location (e.g., coastal, plain and/or hilly), social capital (defined as social network-based financial support), prior disaster experience (via damage assessment and labour market outcomes) and other socio-economic controls. The Climate Change and Disaster Management Knowledge and Perception Index (CCDMKPI) has been derived from responses regarding knowledge and perception about climate change, disaster, disaster management and knowledge on possible effects/impacts of climate change using MCA methodology. Social capital has been defined as social network-based financial support available during or after disaster during 2009-'14 from any government/non-government organization depicting the strength of social networks in the community. Our assumption on social capital here is households who are more engaged in community activities have better access to information, expertise and material resources through their social networks.[4]

[4] See Hoffmann and Muttarak (2017).

CHAPTER 5

EMPIRICAL RESULTS

5.1 The Determinants

We estimate model 1 (equation 1) to identify the determinants of households' disaster preparedness behaviour in Bangladesh. Our baseline specification involves four disaster preparedness indexes as dependent variables (i.e., left-hand side variables). Our a-priori assumption is disaster preparedness which is primarily determined by climate change and disaster risk management knowledge and perception, education, access to safe drinking water, electricity, sanitation, resilient infrastructure, remittance, social capital, disaster displacement, religious beliefs, economic development (including wealth and labor market outcomes), types of disasters, location and other socio-economic controls. To estimate the impacts of perceived knowledge of climate change and disaster and disaster management knowledge and perception, we develop and employ two indexes of the same as our independent variables. Table 5.1 demonstrates the determinants of households' disaster preparedness behaviour.[1]

Table 5.1

The Determinants of Household Disaster Preparedness Behaviour

Variables	(1) dpi	(2) epi	(3) ppi	(4) ipi
Female headed hh	0.00397	-0.00601	-0.00317	0.0150
	(0.0125)	(0.0155)	(0.0140)	(0.0119)
rural	0.00201	-0.00136	0.0125	0.00731
	(0.0118)	(0.0120)	(0.0130)	(0.0125)
Dep_mem	0.00298	0.00164	0.00331*	0.00119
	(0.00191)	(0.00195)	(0.00185)	(0.00197)
House ownership	-0.0251*	-0.0142	-0.0112	-0.0276**
	(0.0134)	(0.0162)	(0.0153)	(0.0132)
landownership_2014	0.00218	-0.0145	-0.0326**	0.0338
	(0.0238)	(0.0194)	(0.0153)	(0.0308)
landownership_2009	0.00359	0.0104	0.0205	-0.0205
	(0.0357)	(0.0298)	(0.0292)	(0.0406)
Proportion_formal_education	-0.0485***	-0.0365***	-0.0459***	-0.0382***
	(0.0106)	(0.0110)	(0.0107)	(0.0106)
Education female hh	0.00654**	0.00764**	0.00798***	0.00276
	(0.00285)	(0.00308)	(0.00298)	(0.00330)
Access_safedrinkingwater	0.0648***	0.0460**	0.0492**	0.0714***
	(0.0228)	(0.0218)	(0.0217)	(0.0232)
Access_electricity	0.00834	0.0101*	0.0110*	0.00328
	(0.00603)	(0.00612)	(0.00603)	(0.00595)
Access_sanitation	-0.0213***	-0.0176***	-0.0176***	-0.0158***
	(0.00612)	(0.00614)	(0.00606)	(0.00608)
Non-birth residence	0.00141	0.00341	0.000318	-0.00278
	(0.0126)	(0.0113)	(0.0129)	(0.0137)

(Cont. Table 5.1)

[1] We also report the determinants including demographic variables in Appendix Table 2.

Variables	(1) dpi	(2) epi	(3) ppi	(4) ipi
Disaster displacement	0.0464*	0.0273	0.0265	0.0558**
	(0.0265)	(0.0249)	(0.0299)	(0.0257)
Internet users	-0.0266	-0.0177	-0.00276	-0.0121
	(0.0388)	(0.0296)	(0.0259)	(0.0352)
Social media users	0.00581	0.00894	-0.0190	-0.0171
	(0.0444)	(0.0358)	(0.0343)	(0.0423)
Resilient infrastructure	0.0221***	0.0204***	0.0240***	0.0140**
	(0.00621)	(0.00577)	(0.00582)	(0.00647)
Remittance	0.0363***	0.0265***	0.0205**	0.0354***
	(0.00879)	(0.00945)	(0.00961)	(0.00922)
Social capital	-0.0680***	-0.0621***	-0.0962***	-0.0409***
	(0.0126)	(0.0131)	(0.0143)	(0.0119)
Financial inclusion	-0.00656	-0.00692	-0.00227	-0.00642
	(0.00898)	(0.00919)	(0.00918)	(0.00871)
inter_muslim	-1.05e-07***	-5.66e-08	-5.36e-09	-1.71e-07***
	(3.61e-08)	(3.67e-08)	(3.54e-08)	(3.85e-08)
inter_hindu	-0.000225***	-0.000136**	-4.75e-05	-0.000213***
	(8.59e-05)	(6.84e-05)	(6.29e-05)	(8.03e-05)
inter_chris	0.000640***	0.000619***	0.000506**	0.000790***
	(0.000225)	(0.000216)	(0.000211)	(0.000251)
inter_budd	0.000397***	0.000331**	0.000151	0.000675***
	(0.000143)	(0.000141)	(0.000117)	(0.000232)
Hydro-meteorological_dis	-0.0791***	-0.0558***	-0.0635***	-0.0865***
	(0.00498)	(0.00433)	(0.00492)	(0.00581)
Geo-climatological_dis	0.0522***	0.0517***	0.0479***	0.0365***
	(0.00628)	(0.00558)	(0.00604)	(0.00695)
Emerging_dis	0.0249***	0.0305***	0.0242***	0.0119**
	(0.00544)	(0.00515)	(0.00545)	(0.00602)
Plain_land_cluster	0.0289***	0.0210**	-0.00241	0.0586***
	(0.00884)	(0.00914)	(0.00789)	(0.0140)
Char_land_cluster	0.0431***	0.0362***	0.00776	0.0724***
	(0.00916)	(0.00940)	(0.00918)	(0.0142)
Coastal_cluster	-0.231***	-0.170***	-0.201***	-0.212***
	(0.0115)	(0.0118)	(0.0111)	(0.0158)
Beel_cluster	0.0135	0.00841	-0.0132	0.0434***
	(0.00904)	(0.00937)	(0.00807)	(0.0140)
Barind_tract_cluster	0.0193**	0.0124	-0.00851	0.0476***
	(0.00961)	(0.0108)	(0.00869)	(0.0141)
Madhupur_cluster	0.0180**	0.0129	-0.00891	0.0488***
	(0.00908)	(0.00936)	(0.00810)	(0.0139)
Per capita income_net	-1.11e-08	-2.14e-08	-1.20e-09	-6.70e-09
	(2.97e-08)	(2.84e-08)	(2.40e-08)	(2.98e-08)
Wealth_index	0.00405	0.00476*	0.00562**	0.00151
	(0.00286)	(0.00283)	(0.00277)	(0.00291)
Day_labour_income	-6.62e-08	-1.27e-07*	-6.09e-08	-4.17e-08
	(6.64e-08)	(6.91e-08)	(6.79e-08)	(6.66e-08)
Salaried_income	4.70e-08*	3.30e-08	3.89e-08*	4.39e-08
	(2.85e-08)	(2.68e-08)	(2.36e-08)	(2.90e-08)
ddmkpi	0.00898***	0.00781***	0.00729***	0.00787***
	(0.00256)	(0.00262)	(0.00255)	(0.00257)
pkcc	0.00934**	0.0113***	0.00881**	0.00553
	(0.00402)	(0.00414)	(0.00434)	(0.00386)
Constant	0.0580	0.0430	0.0620*	0.0296
	(0.0358)	(0.0329)	(0.0341)	(0.0381)
Observations	143,980	143,980	143,980	143,980
R-squared	0.022	0.013	0.015	0.022

Source: Author's calculations.

Note: Robust standard errors are in parentheses*** p<0.01, ** p<0.05, * p<0.1

Our results strongly indicate that knowledge and perception of both climate change, disaster and disaster risk management are positive and significant determinants of disaster preparedness behaviour in Bangladesh, which is consistent with previous literatures in other country contexts as well (e.g., Hoffmann and Muttarak, 2017; Muttarak and Lutz, 2017; Zhang *et al.*, 2017; Muttarak and Pothisiri, 2017; Dash and Gladwin, 2007). In Bangladesh, disaster risk perception explains around 1.5 per cent of formal education with nearly 7.4 per cent of female education compared to the mean. Comparatively, disaster risk perception explains 11.1 per cent of formal education in Thailand with no evidence in the context of the Philippines as evident in Hoffmann and Muttarak (2017).[2] Our estimation results reveal a negative and significant relationship between proportion of formal education among household members and disaster preparedness; however, education level of female household heads significantly increases disaster preparedness. This finding has been justified by Muttarak and Pothisiri (2017) and Lutz, Muttarak and Striessnig (2014) as well. Our finding of negative relationship between formal education and disaster preparedness can be partly justified by the lack of information regarding informal education in our data, which in our view might have a stronger role in disaster risk perception to increase preparedness among disaster-affected people in Bangladesh. Individual disaster preparedness could also differ by demographic and educational composition.[3] We also find perceived knowledge of climate change as positive and significant determinant of disaster preparedness. In Bangladesh, climate change perception accounts for around 1.5 per cent of formal education whereas education levels of female household heads explains almost 7.7 per cent compared to the mean, indicating the overwhelming importance of female education in climate and risk reduction policies in Bangladesh. This finding is further emphasized by Witvorapong *et al.* (2015) with positive externalities of disaster risk reduction measures in communities with a higher proportion of female education.[4]

Among other determinants, resilient infrastructure and remittance are found to be significant drivers of disaster preparedness behaviour. Household responses to adoption of numerous forms of preparedness measures ranges between 2 and 3.6 per cent due to increase in remittances while ranging between 1.4 and 2.4 per cent increase due to percentage increase in residing in better housing (i.e., resilient infrastructure). Access to safe drinking water, electricity and sanitation also influences preparedness behaviour significantly. Recent literatures have identified social capital as an important determinant to exhibit positive externalities in disaster mitigation through preparedness (e.g., Cummings *et al.* 2018; Witvorapong *et al.*, 2015; Sadeka *et al.*, 2015; Muttarak and Lutz, 2017). Our findings show that social capital is a robust determinant of adoption of

[2]Hoffmann and Muttarak's (2017) sample includes only female respondents in the case of Philippines.

[3] See Muttarak and Pothisiri (2013).

[4] However, Chankrajang and Muttarak (2017) found no statistically significant relationship between years of schooling and concern about global warming in Thailand.

preparedness measures. However, we find a negative significant result, which also corresponds with the literature to some extent. According to Cummings *et al.* (2019), the implications of social capital are found to differ based on its definition and types. As previously highlighted, our definition of social capital indicates to availability of social network-based financial support available during or after disaster in the period 2009-'14 from any government/non-government organization. Our negative and significant result indicates lack of strength in social networks among the disaster-affected communities across the country. We believe, this is an important finding as proper government interventions to provide better access to information, expertise and material resources through social networks will not only encourage adoption of disaster preparedness measures; it would further complement the traditional definition of social capital[5] of bonding and bridging at the recovery stage as well.

We identify disaster displacement as an important determinant of disaster preparedness behaviour of households. Disaster displacement is found to be a significant determinant exhibiting positive relationship with disaster preparedness. It is important to take note of the construction of this particular variable as this implies its difference with voluntary migration. We particularly identify households who are not currently living in their birthplace. The next subsequent question asks them to highlight the reasons of moving from their birthplace. A total of 4,118 identified households are found to live outside their birthplace, of which a total of 832 households are found to be forcibly displaced because of natural disasters. Our positive and significant result of disaster displacement variable indicates that displaced people are found to be better prepared due to their past disaster experience and actively respond to government interventions and policies.[6] This finding is crucial to understand integrated migration policies and hence design localized public interventions towards climate-induced disaster mitigation policies in the context of Bangladesh and other developing countries with high climatic risks.

The "climate-development" literature has widely acclaimed the role of religious beliefs in the last decade especially in designing cross-cutting intervention policies towards adaptation and mitigation (e.g., Schipper *et al.*, 2014; Schipper, 2010; Ha, 2015). This motivated us to include variables based upon contemporary religious beliefs and systems in our empirical specification. We utilize the question where the respondents (household members) need to mention their religious beliefs. We then interacted the number of affected people belonging to various religious systems with the number of respective religious institutions and holy places that exists in the respective districts of Bangladesh. The data on the number of religious institutions and holy places have been collated from the District Statistics of the Bangladesh Bureau of Statistics. We estimated the interaction terms as probable determinants of disaster preparedness behaviour in our baseline model as we assume people adhering to specific religious beliefs are more likely

[5] See Aldrich (2012).
[6] See Martin *et al.* (2014); Billah *et al.* (2014).

to take shelter in the holy places of their own religion in the advent of a natural disaster. This will further provide an ample scope to understand the usefulness of utilizing religious institutions as shelter places at the pre-disaster stage. Moreover, in many cases evidences have shown that disaster vulnerable people, in particular women, are more likely to take shelters in religious institutions due to their belief that God is going to save them and nothing will happen to them if they take shelter in holy places. We include four (4) interaction terms for affected people belonging to the major religions, namely, Muslim, Hindu, Christian and the Buddhist. Our results on the interaction terms reveal that religious belief is a significant determinant of disaster preparedness behaviour in the context of Bangladesh. Intriguingly, the interaction terms with the number of Christians and the Buddhist seem to exhibit positive and significant relationship compared to a significant and negative relationship with the Muslim and the Hindu believers. We expect there might be several reasons behind this trajectory. As the Muslim and the Hindus are greater in numbers, people might have responded to the government's early warning policy and preferred to take shelter in more conventional shelter places, e.g., multi-purpose cyclone shelters. In addition, the multi-purpose cyclone shelters are designed to protect and provide safety to humans along with their livestocks in response to early warning interventions in the advent of natural disasters.

As defined earlier, we have clustered 12 disasters into three groups, namely hydro-meteorological disasters (i.e., flood, storm/tidal surge, cyclone, tornado, landslide and river/coast erosion), geo-climatological disasters (i.e., drought, salinity, water logging) and emerging disasters (i.e., thunderstorm, hailstorm and others) to delineate the effects of sudden and slow on-set events. We attempt to capture the impacts of disaster clusters by adding a disaster fixed effect in our model (i.e., model 1). We observe that all the disaster clusters are significant and have impact on the disaster preparedness behaviour of households. However, it is interesting to note here that the hydro-meteorological disasters are portraying a negatively significant relationship with disaster preparedness. It might be because of the timing and extent of coverage of a number of events happening multiple times as these disasters are more frequent in Bangladesh and the questions' are based on the events during the period from 2009 to 2014. Policy wise, it might also indicate lack of adherence to particular government interventions, e.g., vulnerable people are often found reluctant to leave their homes and assets due to lack of security even after the early warning for specific disasters are provided.[7] More interestingly, literatures have identified various sources of vulnerability to particular disasters e.g. cyclone affected people are found to be more vulnerable than flood affected people (Toufique and Yunus, 2013) and coastal districts are found more vulnerable to cyclones in the Indian context (e.g., Mohapatra *et al.,* 2012; Sharma and Patwardhan, 2008). The latter evidence has further been re-emphasized in our results of coastal cluster, which is found to show evidence of negative and significant relationship with disaster preparedness.[8] The other location

[7] See Siebeneck *et al.* (2012); Parvin *et al.* (2019).
[8] See Ahsan *et al.* (2016).

clusters[9] i.e., Plain land, Char land, Barind tract, Madhupur cluster and Beel cluster are overall found to demonstrate significantly positive relationship with disaster preparedness except few exceptions in cases of particular preparedness measures.

Literatures have widely highlighted the relevance of development outcomes as important determinants of disaster preparedness behaviour; in particular income, wealth, labour market outcomes and demonstrated their relationship with education and disaster policies in several contexts (e.g., Lutz *et al.,* 2014; Najafi *et al.,* 2015). Our results represent that wealth and salaried income are positively and significantly associated with disaster preparedness compared to net per capita income and daily wages. Per capita income (net) is found to have a negative relationship (but insignificant) along with daily wages, which is also not found to be strongly correlated with disaster preparedness behaviour. However, our results found a strong positive relationship between knowledge, perception and disaster preparedness, which we assume partially mediated through formal education in our case indicating to better income-earning opportunities.[10]

5.2 Household Loss and Damage

To address our second research question, we estimate model 2 (equation 2) by splitting into two parts. In this section, we first estimate the impacts of climate-induced natural disasters on household loss and damage. We identify two channels to estimate loss and damage, i.e., via unemployment and production. We understand this is crucial because it will provide us an ample scope to justify the direct and indirect response of disaster preparedness measures in mitigating household loss and damage, thereby substantiating a risk-reduction pathway towards sustainable development. Table 5.2 reports the impacts of climate-induced natural disasters on household loss and damage via unemployment.

[9] The location clusters are based upon the Agro-ecological Zones (AEZs) of Bangladesh. See also Asaduzzaman and Anik (2017).

[10] Our results, using Instrumental Variables (IV) approach (Chapter 6), show that income is not endogenous in our model and does not influence the decision-making process of disaster-affected households whether to adopt disaster preparedness measures.

Table 5.2

Impacts of Climate-induced Natural Disasters on Household Loss and Damage (via unemployment)

Variables	(1) Per capita income loss	(2) Day labor income loss	(3) Salaried income loss
Female headed hh	6,867	-5,421*	4,956
	(5,435)	(3,019)	(4,623)
rural	7,845**	118.4	-5,847
	(3,807)	(2,632)	(5,436)
Dep_mem	-81.33	2,536***	1,916*
	(1,235)	(591.7)	(995.5)
House ownership	4,194	-10,257**	-1,489
	(3,437)	(4,754)	(4,208)
landownership_2014	-3,539	-19,782*	-1,668
	(5,608)	(11,941)	(5,399)
landownership_2009	6,281	9,837	5,044
	(6,988)	(14,219)	(7,361)
occup_agri	3,373	-5,662***	-13,562***
	(3,407)	(1,532)	(2,228)
Proportion_formal_edu	-4,872	-15,466***	16,787***
	(4,237)	(2,539)	(2,552)
Education female hh	-1,349	688.5	-269.2
	(1,680)	(696.6)	(1,679)
Access_safedrinkingwater	-3,326	-726.9	6,068***
	(6,173)	(4,065)	(1,921)
Access_electricity	-3,242	-8,884***	932.6
	(2,260)	(1,661)	(1,658)
Access_sanitation	-6,623***	-11,103***	5,585***
	(2,273)	(1,565)	(1,577)
Non-birth residence	-6,640*	4,551	2,235
	(3,971)	(4,816)	(5,158)
Disaster displacement	18,165	26,517	-919.0
	(11,776)	(20,213)	(9,219)
Internet users	-15,044***	-3,592	-5,047
	(5,157)	(5,964)	(9,800)
Social media users	23,172	-3,163	6,137
	(14,136)	(6,700)	(11,900)
Resilient infrastructure	5,468**	-4,730***	1,774
	(2,689)	(1,447)	(2,110)
Remittance	2,624	-19,150***	-20,250***
	(10,862)	(1,250)	(6,789)
Social capital	3,391	13,157***	-1,604
	(2,332)	(2,649)	(2,027)
Financial inclusion	507.7	3,189	-289.4
	(2,298)	(2,154)	(2,129)
inter_muslim	0.0548	0.0250**	0.0162
	(0.0353)	(0.0109)	(0.0122)
inter_hindu	-44.43**	-21.40	-49.86***
	(22.66)	(18.98)	(11.66)
inter_chris	-252.4	-529.8***	2.496
	(153.8)	(101.1)	(125.7)
inter_budd	-138.5	-133.4*	8.200
	(86.88)	(71.36)	(56.71)
Hydro-meteorological_dis	24,913***	17,627***	7,379***
	(2,928)	(1,682)	(2,072)
Geo-climatological_dis	27,284***	8,454***	6,517***
	(3,137)	(1,732)	(1,851)
Emerging_dis	-414.5	-4,428***	-892.4
	(2,819)	(1,613)	(2,176)
Plain_land_cluster	17,142***	9,969**	14,271***
	(4,033)	(3,891)	(3,709)

(Contd. Table 5.2)

Variables	(1) Per capita income loss	(2) Day labor income loss	(3) Salaried income loss
Char_land_cluster	9,070*	4,213	7,188*
	(5,332)	(4,335)	(3,827)
Coastal_cluster	7,747*	10,630***	5,422*
	(4,607)	(3,959)	(3,213)
Beel_cluster	2,554	7,848*	-337.8
	(5,158)	(4,266)	(3,574)
Barind_tract_cluster	3,311	11,517**	3,589
	(4,582)	(4,693)	(3,630)
Madhupur_cluster	-28,548***	342.6	-1,411
	(8,566)	(6,746)	(7,155)
Per capita income (net)	0.827***	0.0333***	0.356**
	(0.181)	(0.00697)	(0.164)
Wealth index	-1,475	-3,870***	1,669
	(1,262)	(648.9)	(1,046)
Constant	-38,153***	46,196***	-24,142**
	(14,639)	(9,780)	(11,478)
Observations	143,980	143,980	143,980
R-squared	0.025	0.006	0.009

Source: Author's calculations.

Note: [a] Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

[b] The annual amount of the daily income and the salaried income has been used to calculate the loss measure in these categories.

To estimate the loss and damage impacts via unemployment, we generate three variables for our estimation purpose. The ICCHL survey records the number of days household members were unemployed due to natural disasters during the period 2009-2014. We calculate net income loss (per capita), daily income loss (annual) and salaried income loss (annual) by multiplying the income variables with the loss of employment days. Therefore, first, we estimate model 2 without DPI (disaster preparedness index) as the right-hand side variable. The dependent variables are net income loss (per capita), daily income loss (annual) and salaried income loss (annual) in our empirical specification [Table 5.2].

As mentioned earlier, we define the 12 disasters into three groups, namely hydro-meteorological disasters (i.e., flood, storm/tidal surge, cyclone, tornado, landslide, and river/coast erosion), geo-climatological disasters (i.e. drought, salinity and water logging) and emerging disasters (i.e. thunderstorm, hailstorm and others). Our a priori assumption is these (three) disaster groups will increase income losses generated through loss of employment days. Our estimation results show that both hydro-meteorological disasters (sudden on-set) and geo-climatological disasters (slow on-set) have significant and positive impacts on all three types of income losses, i.e., net income loss (per capita), daily income loss (annual) and salaried income loss (annual). Interestingly, the emerging disasters seem to decrease the net income effect (although not significant) of household loss. This might be due to the indirect relationship between income losses and emerging disaster group via the unemployment channel justifying further research in this category.

Table 5.3
Impacts of Climate-induced Natural Disasters on Household Loss and Damage (via production)

Variables	(1) Total Damage	(2) Agricultural loss	(3) Crop loss	(4) Non-crop loss
Female headed hh	-255.1	-497.0***	-444.0***	-52.96***
	(354.6)	(26.36)	(21.88)	(13.22)
rural	656.1***	504.1***	410.2***	93.89***
	(135.3)	(30.46)	(21.75)	(17.52)
Dep mem	324.9***	170.3***	129.0***	41.29***
	(34.68)	(9.365)	(7.208)	(4.648)
House ownership	-479.4	446.3***	348.8***	97.57***
	(305.5)	(27.36)	(18.37)	(18.96)
landownership_2014	-2,830***	-71.15	-45.39	-25.76
	(850.8)	(58.90)	(51.21)	(26.45)
landownership_2009	4,019***	558.8***	440.3***	118.5***
	(827.1)	(62.24)	(53.45)	(29.26)
occup_agri	695.0***	809.7***	730.7***	78.99***
	(76.35)	(17.69)	(12.78)	(10.56)
Proportion_formal_edu	560.6***	246.6***	159.3***	87.22***
	(142.1)	(29.23)	(22.95)	(16.12)
Education female hh	-123.1**	-44.07***	-32.63***	-11.44**
	(54.84)	(8.431)	(6.641)	(4.562)
Access_safedrinkingwater	-924.9***	-498.4***	23.32	-521.7***
	(125.8)	(58.51)	(31.08)	(45.74)
Access_electricity	348.7***	262.2***	214.2***	47.95***
	(79.93)	(17.31)	(14.09)	(8.800)
Access_sanitation	-90.49	61.37***	92.79***	-31.42***
	(82.30)	(18.33)	(15.01)	(9.145)
Non-birth residence	33.48	11.06	-4.046	15.11
	(199.1)	(47.83)	(36.81)	(26.53)
Disaster displacement	-936.6***	-205.8**	-111.2*	-94.56**
	(201.1)	(81.78)	(67.09)	(41.24)
Internet users	114.7	-46.75	-63.52	16.77
	(303.7)	(118.8)	(72.52)	(77.17)
Social media users	-61.02	-36.55	-8.507	-28.04
	(360.3)	(131.1)	(83.58)	(84.02)
Resilient infrastructure	324.9***	400.4***	244.6***	155.8***
	(100.1)	(23.41)	(17.73)	(13.53)
Remittance	-485.2**	-212.8***	-55.87	-157.0***
	(202.3)	(48.77)	(38.89)	(23.33)
Social capital	201.5**	-76.50***	-136.0***	59.46***
	(98.36)	(26.14)	(19.06)	(16.68)
Financial inclusion	313.5***	215.9***	127.3***	88.59***
	(84.72)	(25.80)	(19.14)	(16.00)
inter_muslim	0.000448	2.88e-05	-0.000148	0.000177***
	(0.000539)	(0.000115)	(9.47e-05)	(5.98e-05)
inter_hindu	-2.729***	-0.645***	-0.917***	0.272**
	(0.524)	(0.179)	(0.127)	(0.117)
inter_chris	12.23	13.34***	17.96***	-4.622***
	(8.052)	(4.157)	(3.984)	(0.858)
inter_budd	-2.176	1.289	4.020***	-2.731***
	(2.095)	(0.880)	(0.762)	(0.391)
Hydro-meteorological_dis	2,882***	1,284***	985.7***	298.7***
	(96.28)	(31.23)	(26.56)	(14.40)
Geo-climatological_dis	1,195***	1,400***	1,221***	179.2***
	(94.04)	(30.58)	(25.47)	(15.31)
Emerging_dis	944.5***	1,045***	974.5***	70.53***
	(93.17)	(29.14)	(24.74)	(13.25)
Plain_land_cluster	511.1***	826.4***	892.7***	-66.30***
	(116.0)	(34.31)	(23.45)	(22.99)
Char_land_cluster	-278.3**	232.0***	352.8***	-120.8***
	(127.7)	(37.67)	(27.68)	(23.40)

(Contd. Table 5.3)

Variables	(1) Total Damage	(2) Agricultural loss	(3) Crop loss	(4) Non-crop loss
Coastal_cluster	156.9	409.7***	140.5***	269.1***
	(111.8)	(35.16)	(22.94)	(24.26)
Beel_cluster	1,449***	298.9***	397.0***	-98.10***
	(317.6)	(39.30)	(28.19)	(25.33)
Barind_tract_cluster	-372.3***	354.6***	469.9***	-115.3***
	(122.5)	(40.17)	(30.76)	(24.11)
Madhupur_cluster	-757.4**	-196.0**	-12.78	-183.2***
	(358.6)	(81.34)	(41.71)	(68.09)
Per capita income (net)	0.00759***	0.00324***	0.00222***	0.00102***
	(0.00179)	(0.000458)	(0.000307)	(0.000201)
Wealth index	293.0***	176.9***	159.3***	17.66***
	(46.17)	(10.19)	(7.993)	(5.536)
Constant	-2,102***	-2,876***	-2,820***	-56.50
	(305.5)	(83.14)	(59.69)	(50.55)
Observations	143,980	143,980	143,980	143,980
R-squared	0.012	0.085	0.108	0.025

Source: Author's calculations.
Note: [a] Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
[b] The mean (average) of the dependent variables has been estimated in the model.

Table 5.3 displays the impacts of climate-induced natural disasters on household loss and damage via production. To estimate the impacts on production, we again estimate model 2 (equation 2) without the DPI indicator on the right-hand side in our empirical specification. The dependent variables are mostly production loss variables, i.e., agricultural loss, crop loss, non-crop loss and total damage. To generate the left-hand side variables, we have used modules 5, 6, 7 and 8 of the ICCHL survey.

Our regression results reveal that all three disaster groups (i.e., hydro-meteorological, geo-climatological and emerging disasters) have a significant and positive relationship with household loss and damage via production. However, the hydro-meteorological (sudden on-set) disasters have a much larger impact on damage including agricultural loss (crop and non-crop) compared to geo-climatological and emerging disasters. This finding is justified as Bangladesh is more prone to floods and cyclones based on its geographical location in the delta region, but we could not rule out the fact that all three groups will likely to have increased and aggravated impacts on micro-development dimensions due to the unfolding nature of climate change in the years to come.

It further needs to be noted here that both the loss and damage channels of household loss and damage as analyzed in this study (i.e., unemployment and production) needs to be carefully examined and continuously monitored with respect to the impacts of the disaster types over time for targeted policy formulation. For example, the emerging disasters (e.g., thunderstorm, hailstorm and others) have shown a negative (not significant) impact on net income loss (per capita) but with a positively significant impact on production losses and damage. We assume that the emerging disasters are less likely to impact income through unemployment channel as the income loss variables represent the loss of net income (per capita) through the loss of employment days of household members due to natural disasters. Comparatively, the production channel might be a better indicator to assess household loss and damage impacts in the case of emerging

disasters as these losses are also been self-reported by the affected households themselves. Nevertheless, we believe this argument needs more evidence in cross-country contexts with varied geographical locations, socio-economic and demographic profiles as well. Our findings on the geological locations (as identified by the agro-ecological zones) do represent that most of these are quite vulnerable (estimations are found positive and significant) with respect to disaster impacts with Coastal, Barind, Beel and Plain land which are found to be strong responders to geophysical vulnerability via both unemployment and production.

5.3 Household Loss Mitigation

In this section we present our estimation findings of model 2 (full model) as outlined in equation 2 and is reported in Table 5.4. In this study, in research question 2, we ask: *Does disaster preparedness be a response mechanism for household loss mitigation in Bangladesh?* To answer this question, we estimate model 2 (full model) with DPI (Disaster Preparedness Index) on the right-hand side. Likewise in the previous section (Section 5.2); we highlight two channels of household loss and damage, namely channel A (unemployment) and channel B (production) to analyze the responsiveness of household disaster preparedness behaviour in loss mitigation. Our a priori assumption is with the adoption of appropriate preparedness measures loss and damage should decrease at the household level.

Table 5.4

The Responsiveness of Disaster Preparedness on Household Loss Mitigation: Channel A

Variables	(1) Per capita income loss	(2) Day labor income loss	(3) Salaried income loss
Female headed hh	2,829	-5,271*	3,084
	(5,410)	(3,002)	(4,652)
rural	4,146	421.6	-7,657
	(3,564)	(2,629)	(5,365)
Dep mem	-4,935***	2,360***	-131.2
	(813.6)	(587.0)	(631.2)
House ownership	1,065	-11,366**	-2,627
	(3,324)	(4,722)	(4,208)
landownership_2014	1,343	-20,079*	805.0
	(5,425)	(11,892)	(5,301)
landownership_2009	3,869	9,543	4,184
	(6,746)	(14,131)	(7,337)
occup_agri	-8,029***	-6,335***	-18,470***
	(2,047)	(1,509)	(2,255)
Proportion_formal_edu	786.7	-17,997***	20,138***
	(4,195)	(2,517)	(2,924)
Education female hh	395.3	905.0	506.4
	(1,670)	(697.6)	(1,654)
Access_safedrinkingwater	1,167	524.2	8,465***
	(6,163)	(3,940)	(1,874)
Access_electricity	1,648	-9,529***	3,727***
	(2,010)	(1,644)	(1,403)
Access_sanitation	-3,605*	-12,208***	7,289***
	(2,035)	(1,553)	(1,476)
Non-birth residence	-4,210	4,775	3,221
	(3,738)	(4,798)	(5,097)

(Contd. Table 5.4)

Variables	(1) Per capita income loss	(2) Day labor income loss	(3) Salaried income loss
Disaster displacement	14,682	27,893	-2,589
	(11,744)	(20,207)	(9,192)
Internet users	-17,464***	-4,035	-6,308
	(5,033)	(5,927)	(9,819)
Social media users	26,144*	-3,556	7,803
	(14,329)	(6,672)	(11,925)
Resilient infrastructure	12,272***	-4,496***	5,128***
	(2,844)	(1,437)	(1,985)
remittance	51,300***	-17,525***	1,531
	(6,246)	(1,152)	(5,577)
Social capital	636.9	11,282***	-2,893
	(2,302)	(2,616)	(2,065)
Financial inclusion	-1,616	3,004	-1,256
	(2,307)	(2,141)	(2,123)
inter_muslim	0.0473	0.0233**	0.0121
	(0.0355)	(0.0108)	(0.0122)
inter_hindu	-46.67**	-26.57	-51.62***
	(22.64)	(19.07)	(11.23)
inter_chris	-306.7**	-519.2***	-16.20
	(152.6)	(100.8)	(124.7)
inter_budd	-100.1	-115.1	22.40
	(86.99)	(71.06)	(55.29)
Hydro-meteorological_dis	23,102***	15,257***	6,674***
	(2,955)	(1,675)	(2,043)
Geo-climatological_dis	29,081***	9,940***	7,333***
	(3,184)	(1,722)	(1,845)
Emerging_dis	854.2	-3,872**	-206.7
	(2,851)	(1,601)	(2,154)
Plain_land_cluster	11,378***	11,603***	11,174***
	(3,898)	(3,881)	(3,183)
Char_land_cluster	5,044	5,614	5,282
	(5,297)	(4,318)	(3,583)
Coastal_cluster	-2,566	3,935	874.7
	(4,514)	(3,918)	(3,149)
Beel_cluster	-1,635	9,183**	-2,780
	(5,315)	(4,260)	(3,510)
Barind_tract_cluster	1,388	12,392***	2,547
	(4,611)	(4,674)	(3,575)
Madhupur_cluster	-21,996***	1,476	1,233
	(8,163)	(6,735)	(6,846)
DPI	-31,304***	-29,268***	-13,383***
	(1,888)	(2,407)	(3,122)
Constant	10,155	52,922***	-5,460
	(9,642)	(9,627)	(7,492)
Observations	143,980	143,980	143,980
R-squared	0.010	0.018	0.004

Source: Author's calculations.

Note: [a] Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

[b] The annual amount of the daily income and the salaried income has been used to calculate the loss measure in these categories.

Our findings reveal that the DPI has a negative and significant relationship with all three categories of losses (via unemployment) been defined, i.e., net income loss (per capita), daily income loss and salaried income loss. The negative (-) sign significance strongly indicates that adoption of various forms of preparedness measures at various disaster stages has loss-mitigating impacts in the advent of climate-induced natural disasters at the household level. It needs to be noted here that the DPI is the accumulated index of three separate preparedness indexes: evacuation (mostly linked with government's

early warning intervention), preservation (linked with government's public awareness intervention adhering to the global 72-hour emergency supplies rule) and infrastructure (linked with government's disaster financial support, e.g., government loan support intervention) preparedness measures.[11] Our findings suggest that DPI is almost 76 per cent effective in mitigating net income loss (per capita) and nearly 81 per cent effective in mitigating salaried income loss (annual) arise via unemployment channel (i.e., loss of employment days due to climate disasters) at the household level [Table 5.4].

Table 5.5

The Responsiveness of Disaster Preparedness on Household Loss Mitigation: Channel B

Variables	(1) Total Damage	(2) Agricultural loss	(3) Crop loss	(4) Non-crop loss
Female headed hh	-255.1	-497.0***	-444.0***	-52.91***
	(354.6)	(26.36)	(21.88)	(13.21)
rural	656.1***	504.1***	410.2***	93.94***
	(135.3)	(30.46)	(21.75)	(17.52)
Dep mem	324.9***	170.4***	129.0***	41.33***
	(34.68)	(9.365)	(7.208)	(4.648)
House ownership	-479.4	446.0***	348.8***	97.23***
	(305.5)	(27.37)	(18.37)	(18.96)
landownership_2014	-2,830***	-71.10	-45.40	-25.71
	(850.8)	(58.91)	(51.21)	(26.46)
landownership_2009	4,019***	558.8***	440.3***	118.5***
	(827.1)	(62.24)	(53.45)	(29.27)
occup_agri	695.0***	809.6***	730.7***	78.87***
	(76.35)	(17.69)	(12.78)	(10.56)
Proportion_formal_edu	560.6***	245.9***	159.4***	86.55***
	(142.1)	(29.23)	(22.95)	(16.13)
Education_female hh	-123.1**	-43.98***	-32.64***	-11.34**
	(54.85)	(8.432)	(6.640)	(4.563)
Access_safedrinkingwater	-924.8***	-497.5***	23.23	-520.8***
	(125.8)	(58.53)	(31.08)	(45.76)
Access_electricity	348.7***	262.3***	214.2***	48.09***
	(79.93)	(17.31)	(14.10)	(8.802)
Access_sanitation	-90.52	61.10***	92.82***	-31.72***
	(82.31)	(18.33)	(15.01)	(9.140)
Non-birth residence	33.48	11.08	-4.048	15.13
	(199.1)	(47.84)	(36.81)	(26.53)
Disaster displacement	-936.5***	-205.2**	-111.3*	-93.90**
	(201.1)	(81.78)	(67.09)	(41.23)
Internet users	114.6	-47.08	-63.48	16.40
	(303.7)	(118.8)	(72.53)	(77.19)
Social media users	-61.01	-36.49	-8.512	-27.98
	(360.3)	(131.1)	(83.58)	(84.04)
Resilient infrastructure	325.0***	400.7***	244.5***	156.1***
	(100.2)	(23.40)	(17.73)	(13.52)
Remittance	-485.1**	-212.4***	-55.92	-156.4***
	(202.4)	(48.78)	(38.90)	(23.33)
Social capital	201.4**	-77.42***	-135.9***	58.44***
	(98.42)	(26.15)	(19.06)	(16.69)
Financial inclusion	313.5***	215.8***	127.3***	88.49***
	(84.71)	(25.80)	(19.14)	(16.00)
inter_muslim	0.000448	2.74e-05	-0.000148	0.000176***
	(0.000539)	(0.000115)	(9.47e-05)	(5.98e-05)

(Contd. Table 5.5)

[11] The construction procedure of these indexes has been outlined earlier in details in Chapter 3.

Variables	(1) Total Damage	(2) Agricultural loss	(3) Crop loss	(4) Non-crop loss
inter_hindu	-2.729***	-0.648***	-0.917***	0.269**
	(0.524)	(0.179)	(0.127)	(0.117)
inter_chris	12.23	13.35***	17.96***	-4.612***
	(8.052)	(4.157)	(3.984)	(0.858)
inter_budd	-2.176	1.295	4.019***	-2.724***
	(2.095)	(0.880)	(0.762)	(0.391)
Hydro-meteorological_dis	2,882***	1,283***	985.8***	297.6***
	(96.47)	(31.24)	(26.56)	(14.41)
Geo-climatological_dis	1,195***	1,401***	1,221***	180.0***
	(94.02)	(30.58)	(25.47)	(15.30)
Emerging_dis	944.5***	1,045***	974.5***	70.91***
	(93.16)	(29.13)	(24.74)	(13.24)
Plain_land_cluster	511.1***	826.8***	892.7***	-65.84***
	(116.0)	(34.31)	(23.46)	(22.99)
Char_land_cluster	-278.3**	232.7***	352.7***	-120.1***
	(127.7)	(37.67)	(27.68)	(23.39)
Coastal_cluster	156.6	406.6***	140.9***	265.7***
	(112.1)	(35.28)	(23.00)	(24.35)
Beel_cluster	1,449***	299.1***	397.0***	-97.84***
	(317.6)	(39.30)	(28.19)	(25.32)
Barind_tract_cluster	-372.3***	354.9***	469.9***	-115.0***
	(122.4)	(40.18)	(30.77)	(24.11)
Madhupur_cluster	-757.4**	-195.7**	-12.81	-182.9***
	(358.6)	(81.34)	(41.71)	(68.09)
Per capita income (net)	0.00759***	0.00324***	0.00222***	0.00102***
	(0.00179)	(0.000457)	(0.000307)	(0.000201)
Wealth index	293.0***	177.0***	159.3***	17.73***
	(46.17)	(10.19)	(7.993)	(5.534)
DPI	-1.360	-13.23	1.405	-14.64**
	(20.79)	(8.283)	(4.916)	(5.998)
Constant	-2,102***	-2,875***	-2,820***	-55.74
	(305.5)	(83.14)	(59.69)	(50.55)
Observations	143,980	143,980	143,980	143,980
R-squared	0.012	0.085	0.108	0.025

Source: Author's calculations.

Note: [a] Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

[b] The mean (average) of the dependent variables has been estimated in the model.

Table 5.5 displays the responsiveness of disaster preparedness on household loss mitigation via production (channel B). We estimate model 2 (full model) with total damage, agricultural loss, crop and non-crop loss as the dependent variables with DPI on the right-hand side to estimate its loss-mitigating impacts. We do note here that agricultural loss is the summation of crop and non-crop loss, whereas total damage further includes land and homestead property damages along with agricultural loss. Likewise unemployment (channel A), our findings reveal that the DPI has a negative (not significant) relationship with at least three categories of losses, e.g., total damage, agricultural loss and non-crop loss. However, the loss-mitigating impact of non-crop loss is found to be negative and significant. Our results show that one unit increase in disaster preparedness will lead to a significant decrease of 14.64 unit in non-crop loss. Intriguingly, the crop loss amount seems to have a positive relationship with the DPI (although not significant). As mentioned earlier, the negative (-) sign significance strongly indicates that adoption of various forms of preparedness measures at various disaster stages has loss-mitigating impacts in the advent of climate-induced natural disasters at the household level. The positive (+) sign denotes that perhaps additional preparedness measures needs to be integrated to effectively mitigate the crop loss amount. Policy wise, it might represent the government's various support package interventions (e.g., low interest micro-credit support, crop insurance, etc.) to effectively mitigate crop loss due to climate-induced natural disasters at the household level.

CHAPTER 6

ROBUSTNESS CHECKS

6.1 Test of Endogeneity: Instrumental Variable (IV) Approach

We test for endogeneity using an instrumental variable (IV) approach and the results are reported in Table 6.1 below.

Table 6.1

Instrumental Variable (IV) Model Results

Variables	(1) dpi	(2) epi	(3) ppi	(4) ipi
Dis prep	-6.871***	-8.751***	-5.954**	-5.455***
	(1.931)	(3.050)	(2.817)	(1.910)
Female headed hh	-0.00530	-0.0172	-0.0112	0.00746
	(0.00755)	(0.0119)	(0.0110)	(0.00747)
rural	-0.0152*	-0.0230*	-0.00254	-0.00644
	(0.00787)	(0.0124)	(0.0115)	(0.00779)
Dep mem	0.00238**	0.000908	0.00274*	0.000704
	(0.00106)	(0.00168)	(0.00155)	(0.00105)
House ownership	0.000520	0.0189	0.0110	-0.00732
	(0.00981)	(0.0155)	(0.0143)	(0.00970)
landownership_2014	-0.0143	-0.0357	-0.0469*	0.0207
	(0.0166)	(0.0263)	(0.0243)	(0.0165)
landownership_2009	0.0261	0.0397	0.0400	-0.00262
	(0.0208)	(0.0329)	(0.0303)	(0.0206)
Proportion_formal_edu	-0.0167*	0.00361	-0.0182	-0.0128
	(0.00985)	(0.0156)	(0.0144)	(0.00974)
Education female hh	0.00307	0.00314	0.00498	3.17e-05
	(0.00215)	(0.00340)	(0.00314)	(0.00213)
Access_safedrinkingwater	0.0119	-0.0215	0.00344	0.0295*
	(0.0168)	(0.0265)	(0.0245)	(0.0166)
Access_electricity	0.00147	0.00140	0.00513	-0.00218
	(0.00386)	(0.00610)	(0.00563)	(0.00382)
Access_sanitation	-0.0113***	-0.00480	-0.00892	-0.00789*
	(0.00412)	(0.00650)	(0.00601)	(0.00407)
Non-birth residence	-0.00368	-0.00322	-0.00408	-0.00676
	(0.00814)	(0.0129)	(0.0119)	(0.00805)
Disaster displacement	0.00119	-0.0295	-0.0127	0.0199
	(0.0229)	(0.0362)	(0.0335)	(0.0227)
Internet users	-0.0285	-0.0207	-0.00443	-0.0137
	(0.0175)	(0.0277)	(0.0255)	(0.0173)
Social media users	0.0151	0.0213	-0.0109	-0.00959
	(0.0206)	(0.0325)	(0.0300)	(0.0203)
Resilient infrastructure	0.00893*	0.00366	0.0127	0.00351
	(0.00528)	(0.00834)	(0.00770)	(0.00522)
Remittance	0.0149*	-0.000287	0.00251	0.0183**
	(0.00813)	(0.0128)	(0.0119)	(0.00804)
Social capital	-0.0244*	-0.00675	-0.0584***	-0.00622
	(0.0134)	(0.0212)	(0.0196)	(0.0133)
Financial inclusion	0.00182	0.00380	0.00499	0.000183
	(0.00460)	(0.00726)	(0.00671)	(0.00455)

(Contd. Table 6.1)

Variables	(1) dpi	(2) epi	(3) ppi	(4) ipi
inter_muslim	-1.73e-08	5.57e-08	7.06e-08	-1.02e-07***
	(3.14e-08)	(4.96e-08)	(4.58e-08)	(3.10e-08)
inter_hindu	-0.000146***	-3.24e-05	2.17e-05	-0.000150***
	(4.25e-05)	(6.71e-05)	(6.20e-05)	(4.20e-05)
inter_chris	-0.000685	-0.00108	-0.000642	-0.000267
	(0.000944)	(0.00149)	(0.00138)	(0.000934)
inter_budd	-0.00116**	-0.00166*	-0.00120	-0.000556
	(0.000536)	(0.000847)	(0.000782)	(0.000530)
Hydro-meteorological_dis	-0.00871	0.0338	-0.00258	-0.0307
	(0.0200)	(0.0316)	(0.0291)	(0.0198)
Geo-climatological_dis	0.0228**	0.0146	0.0224*	0.0131
	(0.00911)	(0.0144)	(0.0133)	(0.00901)
Emerging_dis	0.0185***	0.0224***	0.0187***	0.00683*
	(0.00410)	(0.00648)	(0.00598)	(0.00405)
Plain_land_cluster	-0.0776**	-0.115**	-0.0949**	-0.0258
	(0.0317)	(0.0500)	(0.0462)	(0.0313)
Char_land_cluster	-0.0788**	-0.120**	-0.0980*	-0.0242
	(0.0364)	(0.0574)	(0.0530)	(0.0360)
Coastal_cluster	-0.135***	-0.0479	-0.118***	-0.135***
	(0.0285)	(0.0450)	(0.0415)	(0.0282)
Beel_cluster	-0.0802***	-0.112**	-0.0947**	-0.0306
	(0.0288)	(0.0456)	(0.0421)	(0.0285)
Barind_tract_cluster	-0.0793***	-0.114**	-0.0942**	-0.0304
	(0.0300)	(0.0474)	(0.0438)	(0.0297)
Madhupur_cluster	-0.0804**	-0.113**	-0.0942**	-0.0289
	(0.0326)	(0.0514)	(0.0475)	(0.0322)
Wealth index	0.00403***	0.00463**	0.00563***	0.00151
	(0.00149)	(0.00235)	(0.00217)	(0.00147)
Constant	0.166***	0.178***	0.156***	0.116***
	(0.0367)	(0.0580)	(0.0535)	(0.0363)
Observations	143,980	143,980	143,980	143,980
R-squared	0.724	0.312	0.413	0.730
Endogeneity test (Chi-squared)	0.349	1.011	0.000	4.171**
P-value	(0.5544)	(0.3146)	(0.9994)	(0.0411)

Source: Author's calculations.
Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Our null hypothesis is net per capita income, daily income (annual) and salaried income (annual) are not instrumental (i.e. exogenous) in the decision-making process whether the household is likely to take any prior preparation in the advent of a natural disaster. Our IV results show that we cannot reject the null hypothesis ruling out the possibility of income and wages as endogenous variables in our estimation framework.

CHAPTER 7
LIMITATIONS

The 2015 "Impacts of Climate Change on Human Life (ICCHL)" Survey is a nationally representative cross sectional self-reported big data that we use in this study. Therefore, the study could not capture the dynamics over time. The objective of the study is twofold; first, to identify the determinants of disaster preparedness behaviour of 143,980 disaster affected households across 64 districts of Bangladesh, and second, to assess the responsiveness of disaster preparedness measures and policy effectiveness towards household loss mitigation in Bangladesh. One of the limitations of ICCHL survey is the coverage of education data, which only covers formal education. This is crucial as we assume that hazard-specific knowledge and understanding gained from non-formal sources and training play a greater role in responding appropriately to hazard risk.[1] In particular, as one of our primary determinants is knowledge and perception of climate change and disasters, we believe data availability of informal education is extremely important to justify this research gap in this study. We further emphasize on the availability of information regarding indigenous knowledge to fully understand the risk perception of disaster-affected households.[2]

We observe lack of appropriate data to assess the policy effectiveness of government interventions, e.g., to understand the reasons behind households reluctance to respond to the early warning information. The designation of the questions needs further improvement in this regard. For example, the ICCHL survey asks respondents to say whether they have received any advance notice or forecast and the sources of the early warning information. The subsequent question asks whether the households have taken any prior preparation. These questions allowed us to check whether households have responded to government's intervention/policy regarding early warning. However, there is no question been asked to record the reasons behind households' non-adherence of such policies of the government which we believe is extremely important for effective policy formulation and implementation as well.

We further felt the need for social bonding and bridging data, data on access to finance (in particular, disaster financial support to the female-headed households) for better understanding of social capital and the policy effectiveness of government's disaster financial support intervention. Data on coping strategies of the affected households for various types of disasters were not available. We did not incorporate any geological data, e.g., rainfall and temperature, etc., as we have dealt with 12 types of natural disasters in three sub-groups and information regarding all disaster types were not available. Therefore, our disaster-affected identifier is the self-reported data and this can be one of the limitations of our study as well (e.g., Karim, 2018).

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[1] See Sharma *et al.* (2013); UNDP (2015).
[2] See Zhang *et al.* (2017).

CHAPTER 8

POLICY EFFECTIVENESS AND RECOMMENDATIONS

From the policy perspective, we start with the research gap of having extremely limited discussions on the effectiveness of the demand-side disaster risk reduction (DRR) policies of the Government of Bangladesh (GoB). Therefore, in the light of our strategic focus on the longer-term solutions to reduce climate and disaster risk at the micro/household level, our research questions have been established to look at the effectiveness of the key policy interventions of the Bangladesh government in DRR through knowledge, perception, education, social capital, infrastructure and household loss mitigation. We looked at three policy interventions of the government, namely existing early warning system, public awareness for preparedness and government disaster financial support, and attempted to answer two research questions.

We first identify the determinants of household disaster preparedness behaviour including justifying the role of climate change and disaster knowledge and perception, human and social capital, disaster displacement, remittance, income, wealth and labour market outcomes. We then attempt to look at the effectiveness of the key government policies and responses in mitigating household loss and damage to sustain economic development at the household level. To incorporate the respective policy responses, our methodological approach has been primarily index creation targeting the policy relevant questions in various modules of the ICCHL survey and thereby include in our empirical specifications for estimation purpose. For example, we initially develop three preparedness indices i.e. evacuation preparedness index (to clarify the extent of the existing early warning policies influencing household evacuation preparedness measures), preservation preparedness index (to clarify the extent of households' adoption of preservation preparedness measures due to public awareness adhering to the global 72-hour emergency supplies rule) and infrastructure preparedness index (to clarify the extent of government's disaster financial support, e.g., government loan support influencing households' infrastructure preparedness measures). We then include these three indices in model 1 (equation 1) as the dependent variables. The estimation results of model (1) provide answer to the first research question and substantiate the determinants of household disaster preparedness behaviour as highlighted in the literature. Using the empirical framework of model 2 (equation 2), we tend to justify the influence of disaster preparedness in mitigating household loss and damage in the Bangladeshi context. We believe this is crucial as this would potentially show us the pathway to bring more efficiency in the existing policies and suggest new policies towards disaster risk reduction and thereby achieve the integrated targets of the mainstream SDGs. It is, however, important to note here that households' responses (demand-side) and government's actions (supply-side) complement one another in most cases; and efficacy of some household responses might depend on several other public interventions and responses as well.

Based on evidence generated from model 1 estimation results (Table 5.1), we argue that the disaster component in our education system (as reflected through formal education only) is not adequately effective to influence household disaster preparedness behaviour. We identify knowledge and perceptions of climate change, disaster and disaster risk management as a robust determinant of such behaviour and suggest integration of knowledge (including indigenous knowledge) component in an inclusive manner.[1] This inclusiveness should go beyond class room education, needs to incorporate community driven informal education (including training) and targeted towards all demographic profiles.[2] However, we do admit the fact that our education story might not be complete because of the unavailability of informal education data in the ICCHL survey. Interestingly, our results strongly suggest that female education (estimated through education level of female household heads) enhances disaster preparedness. This finding is further re-emphasized by Muttarak and Pothisiri (2017), Lutz, Muttarak and Striessnig (2014) and Witvorapong *et al.* (2015). Therefore, in addition to formal education, our policy recommendation is to include more women in community-based social networks and cooperatives and increase investments in female informal education (e.g., training) as well. This will lead them to acquire knowledge on climate-induced disasters and preparedness and provide incentives towards female leadership at various disaster stages in disaster-prone regions.

As mentioned earlier, we define social capital as social network-based financial support available during or after disaster in the period 2009-'14 from any government/non-government organization depicting the strength of social networks in the community. Our assumption on social capital here is households who are more engaged in community activities have better access to information, expertise and material resources through their social networks.[3] In this study, we went beyond the traditional definition of social capital indicating social bonding bridging etc. because of data unavailability in the ICCHL survey. Our data provide us an ample scope to understand the impact of social network-based disaster finance availability on preparedness which we highlight in this study. Our findings reveal that social network plays an important role in determining disaster preparedness behaviour, particularly disaster financial support (i.e., infrastructure preparedness in this study) in disaster-affected regions of Bangladesh. We suggest government should enhance the coverage and limits of social network-based financial support with periodical monitoring of such assistance. Use of technology is strongly encouraged to keep track of such network activities including disaster finance, identify and update on the real affected people to bring more efficiency in the prevention and recovery process. Government should also build partnership with the non-government organizations (NGOs) in disaster-affected regions to support in this process.

[1] O'Neill *et al.* (2020); Ngo *et al.* (2020).
[2] See UNDP (2015).
[3] See also Hoffmann and Muttarak (2017).

We find access to basic services, that is, access to safe drinking water, electricity and access to sanitation as significant drivers of household disaster preparedness behaviour. Intriguingly, we find a negative relationship with sanitation access indicating the need for improved sanitary conditions in the disaster-affected regions to reduce vulnerability.[4] Resilient infrastructure (i.e., stronger houses) is also found to be a significant determinant of preparedness emphasizing our policy suggestion to invest and incentivize building stronger houses in the vulnerable regions. This policy recommendation is consistent with the government's key area of intervention (i.e., building climate resilient infrastructure) as outlined in the Intended Nationally Determined Contributions (INDC) to address the adverse impacts of climate change.

Internal displacement of disaster-affected people is found to be a robust determinant of household disaster preparedness behaviour.[5] Our assumption is disaster displaced people are more likely to adopt preparedness measures due to their disaster experience. We have to take note of the fact that the flow of this type of displacement (forced migration) could differ based on the disaster type and magnitude and ineffectiveness of government interventions as well.[6] The designation of internal migration policy needs not only to incorporate livelihood support but also necessary disaster support to create a congenial environment for the returnees based on their voices (e.g., Siebeneck *et al.*, 2012). We believe disaster recovery policies are absolutely critical and need to complement preparedness policies for safe return of the displaced households to their origin that would release urban pressure and ensure sustainable livelihoods at both ends. Our measurement regarding religious beliefs represents strong relationship with preparedness. However, these relationships are found to vary across different religious systems. On the policy note, we recommend incorporation of climate and disaster knowledge in all kinds of religious books in the school curriculum (all versions) as most religions emphasize on protecting biodiversity and the ecosystem. We believe religious systems could play a strong role in enhancing climate change and disaster risk knowledge and perception. Religious institutions could be used by community leaders to disseminate awareness messages regarding adherence to public interventions.

Despite its geographical location and a disaster-prone nation, Bangladesh is more vulnerable to hydro-meteorological disasters compared to geo-climatological and emerging disasters as earlier defined. This attribute has also been reflected in our results on these three groups of natural disasters. All three groups are found to be significant determinants of disaster preparedness behaviour with hydro-meteorological events (i.e., flood, storm/tidal surge, cyclone, tornado, landslide and river/coast erosion) exhibiting a negative relationship. Policy wise, it also indicates that there is still need for more investments in preparedness measures such as early warning, preservation and infrastructure preparedness. This should also complement with increased public investments in increasing the number of cyclone shelters and other supply-side risk

[4] See also Toufique and Yunus (2013).
[5] See Rahman and Gain (2020).
[6] See Barlemann and Tran (2020).

reduction measures, e.g., embankments, coastal polders, bridges and culverts, etc.[7] The coastal cluster is also identified to be vulnerable and effectiveness in the existing policies needs to be ensured and effectively implemented. The government policies at the post-disaster stage (e.g., improving the logistics and timely availability of emergency supplies in areas that require a relatively higher level of preparation) also need to be complemented as efficacy in the demand-side policies depends quite largely the complementary supply-side public interventions.[8] We further emphasize on effective and targeted climate change policies for geo-climatological and emerging disasters as well.

In sections 5.2 and 5.3, we highlight the household loss and damage (via unemployment and production) and show how household disaster preparedness could be a sustainable response mechanism towards sustainable development through household loss and damage mitigation. Our contribution to the "climate-development" literature is three-fold: first, we argue that in the absence of a globally agreed loss and damage framework, this study conceptualizes disaster preparedness as a risk reduction pathway towards sustainable development. Second, we provide strong empirical evidence to what extent disaster preparedness could reduce household loss and damage arising from 12 types of natural disasters among 143,980 households across 64 disaster affected regions (including agro-ecological zones) of Bangladesh using big data for the first time in this study. Third, we strongly argue that integration of development and disaster risk reduction policies could further reduce the amount of losses arising from climate-induced natural disasters, implying integrated impacts across various SDG targets at the micro-household level [See Tables 8.1 and 8.2 below].

Table 8.1

Disaster Preparedness as Response Mechanism (via unemployment)

Variables	(1) Per capita income loss	(2) Day labor income loss	(3) Salaried income loss
dpi	-30,879***	-29,474***	-13,281***
	(1,881)	(2,395)	(3,107)
Constant	42,212***	28,075***	16,587***
	(1,007)	(668.7)	(801.2)
Observations	143,980	143,980	143,980
Integrated development response: interplay between determinants and preparedness			
Female education*dpi	-262.0***	-276.8***	-101.2***
	(25.23)	(38.08)	(26.12)
Social capital*dpi	-8,385**	-14,941***	-335.9
	(4,155)	(4,993)	(4,127)
Resilient infra*dpi	-18,802***	11,900***	-19,763*
	(5,957)	(3,758)	(11,029)
Constant	42,077***	27,612***	16,668***
	(1,011)	(663.7)	(822.1)
Observations	143,980	143,980	143,980

Source: Author's calculations.

Note: [a] Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

[b] The estimations do not include the controls of equation(s) 1 and 2.

[7] Our results also reconfirm the policy findings of Toufique and Yunus (2013) to decrease vulnerability.

[8] See Maruta *et al.* (2020).

Table 8.2

Disaster Preparedness as Response Mechanism (via production)

Variables	(1) Total damage	(2) Agricultural loss	(3) Crop loss	(4) Non-crop loss
dpi	-59.81***	-0.401	45.37***	-45.77***
	(20.64)	(8.510)	(5.128)	(6.002)
Constant	3,110***	1,567***	1,272***	294.4***
	(37.68)	(8.931)	(7.086)	(4.775)
Observations	143,980	143,980	143,980	143,980
Integrated development response: interplay between determinants and preparedness				
Female education*dpi	-0.646*	-0.0312	0.436***	-0.468***
	(0.388)	(0.131)	(0.0821)	(0.0860)
Social capital*dpi	9.939	-6.036	6.177	-12.21
	(38.87)	(19.89)	(13.62)	(11.86)
Resilient infra*dpi	-28.95	22.75	43.91***	-21.16
	(46.01)	(21.77)	(11.83)	(17.18)
Constant	3,110***	1,566***	1,272***	294.1***
	(37.72)	(8.934)	(7.087)	(4.783)
Observations	143,980	143,980	143,980	143,980

Source: Author's calculations.

Note: [a] Robust standard errors are in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

[b] The estimations do not include the controls of equation(s) 1 and 2.

CHAPTER 9

CONCLUDING REMARKS

The overall goal of this study is to identify the directly observable determinants' of household disaster preparedness behaviour in Bangladesh. Our objective is to primarily examine the role of climate change and disaster knowledge and perception, education, prior disaster experience (via disaster damage and labor market outcomes), and other potential determinants (e.g., income, wealth, location, disaster displacement, remittance, social capital, financial inclusion, etc.). The study further analyzes households' loss mitigation mechanism through adoption of household preparedness measures and effectiveness of key government policies on 143,980 households affected by 12 types of natural disasters during the period 2009-'14 across 64 districts of Bangladesh.

The National Plan for Disaster Management (NPDM) 2016-2020 reflected Bangladesh's initiatives since the creation of the Disaster Management Bureau in 1993 in line with the paradigm shift in disaster management from conventional response and relief to a more comprehensive risk reduction culture with development linkages. The plan is built on GoB's past successes in disaster risk reduction by making a paradigm shift from purely emergency response to include measures for building resilience. However, it also critically analyzes disaster risk in the current development context within changing social, political, economic and environmental circumstances. Similarly, the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009 has been prepared as a living document and is expected to change depending upon new scientific findings, development priorities of the country and the pace and nature of international negotiations. Therefore, in the light of the strategic focus on the longer-term solutions to reduce climate and disaster risk at the micro/household level, we investigate two research questions and looked at the effectiveness of three demand-side policy interventions of the government: early warning system, public awareness and government disaster financial support.

This study provides strong context-specific empirical evidence on the possible determinants of household disaster preparedness behaviour utilizing a unique and comprehensive big data in Bangladesh. Our results show that, in Bangladesh, disaster risk perception explains around 1.5 per cent of formal education with nearly 7.4 per cent of female education compared to the mean.[1] Similarly, climate change perception accounts for around 1.5 per cent of formal education whereas education levels of female household heads explain almost 7.7 per cent compared to the mean, indicating the overwhelming importance of enhanced disaster education (formal and non-formal) for women in climate and disaster risk reduction policies in Bangladesh. We strongly argue that mainstreaming disaster education across education, climate change and disaster risk reduction policies could significantly enhance responsiveness to our disaster preparedness behaviour and thereby increase household resilience.

[1] See Wachinger *et al.* (2013).

We also found that household responses to adoption of numerous forms of preparedness measures ranges between 2 per cent and 3.6 per cent due to increase in remittances while ranging between 1.4 per cent and 2.4 per cent increase due to percentage increase in residing in better housing (i.e. resilient infrastructure). Access to safe drinking water, electricity and sanitation also influences preparedness behaviour significantly. Our findings show that social capital is a robust determinant of adoption of preparedness measures. We believe, this is an important finding as proper government interventions to provide better access to information, expertise and material resources through social networks will not only encourage adoption of disaster preparedness measures; but also complement the traditional definition of social capital of bonding and bridging at the recovery stage.

We identify disaster displacement as an important determinant of disaster preparedness behaviour of households. Our positive and significant result of disaster displacement variable indicates that displaced people are found to be better prepared due to their past disaster experience and actively respond to government interventions and policies. This finding is crucial to understand integrated migration policies and hence design localized public interventions towards climate-induced disaster mitigation policies in the context of Bangladesh and other developing countries with high climatic risks.

Our results represent that wealth and salaried income are positively and significantly associated with disaster preparedness compared to net per capita income and daily wages. Per capita income (net) is found to have a negative relationship (but insignificant) along with daily wages, which is also not found to be strongly correlated with disaster preparedness behaviour. However, our results found a strong positive relationship between knowledge, perception and disaster preparedness which we assume partially mediated through formal education in our case, indicating to better income-earning opportunities.

Again, our contribution to the 'climate-development' literature is three-fold. First, in the absence of a globally agreed loss and damage framework, this study conceptualizes disaster preparedness as a pathway towards sustainable development. Second, we provide strong empirical evidence to what extent disaster preparedness could reduce household loss and damage arising from 12 types of natural disasters among 143,980 households across 64 disaster affected regions (including agro-ecological zones) of Bangladesh using big data for the first time in this study. Third, we strongly argue that integration of development and disaster risk reduction policies could further reduce the amount of losses arising from climate-induced natural disasters implying fulfillment of several cross-cutting SDG goals related to climate and disaster risks (e.g., SDGs 1, 2, 4, 11 and 13). It needs to be noted here that the DPI is the accumulated index of three separate preparedness indexes: evacuation (mostly linked with government's early warning intervention), preservation (linked with government's public awareness intervention adhering to the global 72-hour emergency supplies rule) and infrastructure (linked with government's disaster financial support e.g., government loan support intervention)

preparedness measures. Our findings suggest that DPI is almost 76 per cent effective in mitigating net income loss (per capita) and nearly 81 per cent effective in mitigating salaried income loss (annual) arise via unemployment channel (i.e. loss of employment days due to climate disasters) at the household level. However, evidence shows that one unit increase in disaster preparedness will lead to a significant decrease of 14.64 unit in non-crop loss via the production channel. Intriguingly, the crop loss amount seems to have a positive relationship with the DPI (although not significant). This denotes that perhaps additional preparedness measures need to be integrated to effectively mitigate the crop loss amount. Policy wise, it might represent the government's various support package interventions (e.g., low interest micro-credit support, crop insurance, etc.) to effectively mitigate crop loss due to climate-induced natural disasters at the household level.

To conclude, despite widespread policy successes at the local and international contexts, it has been evident that non-adherence to some of the government policies still remains which translates to their ineffectiveness at various contexts. For example, vulnerable people are often found reluctant to leave their homes and assets due to the lack of security despite early warning or they often look for high lands nearby their houses or take shelter on the embankments rather than flood shelters. A recent high-level consultation meeting delineated that public awareness interventions might not be fully effective without high perception and knowledge level regarding climate change and disaster risk impacts in the short- to medium-longer term. This again reiterates the fact that households' responses (demand-side) and government's actions (supply-side) complement one another in most cases and efficacy of household responses could deliberately depend on other public interventions and responses as well. In some cases, effectiveness of the demand-side policies in terms of the uptake of preparedness measures might depend on the behavioural responses of the households. We assume that uptake of preparedness measures due to policy intervention of early warning information might depend on the timing of disaster occurrences, i.e., deliberation of the 'what to do list' in formal education (via textbooks) might not lead to full effectiveness of these policies in many cases; rather, informal education and short-term skill based designated education programmes might address several of these issues including enhanced resilience gained through knowledge and perception. We, therefore, recommend short-term and disaster-specific '72 hour early warning-based preparedness education programme' and/or '3-5 day flood forecasting model-based preparedness education programme' as potential solutions that require further research.

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APPENDIX

APPENDIX TABLE 1: DESCRIPTION OF THE VARIABLES AND THEIR SOURCES

NO.	VARIABLES	DESCRIPTION OF THE VARIABLES	DATA SOURCE
1	Total damage	The sum of agricultural loss (including crop and non-crop), land damage and homestead property damage (years 2009-'14).	ICCHL, 2015
2	Agricultural loss	The sum of total crop and non-crop loss (years 2009-'14).	ICCHL, 2015
3	Crop loss	Total loss recorded from crop products (e.g. Rice, Potato, Lentils, Maize, Fruits, Oilseed, Tobacco, Sugarcane, Jute, Spices, Others)	ICCHL, 2015
4	Non-crop loss	Total loss recorded from non-crop products (e.g. Cow, Buffalo, Goat, Pig, Horse, Poultry, Pigeon, Pet Bird, Fish, Shrimp, Crab)	ICCHL, 2015
5	Land damage	Total loss recorded from homestead land, orchard/nursery land, cultivable land, pond/wetland and other land.	ICCHL, 2015
6	Homestead property damage	Total loss recorded from residence damage, kitchen damage, cowshed damage and loss of homestead forestry.	ICCHL, 2015
7	Per capita income (net)	The per capita difference between total income (sum of annual income from agricultural sector, household income from other non-agricultural sources and other income sources of the household) and agricultural production cost (2014 economic valuation).	ICCHL, 2015
8	Per capita income loss	Per capita income (net) * loss of employment days due to natural disasters	ICCHL, 2015
9	Day labor income loss	Day labor income (annual) * loss of employment days due to natural disasters	ICCHL, 2015
10	Salaried income loss	Salaried income (annual) * loss of employment days due to natural disasters	ICCHL, 2015
11	Female headed households	If sex of the household head is female; then 1, otherwise 0.	ICCHL, 2015
12	Rural	If the household members are born in the rural area (village); then 1, otherwise 0.	ICCHL, 2015
13	Dependent member	Dependent member is defined when age limit is < 15 and > 60.	ICCHL, 2015
14	Marital Status	If the household head is married; then 1, otherwise 0.	ICCHL, 2015
15	House ownership	If the household owns a residence; then 1, otherwise 0.	ICCHL, 2015
16	Land ownership (2014)	Total operational land owned (2014).	ICCHL, 2015
17	Land ownership (2009)	Total operational land owned (2009).	ICCHL, 2015
18	Proportion of formal education	Proportion of household members taken any type of formal education i.e. primary, secondary or tertiary.	ICCHL, 2015

NO.	VARIABLES	DESCRIPTION OF THE VARIABLES	DATA SOURCE
19	Education level of female household head	Education level of female household head.	ICCHL, 2015
20	Access to safe drinking water	If the household has access to drinking water from pipeline, shallow/deep tube well; then 1, otherwise 0.	ICCHL, 2015
21	Access to electricity	If the household has access to energy from electricity and solar power; then 1, otherwise 0.	ICCHL, 2015
22	Access to sanitation	If the household has access to toilet/latrine facility from concrete/slab (water sealed and not sealed); then 1, otherwise 0.	ICCHL, 2015
23	Non-birth residence	If the household members are residing other than their place of birth; then 1, otherwise 0.	ICCHL, 2015
24	Disaster displacement	Displaced and residing in an area other than birth district because of disasters.	ICCHL, 2015
25	Internet users	If the household members uses internet; then 1, otherwise 0.	ICCHL, 2015
26	Social media users	If the household members uses social media; then 1, otherwise 0.	ICCHL, 2015
27	Resilient infrastructure	If the type of infrastructure of household's main residence is concrete and half-concrete; then 1, otherwise 0.	ICCHL, 2015
28	Remittance	If the household received remittance; then 1, otherwise 0.	ICCHL, 2015
29	Social capital	If the household receive any financial support from any government/non-government organization during or after disaster from 2009-2014; then 1, otherwise 0.	ICCHL, 2015
30	Financial inclusion	If the household took any loan at post-disaster period; then 1, otherwise 0.	ICCHL, 2015
31	Interaction_Muslim	Number of Muslims * Number of Mosques and Eidgahs in the district	ICCHL, 2015; District Statistics (BBS)
32	Interaction_Hindu	Number of Hindus * Number of Temples in the district	ICCHL, 2015; District Statistics (BBS)
33	Interaction_Christian	Number of Christians * Number of Churches in the district	ICCHL, 2015; District Statistics (BBS)
34	Interaction_Buddhist	Number of Buddhist * Number of Pagodas in the district	ICCHL, 2015; District Statistics (BBS)
35	Hydro-meteorological disasters	If the household is affected by Flood, Storm/Tidal Surge, Cyclone, Tornado, Landslide, River/Coast Erosion; then 1, otherwise 0.	ICCHL, 2015
36	Geo-climatological disasters	If the household is affected by Drought, Salinity, Water Logging; then 1, otherwise 0.	ICCHL, 2015
37	Emerging disasters	If the household is affected by Thunderstorm, Hailstorm, Others; then 1, otherwise 0.	ICCHL, 2015

NO.	VARIABLES	DESCRIPTION OF THE VARIABLES	DATA SOURCE
38	Plain land cluster	If the household is located in the plain land cluster of the AEZs; then 1, otherwise 0.	ICCHL, 2015; Banglapedia, 2014
39	Char land cluster	If the household is located in the char land cluster of the AEZs; then 1, otherwise 0.	ICCHL, 2015; Banglapedia, 2014
40	Coastal cluster	If the household is located in the coastal cluster of the AEZs; then 1, otherwise 0.	ICCHL, 2015; Banglapedia, 2014
41	Beel cluster	If the household is located in the beel cluster of the AEZs; then 1, otherwise 0.	ICCHL, 2015; Banglapedia, 2014
42	Barind tract cluster	If the household is located in the barind tract cluster of the AEZs; then 1, otherwise 0.	ICCHL, 2015; Banglapedia, 2014
43	Madhupur cluster	If the household is located in the Madhupur cluster of the AEZs; then 1, otherwise 0.	ICCHL, 2015; Banglapedia, 2014
44	Day labor income (annual)	Household day labor income (annual) from other non-agricultural sources	ICCHL, 2015
45	Salaried income (annual)	Household service income (annual) from other non-agricultural sources	ICCHL, 2015

Source: Author's elaborations.

APPENDIX TABLE 2: THE DETERMINANTS OF HOUSEHOLD DISASTER PREPAREDNESS BEHAVIOUR (INCLUDING DEMOGRAPHIC VARIABLES)

Variables	(1) dpi	(2) epi	(3) ppi	(4) ipi
Avg age of mem	-0.000908*	-0.00106*	-0.000916*	-0.000430
	(0.000538)	(0.000618)	(0.000535)	(0.000494)
age_0_4	0.00309	0.00341	-0.000585	0.00462
	(0.0106)	(0.0114)	(0.0107)	(0.0105)
age_5_15	-0.000445	0.000904	-0.00216	-0.000466
	(0.00953)	(0.0104)	(0.00957)	(0.00943)
age_16_36	0.000699	-0.000649	-0.000203	0.00238
	(0.00261)	(0.00304)	(0.00269)	(0.00265)
age_37_60	0.00686*	0.00602	0.00909**	0.00394
	(0.00407)	(0.00438)	(0.00408)	(0.00394)
Marital status	0.0129**	0.00908*	0.00299	0.0208***
	(0.00527)	(0.00530)	(0.00530)	(0.00528)
Female headed hh	0.00927	-0.00143	0.00220	0.0192
	(0.0127)	(0.0161)	(0.0141)	(0.0122)
rural	0.00107	-0.00185	0.0123	0.00558
	(0.0118)	(0.0120)	(0.0130)	(0.0125)
Dep mem	0.000617	-0.00214	0.00287	-0.000323
	(0.00776)	(0.00823)	(0.00775)	(0.00765)
House ownership	-0.0239*	-0.0120	-0.0104	-0.0274**
	(0.0135)	(0.0162)	(0.0153)	(0.0132)
landownership_2014	0.00315	-0.0129	-0.0317**	0.0339
	(0.0238)	(0.0194)	(0.0153)	(0.0308)
landownership_2009	0.00337	0.0101	0.0198	-0.0201
	(0.0357)	(0.0298)	(0.0292)	(0.0406)
Proportion_formal_edu	-0.0602***	-0.0492***	-0.0548***	-0.0468***
	(0.0114)	(0.0118)	(0.0114)	(0.0112)
Education female hh	0.00616**	0.00709**	0.00763**	0.00268
	(0.00285)	(0.00310)	(0.00297)	(0.00330)
Access_safe drinking water	0.0649***	0.0460**	0.0493**	0.0717***
	(0.0228)	(0.0218)	(0.0217)	(0.0232)
Access_electricity	0.00884	0.0112*	0.0113*	0.00317
	(0.00602)	(0.00608)	(0.00601)	(0.00596)
Access_sanitation	-0.0206***	-0.0165***	-0.0172***	-0.0156**
	(0.00612)	(0.00617)	(0.00608)	(0.00608)

Variables	(1) dpi	(2) epi	(3) ppi	(4) ipi
Non-birth residence	-0.00152	0.00134	-0.000315	-0.00758
	(0.0126)	(0.0114)	(0.0130)	(0.0137)
Disaster displacement	0.0464*	0.0273	0.0268	0.0557**
	(0.0265)	(0.0249)	(0.0299)	(0.0257)
Internet users	-0.0231	-0.0153	-0.00179	-0.00664
	(0.0387)	(0.0296)	(0.0259)	(0.0351)
Social media users	0.00557	0.00873	-0.0191	-0.0174
	(0.0444)	(0.0358)	(0.0343)	(0.0423)
Resilient infrastructure	0.0225***	0.0213***	0.0243***	0.0138**
	(0.00622)	(0.00577)	(0.00581)	(0.00650)
Remittance	0.0369***	0.0283***	0.0211**	0.0347***
	(0.00883)	(0.00942)	(0.00959)	(0.00926)
Social capital	-0.0680***	-0.0623***	-0.0963***	-0.0408***
	(0.0126)	(0.0131)	(0.0143)	(0.0119)
Financial inclusion	-0.00737	-0.00785	-0.00299	-0.00691
	(0.00899)	(0.00918)	(0.00919)	(0.00872)
inter_muslim	-1.05e-07***	-5.59e-08	-4.75e-09	-1.73e-07***
	(3.62e-08)	(3.67e-08)	(3.55e-08)	(3.86e-08)
inter_hindu	-0.000220**	-0.000127*	-4.18e-05	-0.000214***
	(8.62e-05)	(6.85e-05)	(6.32e-05)	(8.05e-05)
inter_chris	0.000642***	0.000619***	0.000500**	0.000797***
	(0.000226)	(0.000217)	(0.000212)	(0.000252)
inter_budd	0.000404***	0.000354**	0.000161	0.000661***
	(0.000144)	(0.000142)	(0.000118)	(0.000232)
Hydro-meteorological_dis	-0.0790***	-0.0555***	-0.0636***	-0.0868***
	(0.00501)	(0.00435)	(0.00494)	(0.00583)
Geo-climatological_dis	0.0524***	0.0523***	0.0479***	0.0363***
	(0.00628)	(0.00562)	(0.00606)	(0.00695)
Emerging_dis	0.0248***	0.0307***	0.0242***	0.0116*
	(0.00545)	(0.00517)	(0.00546)	(0.00603)
Plain_land_cluster	0.0299***	0.0223**	-0.00121	0.0585***
	(0.00887)	(0.00918)	(0.00793)	(0.0140)
Char_land_cluster	0.0440***	0.0375***	0.00908	0.0721***
	(0.00919)	(0.00949)	(0.00926)	(0.0142)
Coastal_cluster	-0.229***	-0.168***	-0.199***	-0.211***
	(0.0115)	(0.0119)	(0.0111)	(0.0158)

Variables	(1) dpi	(2) epi	(3) ppi	(4) ipi
Beel_cluster	0.0151*	0.0106	-0.0112	0.0435***
	(0.00910)	(0.00951)	(0.00818)	(0.0140)
Barind_tract_cluster	0.0207**	0.0143	-0.00670	0.0474***
	(0.00966)	(0.0110)	(0.00880)	(0.0141)
Madhupur_cluster	0.0197**	0.0153	-0.00673	0.0489***
	(0.00913)	(0.00946)	(0.00820)	(0.0139)
Per capita income (net)	-8.24e-09	-2.25e-08	3.54e-10	-1.39e-09
	(2.76e-08)	(2.62e-08)	(2.25e-08)	(2.75e-08)
Wealth index	0.00412	0.00507*	0.00559**	0.00140
	(0.00287)	(0.00285)	(0.00278)	(0.00292)
q32_day_labor	-7.76e-07	-1.30e-06*	-6.32e-07	-7.02e-07
	(7.01e-07)	(7.16e-07)	(6.89e-07)	(8.48e-07)
q32_service	6.19e-07**	5.02e-07*	5.07e-07**	5.31e-07*
	(2.89e-07)	(2.69e-07)	(2.39e-07)	(2.94e-07)
ddmkpi	0.00899***	0.00783***	0.00729***	0.00788***
	(0.00256)	(0.00261)	(0.00255)	(0.00256)
pkcc	0.00931**	0.0113***	0.00880**	0.00548
	(0.00402)	(0.00414)	(0.00434)	(0.00386)
Constant	0.0755*	0.0679*	0.0825**	0.0308
	(0.0399)	(0.0389)	(0.0394)	(0.0416)
Observations	143,980	143,980	143,980	143,980
R-squared	0.023	0.014	0.015	0.022

Source: Author's Calculations.
Note: Robust standard errors are in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 3: A Review of the Literature

NO.	STUDY DESCRIPTION	DATA/TIME PERIOD	SAMPLE/METHODS	RESULTS/OUTCOMES	POLICY RECOMMENDATIONS	RESEARCH GAP
1	Author: Hoffmann and Muttarak (2017) Publication: World Dev. Study area: Philippines, Thailand Natural Disaster: ND (Fl, L, Ty, Ts, Ws, D,Q)	Database Used: Face- to-Face interviews Time Period:2013(Thailand), 2014(Philippines)	Sample size: 889 Filipino and 1319 Thai respondents Modeling techniques: Logit, ordered logit, KHB, extended order logit.	Education enhances preparedness behavior, especially for those who have no prior experience. Income has no rule in determining preparedness activities for both countries. However, education promoting disaster preparedness is context specific. Philippines: no mediating factors explain effect of education on preparedness behavior. Thailand: Effect of education on disaster preparedness is mediated through social capital and disaster risk perception.	Investment in human capital is a must for promoting preparedness actions. Public funding in universal education will also benefit precautionary behavior at household as well as personal level. Government also should invest in disaster risk reduction measures.	Better data sources like nationally representative surveys can be used or alternatives techniques can be employed, More refined measurement of education will be a significant contribution.
2	Author: Faupel et al.(1992) Publication: Int. Journal of Mass Emergencies and disaster Study area: Charleton, South Carolina, USA Natural disaster: Hurricane	Database used: Face-face interviews Time period :1990(Feb and March)	Sample size: Workshop (N=198) And General (N=511) Modeling techniques: t test, OLS	Participating in any disaster education program is significantly related to preparedness measures. Effect of education is not important for response or planning. Prior hurricane experience is	Disaster education efforts are worthwhile and should be continued. But the content and process of these efforts should be improved.	Techniques other than t test or OLS should be used to account for factors such as education, income and adaptive

NO.	STUDY DESCRIPTION	DATA/TIME PERIOD	SAMPLE/METHODS	RESULTS/OUTCOMES	POLICY RECOMMENDATIONS	RESEARCH GAP
				significant for adaptive response but impact is minimal for longer term planning activity.		response.
3	Author: Witvorapong *et al.* (2015) Publication: PLOS one Study Area: Phang Nga, Thailand Natural disaster: Tsunami	Database used: Household survey, population and housing census Time period :2010,2012	Sample Size: 557 households Modeling technique: Multivariate probit model	Individuals who have prior Tsunami experience participate more in community activities and respond to earthquake hazards. Women are more likely to prepare emergency kits and have emergency kits compared to men. Living in a community where there is high proportion of woman with tertiary education increases the probability of engaging in community activities as well as carrying out disaster risk reduction measures. Presence of household members with disability increases the probability of having emergency plan or disaster supplies.	Promoting civic and social engagement can be beneficial to disaster mitigation. Promoting social protection can generate a positive externality in reducing vulnerability and disaster risk. Investing in and broadening girls' access to quality education has far reaching consequences.	Social participation can be included as endogenous independent variable which describes disaster preparedness outcomes. A different timing assumption is also plausible.
4	Author: Reininger *et al.*(2013) Publication: Social Science and medicine	Database used: Households survey Time period:2008	Sample size:3088 Modeling techniques: Multivariate logistic regression model	There is significant relationship between social capital (perceived civic trust	It is important to enhance social resources available among family and friend as a crucial disaster	Studies where civic engagement is low can examine

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	Study area: Texas, USA Natural disaster: Hurricane			and perceived fairness) and disaster preparedness. Exchange of trust during social interactions improves disaster preparedness. Preparedness increases with age across factors of social capital.	preparedness action.	to see if well planned interventions to increase social capital factor increase preparedness. Intervention models using neighborhood bloc leaders or community gatekeepers can also be considered.
5	Author: Onuma *et al.*(2017) Publication: Int. Journal of Disaster Risk Reduction Study area: Japan Natural disaster: Earthquakes	Database used: Internet survey Time period:2013	Sample size: 20,726 Modeling techniques: OLS, probit regression	Damage experience increases the level of preparedness in all 3 categories but evacuation experience has impacts on basic preparedness and evacuation preparedness but not on energy/heat preparedness. Damage experience affects level of preparedness largely compared to evacuation experience. Overall damage experience has robust impact on preparation of emergency items.	Public administrators should provide information on potential disaster risks and should immediately response when the disaster hits. Emergency drills should be frequently implemented. More funds should be allocated to areas where risk of large scale disaster is high but level of preparedness is relatively low.	Similar exercise can be done at other disaster prone countries.

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6	Author: Muttarak and Pothisiri (2013) Publication: Ecology & Society Study area: Phang Nga, Thailand Natural disaster: Earthquakes	Database used: Face-to-Face interviews, Population and housing census Time period: 2010, 2012	Sample size: 557 Modeling techniques: Chi square tests, ANOVA, partial proportional odds model	Education is positively associated with preparedness actions at the individual, household and village levels. Disaster education is effective if participants are highly educated. Education of household members also enhances disaster preparedness, especially among those who were not affected by previous tsunami. Individual disaster preparedness differs by demographic and educational composition of the village.	Policies ensuring universal access to formal education at least at the secondary level help mitigate disaster impacts and reduce vulnerability.	Further study with descriptive data on the rule of formal education on disaster preparedness can be done. Study that looks into identifying who implemented the preparedness measures in a household can be a further contribution.
7	Author: Chankrajang and Muttarak (2017) Publication: Ecological Economics Study area: Thailand Natural disaster: Global warming	Database used: Nationally representative surveys Time period:2010,2013	Sample size:3900 Modeling techniques: Instrumental variable	Formal education encourages pro-environmental behaviour significantly. No statistically significant relationship is found between years of schooling and concern about global warming and between education and willingness to pay for environmental tax.	Public investment in the supply of education should be increased since such investment involves positive externalities.	Surveys that provide income data can be used in future studies to see if its relationship with willingness to pay for the environment is significant.

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8	Author: Ronan *et al.*(2001) Publication: The Australasian Journal of Disaster and Trauma Studies Study area: Auckland, New Zealand Natural disaster: Hazards and mass emergencies	Database used: Children survey Time period: 2001	Sample size: 440 Modeling techniques: Descriptive analysis	Over 8 to 10 children reported moderate to strong belief in perceived ability to cope up in case of future hazard. Hazard educated children had more stable risk perceptions, reduced hazard related fears and more aware about appropriate hazard related protective behaviors to non-educated children.	Education programmes promoting realistic risk perceptions through presenting physical data and related discussion are recommended. Education programmes and adult communication must be designed to impart messages with a sense of control and confidence.	Same analysis can be implemented in other areas.
9	Author: Zhang *et al.* (2017) Publication: Int. Journal of Environmental Research and Public Health Study area: Zhejiang, China Natural disaster: Typhoon	Database used: Face-to-Face Interviews Time period: 2015	Sample size: 659 Modeling techniques: univariate and multivariable analysis	Respondents had high risk perception of property damage but risk perception of health damage and life threat caused by typhoon was not sufficient. Television was the main way to get information before typhoon. Residents who have clear understanding of typhoon signals were more likely to adopt measures than others.	The government must prepare strategies involving educational activities, improve preparedness for typhoon and expand the coverage of disaster insurance to residents of rural area.	Further studies can compare the differences of people's perception and risk perception before and after the landfall of the typhoon.
10	Author: Pajooh and Aziz (2014) Publication: Nat. Hazards Earth syst. Sci. discuss.	Database used: Questionnaire survey Time period: 2014	Sample size:214 Modeling techniques: Cronbach Alpha reliability analysis	For residents of Kuala Lumpur, level of preparedness is still at lower level. Men, high	Proper communication channel must be proposed. Potential preparedness evaluation depends on	Extensive collection of data is better representation of

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	Study area: Kuala Lumpur Natural disaster: Flash flood, disaster			level of income & education had higher preparedness compared to their counterparts. Race did not affect preparedness.	residents, government and past experience. Government should take various approaches to increase awareness among people.	outcome. Detail study on evaluation routes can be conducted.
11	Author: Najafi *et al.* (2015) Publication: PLOS currents Study area: Tehran, Iran Natural disaster: Earthquakes	Database used: Face-to-Face interviews Time period: 2014	Sample size:1,250 Modeling techniques: t test, ANOVA, Stepwise multiple regression analysis	Disaster preparedness behaviour is affected mainly by disaster experience in the past, monthly income level, residential district and occupation, but these account for only 16.2% variation in preparedness behavior. Age, home ownership, number of household members, being household head, education do not determine preparedness behavior	Government officials, emergency agencies, community leaders and educators should concentrate on low income, unemployed people and individuals who live in high risk districts, especially the ones who do not possess any prior disaster experience.	Factors other than the ones used in this study should be included in further studies about Tehran inhabitants.
12	Author: Lutz *et al.* (2014) Publication: Environment and development Study area: Panel Natural disaster: Hydro-meteorological hazards	Database used: Emergency events database Time period: 1970-2010	Sample size:167 countries Modeling techniques: Sensitivity analysis, multidimensional demography	Female education can reduce disaster fatalities. Per capita is not a significant determinant of reducing mortality risk from disaster.	Green climate funds should be provided to educators, not engineers. For enhancing adaptive capacity vis-à-vis future climate change of societies, universal education in poor countries should be given top priority.	More differentiated global climate models can be applied.
13	Author: Sadeka *et al.* (2015) Publication: Journal of the	Database used: N/A Time period: N/A	Sample size: N/A Modeling techniques: Descriptive analysis	Social capital and disaster preparedness help each other	NGOs and government agencies should adopt a number of policies and	Further research should include cross

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	Social Science Researches Study area: N/A Natural disaster: ND			mutually and both work to ensure a sustainable livelihood. Social capital also allows individuals to undertake disaster preparation, receive warnings, help find out shelter and supplies, and help obtain immediate aid and initial recovery assistance.	programs that would significantly improve the bonding social capital among community members and thereby strengthen social networks.	sectional study.
14	Author: Cummings *et al.* (2019) Publication: The Journal of Dev. Studies Study area: Jessore, Bangladesh Natural disaster: N/A	Database used: Route to the sustainable development programme, interviews Time period: 2016-2012	Sample size:136 villages Modeling techniques: Nahapiet and Ghoshal (1998) framework	Three subtypes of social capital such as bonding, bridging and linking have very different implications in terms of access to knowledge and have different modes of knowledge creation. Exchange of gift is visible manifestation of social capital, but trust is more important in this regard.	Leveraging knowledge (which is very crucial for development at the grassroots level) and social capital needs dedication as well as efforts from people at the grassroots level and NGOs who are helping them.	Further studies can be replicated based on this programme.
15	Author: Islam (2010) Publication: Disaster Management and Relief Bhaban: Bangladesh Study area: Bangladesh Natural disaster: Tornado	Database used: N/A Time period: 2004-2009	Sample size: N/A Modeling techniques :Descriptive analysis	Several issues like vulnerability, hazards and disaster risk reduction measures are now placed in text books starting from elementary level to	In order to ensure Sustainability of a specific programme, capacity of partners in terms of training, Infrastructure, curriculum, syllabus, research support and education are vital.	Further Studies may concentrate on other specific disasters.

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				Masters. New Warning signals for Cyclone and Weather and Disaster News-published by Disaster Management Bureau.	Networking from similar international organizations is also crucial.	
16	Author: Muttarak and Lutz (2014) Publication :Ecology and society Study area: Low and middle income countries Natural disaster: geophysical, meteorological, hydrological, climatological and biological disasters	Database used: N/A Time period: N/A	Sample size: N/A Modeling techniques: Descriptive analysis	Formal education has positive impact on reducing vulnerability; this is true for country level as well as individual/household level. After accounting for wealth/income, education remains significant.	Empowerment of human resources which leads to flexibility in reacting to the emerging challenges is a wiser strategy. Investment in girl's education and at the same time imposing enforcement on female school enrolment and completion should be given top priority.	Further analysis should include other studies rather than few studies like this one.
17	Author: UNDP India (2015) Publication: UN Development Programme Study area: Odisha, India Natural disaster: Flash flood, Flood, Tropical Cyclone	Database used: Secondary data, field interviews Time period: 2002-2012	Sample size: 9 districts Modeling techniques: Descriptive	Quick response to emergency situation and detailed preparedness were instrumental in managing disaster successfully. Special attention was provided to vulnerable people as well as to district social welfare officials to ensure special care for pregnant, lactating women, children and old people with	Media and the internet can be used to effectively transmit information. Future community based disaster management plans must be linked with grassroots institutions. Better coordination and synchronization between various organizations that are at work are needed both during and after a disaster. Needs of the most vulnerable people should be addressed and training and	Similar studies can be highly relevant for India and other countries in the world.

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				disabilities. At the community and village level, more people felt that training in search and rescue or first aid should be organized more frequently. Medical teams were available in the seriously affected areas. The trainings helped people understand the warnings that were issued and the action that needed to be taken.	capacity building activities need to be organized periodically.	
18	Author: Wu *et al.* (2012) Publication: Transportation Research Part F Study area: USA Natural disaster: Hurricanes	Database used: Survey questionnaire Time period:2006	Sample size: 9 counties/parishes. Modeling techniques: Means, standard deviations, inter-correlations	Coastal distance was positively correlated with evacuation departure time. Food and lodging costs were significantly correlated with each other and also with transportation cost, evacuation distance and evacuation duration. Jurisdictions that experienced greater impact had higher evacuation cost and those that were struck hardest had significantly greater evacuation duration. Those who lived	Content and timing of warnings by local officials and television coverage matter in case of evacuation time. Evacuees choose their evacuation routes based exclusively on conditions en route.	Further research can include items in the questionnaire that identify locations of friends/relatives.

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				farther from coast were significantly less likely to stay in hotels/motels rather than public shelters. Those who evacuated longer distances experienced greater evacuation travel time and additional travel time, longer evacuation duration and greater cost for lodging, food and transportation. Food and lodging costs were higher for larger families with children and those with higher incomes. Evacuees relying on personal experience had lower evacuation travel times and additional travel times.		
19	Author: Whitehead *et al.* (2000) Publication: Global Environmental Change Part B: Environmental Hazards Study area: North Carolina Natural disaster: Hurricane	Database used: Telephone survey Time period: 1999	Sample size: 895 cases Modeling techniques: Logit and multinomial logit regression models	Households are more likely to go someplace safer during a hurricane if given a mandatory order compared to a voluntary one when they make evacuation decisions. But the behavioral response to a voluntary evacuation order is small when	The voluntary evacuation order is not a fruitful method for generating the intended number of evacuees. Hurricane prediction technologies that are more reliable would be helpful to emergency managers while they deliver orders for evacuation.	Presentation of more specific and dynamic hypothetical storm information during storm would better replicate the situation for those who are

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				storm intensity is held constant. When making evacuation decisions, households do not rely on their perceived risk from wind but from flooding. Households also rely on the most important measure of risk, storm intensity, when making evacuation decisions. Pet ownership can restrict evacuations also. Storm intensity does not contribute towards the evacuation destination decision.		considering evacuation. Further research can be done into the effects of voluntary evacuation orders and other information on the perceived risk of a hurricane.
20	Author: Siebeneck *et al.*(2012) Publication: Natural Hazards Study area: Texas, USA Natural disaster: Hurricane	Database used: Survey Questionnaire Time period: 2008	Sample size: 341 households Modeling techniques: Inter-correlations, Multiple regression analyses	Returnees overestimated the problems they would encounter during the re-entry process. This might be because they were not sure about the nature and extent of the risks they would face upon returning. Ethnic minorities and individuals with lower levels of education had greater expectations of looting in the zone than did other socio-	It is urgent to understand about the effectiveness of the news media and social media in communicating the re-entry message so that emergency managers and business owners can use these tools to communicate re-entry messages in the aftermath of disasters. Emergency managers should recognize that returning households differ in the degree to which they expect and experience re-entry problems.	Future research should examine whether these findings are replicated after other hurricanes and what role media and information sources play while taking the decision to return home. How previous evacuation and re-entry experiences

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				demographic groups. No significant relationship was found between geographic factors and re-entry concerns, between concern about access to utilities and re-entry compliance, between expected physical risk and re-entry plan. Higher levels of concern related to the physical risk caused by damaged structures were positively related to early returns.		shape household response to re-entry plans should also be examined. Better models predicting return compliance can assist emergency managers in the development of more effective re-entry strategies.
21	Author: Sharma *et al*. (2009) Publication: Climatic Change Study area: Krishna district, Andhra Pradesh, India Natural disaster: Cyclone	Database used: Descriptive open-ended questionnaire Time period: 2003	Sample size:9 villages Modeling techniques: Qualitative, Fisher's exact test	Belief about warning received from the government was only limited to the occurrence of the cyclone. Certainty associated with the warning may not necessarily have the expected positive correlation with response to warning. Past experience affects response to warning in complex ways depending on the type of experience that the	It is essential to identify the factors, such as generally message or sender characteristics, that could be manipulated directly to improve the response to warning.	Study with a larger dataset might provide a better picture about the importance of the type of channel on the response to the warning.

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				warning recipient had in a prior hazard situation. Evacuation behaviour is significantly related to environmental cues, prior warning experience, perception of safety during evacuation and perception of quality of stay at the relief camps and the number of channels through which a person receives the warning message. Homogeneity in terms of occupation and the size of the village plays significant role in determining whether decisions about evacuation would be taken at the community level or at household level.		
22	Author: Sharma and Patwardhan (2008) Publication: Mitigation and Adaption Strategies for Global Change Study area: India Natural disaster: Cyclone hazard	Database used: IMD (Indian Meteorological Department 1996), Handbook of Fisheries Statistics, Census of India, 2001, 'Mausam' journal of India Meteorological Department, Center for	Sample size: 24 coastal districts Modeling techniques: Rank correlation matrix, cluster analysis	Krishna, Jagatsinghpur and Kendrapara are vulnerable in terms of all three components of vulnerability such as hazard component, exposure and impact components but Nellore	Cluster approach is a better approach than index approach because it provides richer information to policy for guiding and prioritizing policy decisions and actions for vulnerability reduction. This approach identifies the needs to be	A similar approach can be employed to identify vulnerable hotspots in case of other hazards.

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		Research on Epidemiology of Disasters, Memoranda of Damages at the state level, Journals, media (newspapers) Time period: 1971-2003		is vulnerable only on account of the hazard component. Krishna did not belong to the set of vulnerable districts in terms of hazard and exposure components. South 24 Parganas and North 24 Parganas are more vulnerable because of hazard and exposure components but they do not figure in the cluster of most vulnerable districts when all three components were used to cluster the districts.	addressed through policy interventions. All three dimensions of vulnerability need to be addressed through the policy interventions.	
23	Author:Bateman and Edwards (2002) Publication:Natural Hazards Review Study area: North Carolina, USA Natural disaster:Hurricane	Database used: Telephone survey Time period: 1999	Sample size: 1,029 households Modeling techniques: Bivariate Logistic Regressions, Multivariate Logistic Regression	It is more likely for women to evacuate during hurricanes because of underlying gender differences in care-giving roles, evacuation preparation, their greater exposure to certain risks, and their greater understanding of subjective risk. Indicators of socio-economic status do not predict evacuation and mediate the effect of	Policymakers need to understand special needs households and their differential access to resources need for disaster preparation, response and recovery.	Subsequent researchers should explore more thoroughly gender differences in risk exposure and perception, and their respective influences on the decision to evacuate. Future studies of disaster response should also

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				sex on evacuation. Having a family member with a special medical need is a strong and positive predictor of evacuation and women care for such needs mostly. Lack of access to working vehicle for women do not predict evacuation and mediate the relationship between sex and evacuation.		distinguish between the intention to evacuate and structural constraints on the capacity to do so.
24	Author:Das (2012) Publication:Natural Hazards Study area: Kendrapada, Orissa, India Natural disaster:Cyclone	Database used: village-level, cross-section Data, Primary Census Abstract of Orissa State Time period: 1991,1999, 2001	Sample size: 262 villages Modeling techniques: Logit and Poisson specifications	Villages in the mangrove habitat areas after clearing the forest and the ones with a large number of marginal workers are most probable, while those situated behind mangrove forests in the leeward side or near a major river directly connected to the sea are least probable of witnessing death during severe cyclone.	Attention should be given in issues such as conserving mangroves in cyclone-prone areas, priority evacuation of villages established in the mangrove habitat before a high-intensity cyclone, etc., for cyclone hazard management.	Findings of the paper are based on the human casualty data of a single cyclone and need to be examined with a wider data set. The results can be replicated for other coastal areas as well.
25	Author: Dash and Gladwin (2007) Publication:Natural Hazards Review Study area: N/A	Database used: N/A Time period: N/A	Sample size: N/A Modeling techniques: Descriptive	Although warning has significant role in understanding of evacuation decisions, but focusing on	Relevant stakeholders need to understand that better prediction of evacuation rates would enable better estimation of potential	Research is needed to understand shadow or spontaneous

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	Natural disaster:hurricane			warning alone provides an incomplete picture of the complicated process that results in evacuation. Risk perception is also crucial. It is important to understand how people transition from hearing warnings to deciding to evacuate—this combines what is known about warning compliance and risk perception.	hurricane consequences that depend on evacuation rates, including clearance times, shelter usage, and potential casualty rates.	evacuators. Research should also focus more directly on risk, the information included in hurricane forecasts, and the timing of those forecasts. Evacuation modelling should incorporate time as well.
26	Author: Sharma *et al.* (2013) Publication: Ecology and society Study area: Coastal zones of India Natural disaster: Cyclone	Database used: Household survey data Time period: 2009	Sample size: 34 villages (212 survey responses) Modeling techniques: Bivariate logistic regression	The relationship between formal education and evacuation is not as strong as expected and it completely disappears when definition of appropriate response is made stricter. There exists positive and significant correlation between education and income. Although Formal education provides greater access to income earning opportunities and enhance welfare in general, but the hazard-	There is value in preserving and promoting the traditional knowledge base along with greater enrolment in the formal education system.	Whether traditional knowledge systems and modern scientific knowledge systems complement or contradict each other need to be investigated further.

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				specific knowledge and understanding gained from non-formal sources play a greater role in responding appropriately to hazard risk.		
27	Author: Masterson and Horney (2013) Publication: PLOS Currents Disasters Study area: Beaufort county, North Carolina, USA Natural Disaster: Hurricane	Database used: Door to Door Interviews Time period: 2011	Sample size:205 households Modeling techniques: Descriptive, stratified two-stage cluster sampling method	There is no significant relationship between demographic or social factors and evacuation. Knowing about an evacuation order does not make a significant difference in a family's decision to leave their home in preparation for Hurricane.	Special attention should be given to households with special needs, non-white residents with high social cohesion, residents with high social capital or social cohesion, males with high social capital, elderly residents with high social cohesion, and while planning future disaster evacuation communications for residents of counties with high risk.	Future studies of this population should increase enrolment substantially to determine to find meaningful interaction. Studies of evacuation behavior should focus on identifying all possible effect measure modifiers.
28	Author: Mohapatra *et al.* (2012) Publication: Natural hazards Study area: India Natural disaster: Cyclone	Database used: Electronic atlas of cyclonic disturbances published by IMD Time period: 1891–2008	Sample size: 96 districts Modeling techniques: Descriptive	West Bengal, Orissa, Andhra Pradesh and Tamil Nadu's coastal districts are more prone and are in the high to very high categories of proneness. The cyclone hazard proneness factor is very high for the districts of Nellore, East Godawari, and Krishna in Andhra	The classification of coastal districts based on hazard criteria may be considered for purposes such as coastal zone management and planning.	Future studies should assess composite cyclone risk of a district, the product of hazard and vulnerability.

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				Pradesh; Yanam in Puducherry; Balasore, Bhadrak, Kendrapara and Jagatsinghpur in Orissa; and South and North 24 Parganas, Medinipur and Kolkata in West Bengal. Some districts of northeast India districts are not near the coast; therefore they are not affected by storm surge requiring large-scale evacuation of population. These districts are mostly affected by depressions and floods happen rarely.		
29	Author: Lindell *et al.* (2015) Publication: International Journal of Disaster Risk Reduction Study area: American Samoa Natural disaster: Earthquake and Tsunami	Database used: Household survey Time period: 2009	Sample size: 5 villages (262 responses) Modeling techniques: Correlations and Inter-correlations	Knowledge of earthquake shaking as an environmental cue for a tsunami was more widespread in American Samoa than in areas affected by tsunamis. Environmental cues were more important than social warnings as sources of first information in rapid onset event. Radio and TV were more	Caution should be taken in generalizing from the findings of slow onset disasters such as hurricanes to rapid onset disasters. Participants in earthquake hazard awareness meetings have higher risk perceptions, but are no more likely to evacuate or avoid negative outcomes than those who do not participate in those meetings.	Future studies should address detailed information about house-holds' responses in tsunamis and other rapid onset disasters. Systematic evacuation analyses should be conducted to address the vulnerability of

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				important than other social sources for first information and additional information. But none of the recommended elements of a warning message was transmitted to a large proportion of the risk area population and no message element was correlated significantly with evacuation.		vehicular evacuees. Further research must also address characteristics of key hazard concept that increase their likelihood of being retransmitted to others.
30	Author: Lim *et al.* (2016) Publication: Natural Hazards Study area: Quezon City, Philippines. Natural disaster :Flood	Database used: Face-to-face interviews Time period:2013-2014	Sample size: 632 Modeling techniques: Discrete choice models	Bagong Silangan households' mode choice is determined by a combination of determinants including the presence of personal vehicles, evacuation distance traveled , evacuation departure timing, education of the head of the household and the presence of small children who are 10 years or younger. Pooled Bahay Toro and Sto. Domingo model determinants are level of education of the head of the household,	The government should mandate the households living in high flood risk areas to prepare a household evacuation plan which will include issues such evacuating mode they will take, where they will go, and the resources such as food, water, and shelter they will need. Home owners in specific villages can also come up with their own plans which may help the sub-district level government to implement effective evacuations in the future.	Future studies should explore the possibility of developing models that can be generalized to cities in the Philippines. Understanding key determinants of gender-based evacuation travel behavior in the area of evacuation decision, departure time, destination, mode and route choice behavior can be addressed

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				house ownership type, evacuation departure timing, their destination, age, the presence of vehicles and the source of warning.		in further studies.
31	Author: Lindell *et al.* (2017) Publication: International Journal of Mass Emergencies and Disasters Study area: Boston, USA Natural disaster: Water contamination	Database used: Households survey questionnaire Time period: 2010	Sample size: 110 responses Modeling techniques: Correlation and regression analysis	As a first source of warning, informal peer networks rivaled the news media and played major role. Warning receipt from an authority increased consumption of boiled water and receipt of a less specific warning tended to increase consumption of bottled water. The distribution of warning times followed a S-shaped distribution, with the largest increase taking place during prime TV news time.	The amounts of bottled water and chlorine bleach available need to be held constant at the time of the incident because people with these resources might be more likely to consume bottled water or personally chlorinate tap water rather than boil water.	Further research on warning response to these types of hazards will provide the basis for developing a comprehensive theory. Future research might ask respondents to list the diseases that could be caused by drinking contaminated water and describe the correct length of time to boil water. Further research is needed to determine if warning times are consistent within a particular hazard

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						agent or reflect a more complex interaction between hazard type and characteristics of the community emergency management system.
32	Author: Ikefuji and Horii (2012) Publication: Journal of Public Economics Study area: N/A Natural disaster: ND	Database used: EM-DAT, the International Disaster Database, CRED, the Universit´e Catholique de Louvain, WDI. Time period: 1960-2010	Sample size: N/A Modeling techniques: Uzawa– Lucas type endogenous growth model	Economic growth can be sustained in the long run only if the per unit tax on the polluting input increases over time. The long-term rate of economic growth is an inverted V-shaped curve relative to the growth rate of the environmental tax. Social welfare is maximized under a less strict environmental tax policy than the growth-maximizing policy.	In terms of the discounted sum of expected utility, a less strict environmental policy is more desirable. If the cost associated with extracting resources or the finiteness of these inputs is significant and changes for some reason, these changes must be absorbed by adjusting the environmental tax rate.	Future research can integrate the analysis of natural disasters with a study of the finiteness of natural resources.
33	Author: Hunt *et al.* (2012) Publication :Animals Study area: United States Natural disaster: Hurricane	Database used survey questionnaire Time period: 2011	Sample size: 90 pet owners and 27 non pet owners Modeling techniques: Descriptive	Owning a pet was not a statistically significant risk factor for evacuation failure prior to Hurricane Irene. Twenty-three percent	Natural disasters thought to be non-threatening in advance can be quite dangerous and can result in negative psychological sequel. Improvements need be made to create an	Future studies that use large sample size can be particularly representatives.

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				of the pet owners who did not evacuate cited pet related reasons as one of the major causes of evacuation failure. Pet-owners with two or more cats cited significant difficulty in evacuation over and above the difficulties reported by dog owners, single cat owners, and non-pet owners. Nearly 70% of all evacuators chose to shelter with a friend or family whereas only 6% who chose to shelter at an emergency evacuation shelter.	efficient and easier pet evacuation process so that pet owners will continue to evacuate in the future. Municipalities need to pay special attention to individuals with multiple cats in the future. Local governments should advertise the locations and benefits of an evacuation shelter more effectively to make citizens aware about their evacuation options and hopefully increase attendance at these shelters.	
34	Author: Huang *et al.* (2012) Publication :Natural Hazards Study area: Texas, USA Natural disaster: Hurricane	Database used survey questionnaire Time period: 2009	Sample size: 562 households Modeling techniques :Factor analysis, Intercorrelations, Prediction analysis	Official warnings, social cues, storm characteristics, expected personal impacts, and evacuation impediments are psychometrically distinct constructs. Expected personal impacts have a direct effect on evacuation decision; other variables (official	Emergency managers must identify the target audiences because right messages should be communicated through the right channels to increase unrealistically low expectations about personal impacts or decrease overestimates of evacuation impediments.	Correlation between risk area and perceived storm charac-teristics should be addressed in future research since reason for positive correlation between them is not clear. Further research

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				warnings, coastal proximity, and social cues) have unpredicted direct effects. Female gender does not have a significant regression coefficient in the prediction of perceived storm characteristics, but they have significant positive correlation. People's expected personal impacts are affected by National Weather Service information about storm conditions. Expected personal impacts are strongly related to evacuation decision. Even after controlling for expected personal impacts official warnings have an impact on evacuation decision. Unnecessary evacuation experience is positively related to perceived evacuation impediments.		is needed to determine whether this pattern of correlation and regression coefficients can be found in other evacuations. Since some of the results conflict with the protective action decision model, more studies are needed to determine whether the conflicting results are replicated and require revision of the model.

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35	Author: Huang *et al.* (2016) Publication :Environment and Behavior Study area: N/A Natural disaster: Hurricane	Database used: Electronic search Time period: 1991-2004	Sample size: 49 studies Modeling techniques: Statistical Meta-analyses	Official warnings, mobile home residence, risk area residence, expectations of severe personal impacts, and observations of social/environmental cues are consistently significant predictors of evacuation decisions, but expected hurricane intensity, expected nearby landfall, homeownership, and reliance on information from peers are weaker predictors. Other demographic characteristics and previous hurricane experience have either minor or inconsistent effects on household evacuation.	Local officials are considered to be very important information sources. Hurricane education materials and warning messages need to define evacuation zones in terms of readily identifiable characteristic. Authorities need not be overly concerned about looting concerns suppressing evacuation compliance in risk areas and must not concern themselves with that the issue that false alarms will decrease future hurricane evacuations.	Variables such as authorities, property concerns, evacuation expense business closing, nearby landfall, service disruption and looting concerns can be addressed in more hurricane evacuation surveys. Studies can take account of the fact that actual and hypothetical evacuation decisions are both vulnerable to framing effects, so the challenge is to determine whether there are conditions in which actual and hypothetical decisions differ in their degree of susceptibility to framing effects. To demonstrate

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						mediation effects, researchers can test multistage, multi-equation models.
36	Author: Drabek (1999) Publication : The Social Science Journal Study area: Colorado, USA Natural disaster: Tornado, flood, Hurricane, ND	Database used: Field interviews Time period: 1996, 1997	Sample size: 57 (Sterling), dozens (Atwood), several hundred tourists and business travellers who happened by chance to be visiting locations that became transformed suddenly from places of fun into places of fear Modeling technique: Interview analysis	Responses to disaster warnings are patterned by invisible webs of constraint. Poorer families are more likely to be isolated socially, so the informal systems that are so much a part of the warning process are less robust. They receive fewer warnings from sources they trust and are more likely to be left in areas of high risk. Ethnic minorities tend not to trust official disaster warners. When disaster warning messages are unclear or imprecise, people demonstrate incredible creativity at interpreting the information so as to minimize their perception of risk. If the trip of tourists and business travellers was	People respond differently to disaster warnings because their range of experiences differ. Design and implementation of an effective community disaster warning system remains only a dream in too many places because uncertainty exists in the information officials have. Length of forewarning, and accessibility of escape routes available have significant influence in classification systems when human responses are the focus of attention.	Future studies can look into empirical testing of alternative taxonomic schemes. Future disaster warning research must be designed and funded to reflect implementation perspective and breadth of scope so as to better fit the emerging needs of a new breed of professional emergency managers.

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				nearly over, people were far less reluctant to give it up and leave areas threatened. Those visiting with relatives while on vacation were far less likely to heed warning messages than those who were in a motel or hotel.		
37	Author: Das (2011) Publication: Economic and Political Weekly Study area: Kendrapada, Orissa, India Natural disaster: Cyclone	Database used: Emergency and tahasildar offices of Kendrapada, Jagatsinghpur and Bhadrakh districts, Cyclone Warning Division, National Centre for Disaster Management (NCDM), Geographic Information System (GIS) files purchased from private source: Digital Cartography and Services, Bhubaneswar, Primary Census Abstract of Orissa for 1991 and 2001. Time period: 1991, 2000, 2001	Sample Size: 1,180 observations (Human death), 558 observations (House damages) Modeling technique: Poisson Regression, Negative Binomial Regression, Ordinary Least Squares, Weighted Least Squares, Tobit Estimates	The existence of mangrove forests reduced human casualties significantly during the cyclone. All poor people were not vulnerable equally during the cyclone and the security and certainty of sources of livelihood influenced their exposure to the cyclone. The protective role of mangrove forests was found to be more effective in reducing deaths than in reducing the damages to static properties like houses.	Given their protective services and an expected increase in high intensity cyclones due to climate change, protection of the existing mangroves must be a priority.	Empirical analysis evaluating the protective serv-ice of mangrove forests during a tropical storm should be done on a more broader scale.
38	Author: Haque (1995) Publication :Environmental Management Study area: Bangladesh Natural disaster: Cyclone	Database used: Field Survey Time period:1992	Sample Size: 162 (urban/ mainland),106 (offshore/rural)	Fatalism, disbelief in the warnings, and fear of losing household assets influenced the en masse	Educational and developmental schemes should be formulated to make people more aware of the severity of the hazards	Separating the perceived need of structural-engineering intervention for

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				inaction in the face of a severe cyclone hazard threat. Coastal inhabitants had a false sense of security that led them to disbelieve the warnings. This disbelief led people to stay in usual place of residence. In the coastal regions of Bangladesh, the need of more coastal embankments and more cyclone shelters were felt strongly by most of the people.	and of precautionary options. Hazard mitigation policies need to be integrated with national economic development plans and programmes. To mitigate more human tragedy, academics, concerned professionals, and practitioners from various disciplines and orientations need to work together and communicate effectively with victims of extreme environmental events.	the purpose of increased crop yield from the objective of mitigating actual hazard loss can be done in further analysis.
39	Author:Kang *et al.* (2007) Publication :Journal of Applied Social Psychology Study area: Texas, USA Natural disaster: Hurricane	Database used: Surveys conducted by the Hazard Reduction & Recovery Center at Texas A&M University. Time period: 2001, 2003	Sample Size: 559 households(First survey), 51 households(Second survey) Modeling technique: Means and Inter-correlations, survey analysis	Coastal residents had accurate insight of the conditions where they would decide to evacuate and many of the actions they would take while implementing that decision. They had accurate expectations about number of vehicles, evacuation shelter types, their information sources, evacuation transportation modes and two of the	Behavioural intentions correspond with actual behaviour when that behaviour is under the person's control. If evacuation expectation surveys can be properly constructed and administered, it may produce reliable results for developing local evacuation plans.	Further research on the correspondence between hurricane evacuation expectations and actual behaviour should involve larger samples in other states to determine whether the results are generalizable. Further research is needed to

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				preparation time components. But expectations regarding the number of trailers taken, evacuation destinations, and three of the evacuation time components were less accurate. Two evacuation time components (i.e., gather household members and pack travel items) showed very similar means at the aggregate level and a significant degree of convergent validity at the individual level. The correspondence between behavioural expectations and later behaviour could be affected by lack of experience with hurricane hazards in many different ways.		determine the extent to which factors such as people lacking information about the consequences of their behaviour, the probabilities of these consequences, normative beliefs, their motivation to comply, or situational constraints and facilitating conditions reduce the correspondence between expectations and behaviour.
40	Author: Mechler and Bouwer (2015) Publication : Climatic Change Study area: Bangladesh Natural disaster: Flood	Database used: Tanner et al. (2007), UNISDR (2011) Time period: 2007, 2011, 2020-2050	Sample Size: N/A Modeling technique: Projections and normalizations, dynamic vulnerability index	Economic vulnerability and vulnerability of loss of life were strongly decreasing in Bangladesh, reductions in later one is especially striking. The reduction	Considering (economic) vulnerability explicitly in projections of future risk is important. Projections made on the basis of hazard and exposure change only can overestimate actual changes in future risk, but at the	Focused and systematic research process can be done for identifying the factors contributing towards risk and

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				in vulnerability can be due to autonomous or exogenous adaptive behaviour. Vulnerability is a key driver when accounting for vulnerability reductions in projections of risk in terms of average annual losses over decades until 2050. Projected risk will increase very strongly when only exposure and hazard are considered dynamic. Risk has been increasing in absolute terms in Bangladesh.	same time it can also underemphasize the efforts to reduce risk.	tackle the methodological challenges involved in working towards more robust estimates of future losses from climate extremes.
41	Author: Taubenbock *et al.* (2009) Publication : Natural Hazards and Earth System Sciences Study area: Padang, Indonesia Natural disaster: Tsunamis	Database used: Remotely sensed data (Aerial survey), Hydrographical survey and field surveys Time period: 2000,2008	Sample Size:1000 households (Socio-economic data) Modeling technique: Inundation modelling, urban morphology analysis, population assessment, socio-economic analysis of the population and evacuation modelling	Zones of high risk for any earthquake triggered tsunami are distributed along the coast but also along lower parts of river mouth and channels. Highly risky zones are seriously affected by water levels and flow velocities which lead to complete damage of less robust houses. Houses and shelters in zones of medium risk can withstand the impact,	To establish more intensive participation of the local stakeholders, additional disciplines or common efforts are necessary. Areas with vertical evacuation solution have to be localized. Standardized and location specific education are needed for the people to teach them on what to do in case of potential tsunami situation and provision of an early warning. It is also important to provide clear information to the people on	Education programs should focus on recommended evacuation routes.

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				but flow path between houses and structures will be characterized by high flow velocities that completely disable evacuation procedure. Zones of low risk will be damaged least by the tsunami impact. Evacuation behaviour might be affected by awareness of the people and household characteristics. Additional shelters will reduce this walking distance for persons living or working close to those shelters.	where the recommended places and routes to evacuate. It is also recommended to empower the people to disseminate the warning in an organized informal way, such as through neighbourhood leaders or trained community teams.	
42	Author: Kotal *et al.* (2013) Publication: IMD NWP Division Study area: Bay of Bengal Natural disaster: Cyclone	Database used: India Metrological Department Time period: 2013	Sample Size: N/A Modeling technique: Statistical linear regression, Multiple linear regression technique, Probability forecast, Dynamic statistical model	Grid point analysis and forecasts of GPP could able to predict the formation and location of the system before 168 hours of its formation. MME could able to predict near actual landfall point (Gopalpur) consistently. Average land fall point error of MME was 20 km and it varied from 36 km (NCEP-GFS) to 144 km (HWRF) for other models. SCIP was	Statistical post processing can add skill to dynamical forecasts and provide useful guidance on landfall point, landfall time, intensity, rapid intensification phases and decay after landfall for operational cyclone forecasting.	Similar analysis can be done for other Natural disasters.

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				superior to HWRF up to 48 hour, HWRF was better at 60 h and 72 h forecasts. SCIP model can successfully predict the landfall intensity of very severe cyclonic storm.		
43	Author: Yadav and Barve (2014) Publication: Proceedings of SOM Study area: Odisha, India Natural disaster: Cyclone	Database used: GoO (2013), UNEP (2013), OSDMA (2013) Time period: 2013	Sample Size: N/A Modeling technique: Case Study	Low casualty in cyclone can be attributed to the level of preparedness done for the cyclone Phailin. Adequate social mobilization, proper capacity building for year's together, appropriate decision and monitoring by government, timely action and selfless volunteerism by hundreds of volunteers throughout the affected districts achieved the zero casualty targets in cyclone Phailin. The communities' cyclone preparedness and response capacities were increased through developing disaster management plans and VCA/risk mapping.	The community members are better aware of cyclone risks in their communities. Cyclone coping mechanisms are reinforced through training, raising awareness about safety measures and disaster exercises/drills, i.e. capacity building. Only relief centric approach is not sufficient to handle the disasters of greater magnitude. Active and coordinated involvement of all agencies and stakeholders is needed for better management. Strengthening and capacity building of community members and volunteers is essential.	Similar case study can be done for other disaster prone areas and assess whether capacity building plays a central role in managing disaster at larger scale.

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44	Author: Baker (1991) Publication : Int. Journal of Mass Emergencies and Disaster Study area: USA Natural disaster: Hurricane	Database used: Panel Survey Data Time period: 1977, 1979, 1983-1985	Sample Size: N/A Modeling technique: Qualititative	Variations in evacuation behaviours are accounted for by 5 factors such as risk level of the area, housing, action by public authorities, prior perception of personal risk and storm specific threat factors. Many individual-difference variables such as age, previous hurricane experience, previous unnecessary evacuation, general hurricane awareness, sex, education and family status.	Hurricane response literatures suggest cautions in developing general evacuation behaviour models and in studying other hazards. In generalizing from too few evacuations or from one hazard to another, one should exercise care.	Future studies can ascertain the importance of variables affecting evacuation rather than determining whether relationships of any magnitude exist.

Source: Author's elaborations.

Note: KHB (The Karlson-Holm-Breen), Fl=Flood,L=Landslides, D=Drought, Ws=Wind storms, Q=Earthquakes, Ts=Tsunami, Ty=typhoons, GPP=Genesis Potential Parameter, NWP=Numerical Weather Prediction, MME=Multi-Model Ensemble, NCEP=National Centre For Environmental Prediction, GFS=Global Forecast System, HWRF=Hurricane Weather Research and Forecast, SCIP=Statistical Dynamic Model Forecast, SOM= Society of Operations Management, OSDMA= Odisha State Disaster management Authority, VCA=Vulnerability and Capacity Assessment, EM-DAT (Emergency Events Database), CRED (Centre for Research on the Epidemiology of Disasters).

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Azreen Karim is an applied development economist and currently working as a Research Fellow at the Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh. Her current research interests include environmental, climate and disaster economics, international and development economics. Azreen's articles have appeared in international reputed journals, namely World Development, The Singapore Economic Review, and Review of Economics and Institutions. She has contributed Book Chapters in the book(s) titled Economics of Natural Disasters (World Scientific Publishing), Global Pandemic and Human Security: Technology and Development Perspective (Springer Nature), and Pandemics Risk, Response and Resilience (Elsevier). In 2015, she was awarded the prestigious Jan Whitwell Prize for best presentation of work undertaken by a doctoral student. She holds a Masters in Economics from York University, Toronto, Canada and a Ph.D. in Economics from Victoria University of Wellington, New Zealand. She has professional practice involvement with the American Economic Association (AEA), Western Economic Association International (WEAI), New Zealand Association of Economists (NZAE) and the Bangladesh Economic Association (BEA).