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Climate Induced Vulnerability and Adaptation by Rural Households in Bangladesh

Engr. Md. Ziaul Hoque, P.Eng.
[B.Sc. Engr. (Civil); M.Sc. Engr. (Env.)]
Individual Consultant,
Construction of Important Bridge on Rural Road **(CIBRR)** Project,
Local Government & Engineering Department (LGED),
Dhaka, Bangladesh.

ABSTRACT

Understanding the complex dynamics of a household's livelihood and Induced vulnerabilities in the face of climate change is challenging. This research paper considers in the southern part of Bangladesh to analyze the complex issues of the vulnerability of livelihoods in the face of climate change. We conducted a questionnaire survey of approximately 15.6% of households in the study area. Consequently, we collected Geographical Information System (GIS) data and satellite imagery to demonstrate the land-use changes concerning vulnerabilities. A total of 54 indicators were selected to assess the livelihood vulnerability index, considering the demographic profiles, livelihood strategies, social networks, food security, water security, income, physical infrastructures, access to health services, and impacts of natural disasters. The results of the study demonstrate that only 21% of the people in the studiedregions are less vulnerable to livelihood impacts in the face of climate change, while 23% of the households remain the most vulnerable. Moreover, inadequate social networks and inefficient livelihood strategies are contributing the most to the household vulnerability indices. Interestingly, the impacts of natural disasters remain the same for the whole study area and endure similarly when assessing household vulnerability. Finally, the study reveals that decision-makers may formulate effective adaptation policies to safeguard people and their livelihoods in the time of unprecedented climatic conditions in this unique area of Bangladesh.

Kew words: *Climate Change, adaptation; planning; households; rural area, sustainable development.*

INTRODUCTION

A number of studies have been used to understand the concept of vulnerability to climate disasters in the different fields of society. The aspect cannot be easily applied because so many issues associated with its events and the effects (Adger et al., 2005; Cardona, 2013; Nelson et al., 2010; O'Brien et al., 2004). Generally, there are two elements related to the vulnerability to climate disasters: consequence as an incidence of an extreme event, which can be recognized as climatically extreme sensitivity (e.g. crop failure, land fertility loss, salinity on land) and the community's resilience to the event (e.g. physical and economic resources, adaptation mechanisms) (Luers et al., 2003; Nelson et al., 2010). However, the widespread impact of climatic disasters especially throughout the agricultural sector has become more and more severe over time. The disasters associated with climate variables such as coastal flooding, cyclones, river erosions, and tidal surge with increasing severity have an impact on the agricultural industry throughout the significant decrease of agriculture production, enhancing crop failure, and increasing farmed animals overall survival (Harvey et al., 2014; Morton, 2007). A wide range of natural and biological mechanisms which drive productivities in agricultural systems, land management and forestry are significantly impacted by inter-annual, monthly and regularly distribution of climate parameters e.g. temperature, radiation, precipitation, water-vapor pressure in the atmosphere and the wind (Easterling et al., 2007). The effects of this climatic variability on agriculture seem to be the most detrimental site. For instance, conventional extreme weather effects of climate change endanger the survival of the people who rely on agriculture (Rosenzweig et al., 2014; Zhai & Juzhong, 2009). Due to climate fluctuations, agricultural production and productivity adjustments are significantly segregated across the various areas of the globe (Lipper et al., 2014).

As agriculture is one of the most climate-infected areas, attempts to highlight and evaluate the overall level of agricultural vulnerability are taken by producing comparative variables focusing on the numerous parameters of vulnerability, the exposure, sensitivity, and adaptive capacity of agroecological systems (Neset et al., 2019). In fact, several literature studies (Acheampong et al., 2014; Aleksandrova et al., 2016; Gbetibouo et al., 2010; Islam et al., 2014; Li et al., 2016; Li et al., 2015; Monterroso et al., 2014; Sujakhu et al., 2018; Wiréhn et al., 2015) took place

across a multitude of dimensions covering various areas of agriculture, such as farming, livestock, fisheries, and forestry. These studies were mainly aimed at helping decision-makers to detect 'access points' in prioritization of adaptation capital, raising awareness about climatic risk and uncertainty, monitoring the implications of adaptation strategies and understanding limitations of the social and environmental scheme that contributes greatly to vulnerability. Overall, the majority of all these researches indicate 'a brief look' on the vulnerability of agricultural systems by incorporation of some frequently used determinants.

However, Bangladesh is regarded as an agrarian-economy dependent growing nation (Nasim et al., 2019) where agricultural households, specifically in the coastal region (Chen & Mueller, 2018; Chowdhury et al., 2012; Hoque et al., 2019; MoA, 2013; Shamsuddoha & Chowdhury, 2007; Younus, 2017; Younus & Kabir, 2018), has become increasingly vulnerable with increasing climatic fluctuations and severe weather occurrences (coastal flooding, tidal storm, cyclone, etc.), with the agricultural devastation (salinization, water shortage, and soil degradation), throughout the timespan (Hoque et al., 2019; Khanom, 2016). For instance, the very last two massive-cyclone occasions, namely, Sidr and Aila took place in 2007 and 2009, triggering a great number of human deaths. They have led to failure in the agricultural sector, livestock farming, and resources. They also have deterioration in economic and environmental functions (Shamsuddoha & Chowdhury, 2007; Younus, 2017). In the meantime, approximately 63% of the coastal arable land territory is hampered by varying levels of soil salinity due to these climate disasters (Hoque et al., 2019; MoA, 2013). Nevertheless, adjusting to an increasing rate of climate induced disasters have become the greatest problem, contributing to a growing demand for better expanded mitigation options, in order to protect coastal people's agricultural properties and resources, and to extrapolate more changing climate in the long term (Brown et al., 2018; Quader et al., 2017; Younus & Kabir, 2018). Therefore, it is extremely important that agricultural vulnerability to climate disasters is assessed to develop and apply intended adaptation policies as well as to characterize major concern sections for agricultural improvement.

Until now, household's agricultural vulnerability analysis studies, particularly in the south-west coastal region of Bangladesh, have not been extensively or adequately characterized. Though there is a substantial number of vulnerability studies (Ahsan & Warner, 2014; Bhuiyan et al., 2017; Hoque et al., 2019; Islam et al., 2014; Islam et al., 2013; Mullick et al., 2019; Rabby et al., 2019; Rakib et al., 2019; Uddin et al., 2019; Younus, 2017; Younus & Kabir, 2018) have found but there is hardly a single study to assess the agricultural vulnerability of household's to climate-induced disasters in the south-western coastal Bangladesh. Therefore, this study was focused on assessing agricultural vulnerability to climate-induced disasters of south-west coastal Bangladesh using agricultural vulnerability indicators under the umbrella of climate-induced disasters vulnerability components of exposure, sensitivity, and adaptive capacity which have been widely used and recognized by the Intergovernmental Panel on Climate Change (IPCC) and recent studies on climate change.

This study has also identified indicators of adaptive capacity that determine the agricultural vulnerability to climate-induced disasters of south-western coastal households in Bangladesh which has also not been assessed by any previous studies in Bangladesh. Further, this analysis has made it easier to understand the agricultural vulnerability of the household's regionally in south-western coastal Bangladesh.

OBJECTIVES OF THE STUDY

The objectives of the study are as follows:

1. To explore the climate induced vulnerability in Bangladesh.
2. To find out the sufferings of rural households in Bangladesh.

METHODOLOGY

The approach and strategy used to pursue a research depends upon the nature of the problem to be studied and research question to be answered. Previous studies in this field are mainly done as research evaluation conducted by the Results for development studies.

A combination of questionnaire survey, in-depth interview, expert opinion and case studies are used to collect first hand data and content analysis technique is applied to validate it. The purpose of using of different methods is that it minimizes the risk of biasness in the study and thus works as a reliable tool.

Research Method

Cresswell (2009) mentions three main approaches for conducting scientific research namely qualitative, quantitative and mixed approach. The study aims to describe the events and respondents perception scientifically. The researcher solely relies on the views of respondents of demand side and supply side as well as experts on this very topic under study. Quantitative approach suits the best to meet the objective of the study. Besides, some questionnaire survey using questionnaire was conducted to make efficient use of time. The research methodology of the study was explanatory in nature. In this research, both primary and secondary data were collected. Most of the data used in the present study have been collected from a recent survey on the different research reports.

Study Area
The study was conducted at Kalapara Upazila at Patuakali district, Samnagar Upazila of Satkhira District, Pathorghata Upazila of Barguna District and Cox's Bazar Sadar Upazila and Moheskhali Upazila of Cox's Bazar District.

Research Design
The choice of an appropriate research design is essential for a scientific study since it gives a framework of what the researcher will do from setting the research question to the operational implications of the data analysis. A research design is 'the arrangements of conditions form collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure' (Selltiz 1965 cited in Aminuzzaman 1991, p.53). Hence descriptive and analytical research designs have been chosen. Because descriptive research design helps to describe the current practices and events while analytical research design enables to establish relationship between variables (Aminuzzaman 1991). Here the research design was survey type.

Source of Data
For this research two types of data are used-
1) Primary Sources
2) Secondary Sources

Primary Sources
Primary information was collected by the researcher/investigator himself through field operations. For having a sound conception of the secondary source was very helpful but this research had special attention on the data and information has been collected from primary sources. In addition to this the observations during the field visit have been incorporated in this research.

Secondary Sources
To conduct this research, secondary data were also collected from various sources including authentic writings, books, thesis, articles, documents etc. of eminent authors, journals, statistical reviews, academic papers, government documents, newspapers, magazines, souvenirs, published and unpublished research works, internet homepages etc. relevant to the main theme of the study.

Survey Method
The study was survey type. Survey Method involves a systematic and comprehensive study of a specific community with a view to the analysis of social problem and presentation of recommendations for its solution. In this research, the tools used for the survey were questionnaire survey, interview schedule and observation.

Sampling Method
Basically, the study used purposive sampling method so as to get the best information to achieve the objectives of the study. This method gave flexibility to the researcher to pick up only people who are likely to have the required information and be willing to share it. Moreover, the sampling method helped to ensure representation of different variation of service providers as well as service seekers. In other words, heterogeneity in the composition of sample of service seekers and providers (age, sex, senior-junior officials, education, and profession) were attempted to maintain as possible.

Sample size
Total 100 respondents will be selected for the study.

Tools for data collection
Questionnaire and request letters were used for data collection.
Questionnaire
Questionnaire was the structured set of questions which were given to the respondent either directly by hand or by courier service, by post, or by mail. It can be described as a document that contains a set of questions, to which the answers are to be provided by the respondent. In this survey the questionnaire has been developed. It was both open and close ended with an aim of having the in-depth information of the target respondents. The questionnaire developed for the respondents of the study area. It is a straightforward question and answer method, but rather tried to collect data through informal discussion of several time by creating a report with the respondents so that the unhesitant could share with me.

In-depth Interview
Besides, gathering information from the respondents of 400 through structured questionnaire, in-depth interview technique had also been used to collect those kinds of information that could not be asked directly.

Data Collection Technique

A brief description of the data collection techniques used in the study is detailed here. Data were collected by face to face interview with the respondents.

Questionnaire Survey

For unique and exploratory research new information are required. Questionnaire survey is the easiest and most widely used instrument for data collection in this regard. This method allows the researcher to come in direct contact with the respondents, to observe their attitude during answering time and to analyze the issue under study in ordinary setting. Thesis Supervisor provided precious suggestions and corrections to make the questionnaire precise enough to meet the objectives of the study without exaggeration. Besides, comments and advice from other faculties and fellow participants during chapter defense had great support to frame up the questionnaire. The researcher went locally and had direct interaction with the respondents. The purpose and objectives of the study were explained to the respondents as simply as possible allocating sufficient time so that they swallow up the idea and can come back with spontaneous thoughts. Thus questionnaires were filled up to avoid unwarranted biasness.

Data Processing and Analysis

In qualitative study the researcher has the freedom to marshal gathered data to meet the desired objectives of the study (Creswell 2009). Partial data of questionnaire survey were processed using simple mathematics. The rest of the data were explained carefully to meet the aim of the study and research question and also attempted to establish relation among the variables. Data were analyzed by using computer program Statistical Package for the Social Sciences (SPSS).

Data Validation

Validity refers to trustworthiness which is done through cross checking the data collected from one source to that of others. If themes are established based on converging several sources of data or perspectives from participants, then this process can be claimed as adding to the validity of the study (Creswell 2009, p.191). In this study data were triangulated during survey and interview and latter justified with secondary data.

RESULTS AND DISCUSSION

Table 1: Age Group of the Respondents

Age Group (in Years)	Frequency	Percentage
21-30	12	12%
31-40	18	18%
41-50	37	37%
51-60	22	22%
61-70	11	11%
Total	100	100%

Source: Field Survey

Age groups of the respondents are described in the above table. From the graph it was found that out of 100 respondents, age group 41-50 years is 37 % which is the maximum and age group 61-70 years is 11 % which is the minimum. Age group 21-30 years was 12%, 31-40 years is 18% and age group 51-60 years was 22%.

Table 2: Gender of the Respondents

Gender	Frequency	Percentage
Male	82	82%
Female	18	18%
Total	100	100%

Source: Field Survey

Gender of the respondents is described above table. From the graph it was found that out of 100 respondents, 82% respondents were male and 18% respondents were female.

Table 3: Educational Qualification

Education	Frequency	Percentage
Illiterate	30	30%
SSC	20	20%
HSC	21	21%
Graduate	18	18%
Masters	11	11%
Total	100	100%

Source: Field Survey

Educational qualifications of respondents are described above table. From the graph it was found that out of 100 respondents, 30% respondents were illiterate which maximum but only 11% respondents were were master's degree holders. On the other hand 20% respondents were SSS passed, 21% respondents were HSC passed and 18% respondents were Graduate.

Table 4: Type of Job of the Respondents

Type of Job	Frequency	Percentage
Government	3	3.0%
Public Representatives	97	97%
Total	100	100%

Source: Field Survey

Job category of the respondents is described above table. From the result it was found that out of 100 respondents 97% respondents were Public Representative and 3.0% respondents were Government Service holder.

Table 5: Type of Organization

Type of Organization	Frequency	Percentage
Union Parishad	70	70%
Municipality	30	30%
Total	100	100%

Source: Field Survey

Category of the Organization is described above table. From the graph it was found that out of 100 respondents, 70% respondents engaged in Union Parishad and 30% respondents are engaged in Municipality.

Table 6: Designation of Public Representatives

Designation	Frequency	Percentage
Chairman	8	8%
Councilor	22	22%
Member	60	60%
Mayor	8	8%
Secretary	2	2%
Total	100	100%

Source: Field Survey

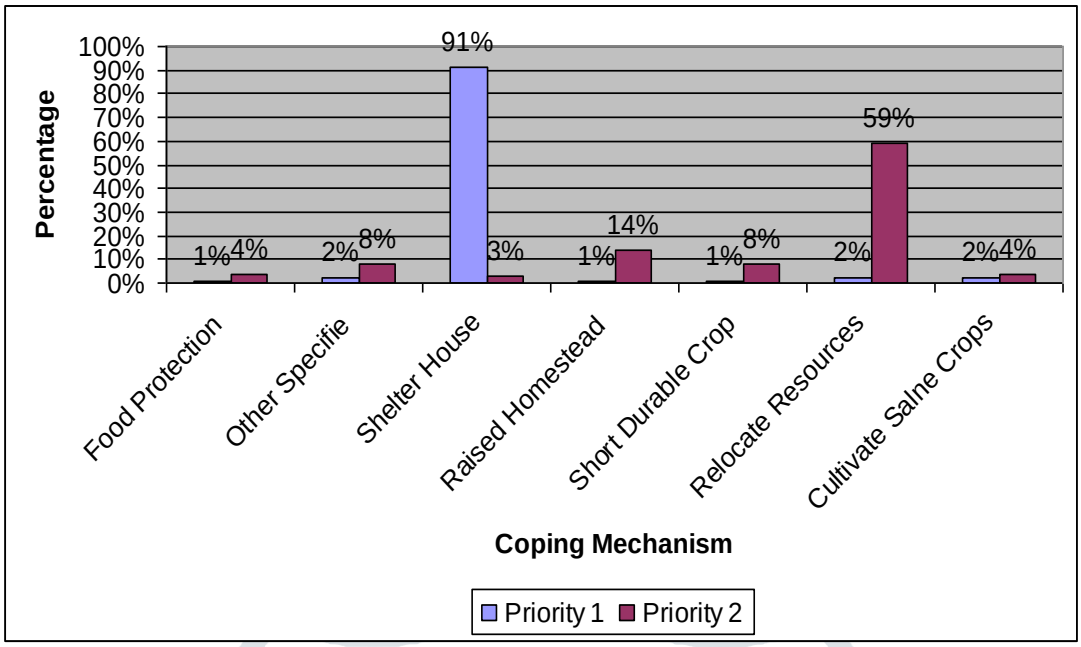
Designation of the Public Representatives is described above table. From the graph it was found that out of 100 respondents, 60% respondents were Member of Union Parishad which is the maximum and 2.0% are Secretary of Union Parishad. Other representatives were Chairman of Union Parishad 8%, Councilor of Municipality are 22%.

Table 7: Coping Mechanism of Climate Induced Hazard

Category	Priority 1	Priority 2
Food Protection	1.0%	4.0%
Other Specifie	2.0%	8.0%
Shelter House	91%	3.0%
Raised Homestead	1.0%	14%
Short Durable Crop	1.0%	8.0%
Relocate Resources	2.0%	59%
Cultivate Salne Crops	2,0%	4.0%

Source: Field Survey

Figure 1: Coping Mechanism of Climate Induced Hazard



Source: Field Survey

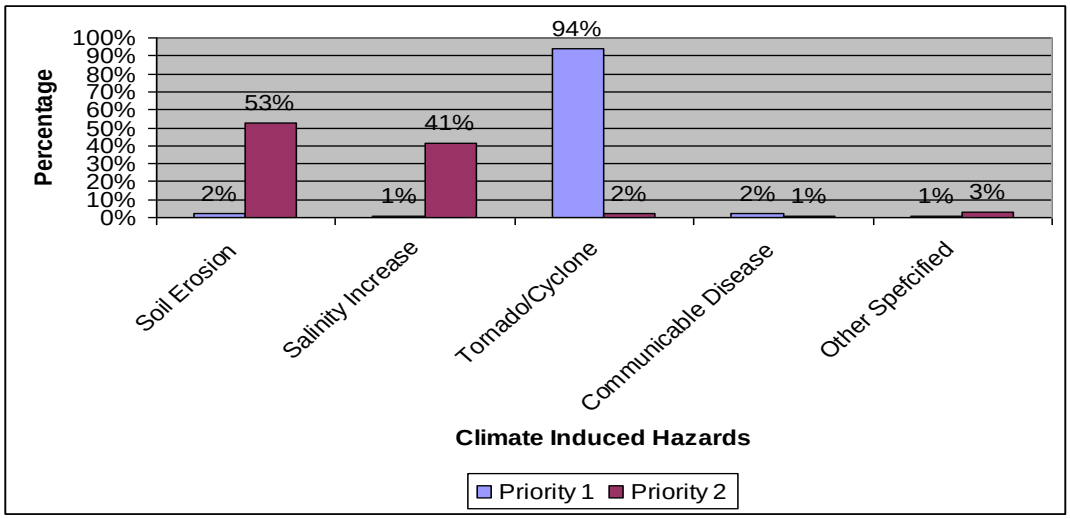
Coping mechanism of the disaster prone areas are described above. Here opinions of the respondents are categorized into Priority 1 and Priority 2. From the graph it was found that in case of priority 1, out of 100 respondents, 91% respondents were agreed that Shelter House is the most effective coping mechanism against natural disaster and other coping mechanisms are Food Protection, Other Specific adaptation measure like take shelter in embankment/dam during disaster period, Raised Homestead, Short Durable Crop, Relocate Resources and Cultivable Saline Crops are 1.0%, 2.0%, 1.0%, 1.0%, 2, 0% and 2.0% respectively. In case of Priority 2, out of 100 respondents, maximum 52% respondents agreed that Relocate Resources is the most effective coping mechanism against natural disaster and other coping mechanisms are Food Protection, Other Specific, Raised Homestead, Short Durable Crop, Relocate Resources and Cultivable Saline Crops are 4.0%, 7.0%, 8.0%, 17%, 8.0%, and 4.0% respectively.

Table 8: Climate Induced Hazards

Hazards	Priority 1	Priority 2
Soil Erosion	2.0%	53%
Salinity Increase	1.0%	41%
Tornado/Cyclone	94%	2.0%
Communicable Disease	2.0%	1.0%
Other Spefcified	1.0%	3.0%

Source: Field Survey

Figure 2: Climate Induced Hazards



Source: Field Survey

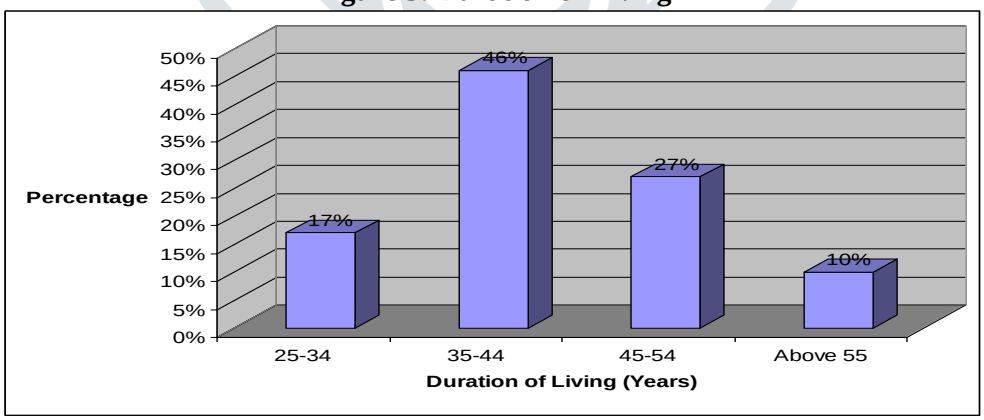
Climate Induced Hazards are described above. Here opinions of the respondents are categorized into Priority 1 and Priority 2. From the graph it was that in case of priority 1, it was found that out of 100 respondents, maximum 94 % respondents agreed that Tornado/Cyclone is the main climate induced hazards, and other climate induced hazards are Soil Erosion, Salinity Increase, Communicable Disease and Other Specified hazards are 2%, 1%, 2%, and 1% respectively. In case of Priority 2, it was found that out of 100 respondents, maximum 53% respondents agreed that Soil Erosion is the main climate induced natural hazards and other climate induced natural hazards are Salinity Increase, Tornado/Cyclone, Communicable Disease and other Specified hazards are 41%, 2%, 1% and 3% respectively.

Table 9: Duration of Living

Sl. No.	Duration	Percentage
1	25-35	17%
2	35-44	46%
3	45-54	27%
4	Above 55	10%
Total		100%

Source: Field Survey

Figure 3: Duration of Living



Source: Field Survey

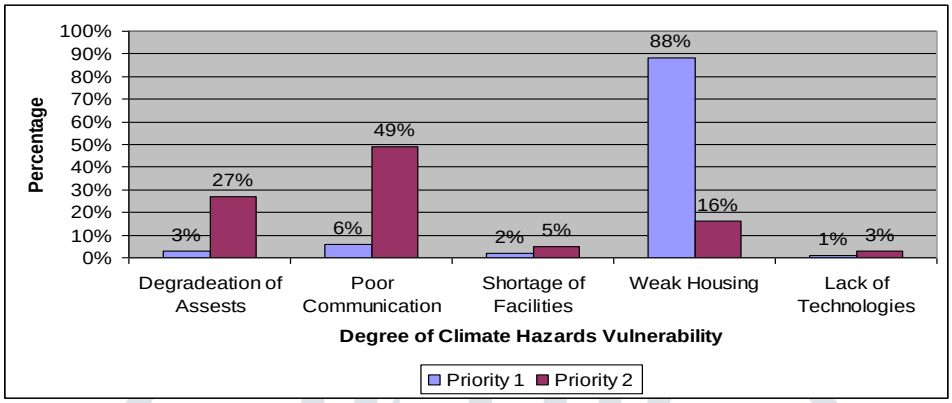
Duration of living of the respondents is described in the above graph. From the graph it was found that duration of living 35-44 years is 46 % which is the maximum and duration of living above 55 years is 10 % which is the minimum. Duration of living 25-34, 45-54 years is 17% and 27 % respectively. The selection of the participants was done randomly.

Table 10: Degree of Climate Hazards Vulnerability

Degree	Priority 1	Priority 2
Degradation of Assets	3.0%	27%
Poor Communication	6.0%	49%
Shortage of Facilities	2.0%	5.0%
Weak Housing	88%	16%
Lack of Technologies	1.0%	3.0%

Source: Field Survey

Figure 4: Degree of Climate Hazards Vulnerability



Source: Field Survey

Degree of Climate Hazards Vulnerability is described above. Here opinions of the respondents are categorized into Priority 1 and Priority 2. From the graph it was that in case of priority 1, out of 100 respondents, 88% respondents agreed that Weak Housing is the effect of natural disaster which is the maximum and lack of technologies is 1% which is the minimum effect of natural hazards. Other effects of natural hazards are Degradation of Assets, Poor Communication, Shortage of Facilities, Weak Housing and Lack of Technologies is 3%, 6%, 2% respectively. In case of priority 2 out of 100 respondents, 49% respondents agreed that Poor Communication is the effect of natural disaster which is the maximum and Shortage of Facilities s 1% which is the minimum effect of natural hazards. Other effects of natural hazards are Degradation of Assets, Weak Housing and lacks of Technologies are 30%, 6% and 4% respectively.

CONCLUSION

Bangladesh is critically vulnerable to climate induced hazards, but the core elements of its vulnerability are primarily contextual. It is probably the only country in the world with most of its territory lying on the deltaic flood-plain of three major rivers and their numerous tributaries. Between thirty to seventy per cent of the country is normally flooded each year. The huge sediment loads brought by these Himalayan Rivers, coupled with a negligible flow gradient add to drainage congestion problems and exacerbate the extent of flooding. The low coastal topography contributes to coastal inundation and saline intrusion inland. Bangladesh also lies in a very active cyclone corridor that transects the Bay of Bengal. The societal exposure to such risks is further enhanced by its very high population and population density, with close to 800 persons per square kilometer in vulnerable areas such as the coastal zones. Very low levels of development and high levels of poverty (between 33 and 40%) add to the social sensitivity to any external hazards. Meanwhile traditional adaptation via seasonal migration to less vulnerable areas within the Indian subcontinent was probably curtailed significantly half a century ago with the creation of a discrete geopolitical entity (East Pakistan), which subsequently became Bangladesh. The internationalization of the region probably also contributed to water sharing conflicts, most notably the building of the Farakka barrage in India that led to the diversion of dry season flows, which exacerbated salinity concerns in the Bangladesh Sundarbans.

Many projected climate change impacts including sea level rise, higher temperatures and evapotranspiration losses, enhanced monsoon precipitation and run-off, potentially reduced dry season precipitation, and increase in cyclone intensity would in fact reinforce many of these baseline stresses that already pose a serious impediment to the economic development of Bangladesh. By the same token, many actions undertaken to address the baseline or contextual risks in Bangladesh are also synergistic with the so called adaptations that might be required as climate change impacts manifest themselves. There is therefore a need to clearly address whether climate change impacts are simply one more reason to lower contextual vulnerability via business as usual economic development activity, or whether adaptation to climate change might require suitable modifications in such projects or highlight the need for entirely new activities, and if so, what such activities might be. Thus far there has been no clear articulation on this important issue, despite the disproportionately high number (and somewhat duplicative nature) of conferences and donor funded projects on climate change that have taken place in Bangladesh over the past decade. New climate

oriented projects in Bangladesh might therefore require a higher threshold of "value added" in the light of the considerable body of knowledge and past experience that has already been accumulated.

This report (like some others before it) indicates a general lack of explicit attention to "climate change" in many government plans and donor project documents in Bangladesh. At the same time however this report also reveals through a more in-depth analysis that despite this lack of explicit mention, a number of adaptations that climate change might necessitate are indeed already underway in Bangladesh through several government-donor partnerships. In particular, considerable progress has been made since the mid- 1990s in implementing such projects. A wide array of river dredging projects have been completed to reduce siltation and facilitate better drainage at times of flooding as well as to boost dry season flows to critical areas such as the Sundarbans. The Ganges Water Sharing Treaty has been signed with India to boost dry season flows and reduce the threat of salinity, and more sophisticated cyclone early warning systems and protection shelters are being developed. All these measures are likely to contribute to reducing the vulnerability of Bangladesh to climate change impacts.

However, there are also some examples of development policies and priorities in Bangladesh that might potentially conflict with climate change responses. In particular, policies to encourage tourism and build tourism infrastructure in vulnerable areas of the coastal zone, particularly the Khulna region, might need to take into account the projected impacts of climate change to reduce the risk of mal-adaptation. On the other hand, plans to encourage ecotourism in the fragile Sundarbans might risk adding one more stress to a fragile ecosystem that will likely be critically impacted by sea level rise and salinity concerns.

With regard to structural adaptations such as coastal embankments and salinity reduction, even though it is true that many of these measures have already been integrated in development projects and policies in Bangladesh, there remains an ongoing challenge with regard to their durability and sustainability. For example, given the high influx of sediments from the Himalayan Rivers each year, measures such as dredging of waterways are not a onetime response but require periodic repetition.

Similarly flow regulators on coastal embankments require constant monitoring and maintenance for the lifetime of such structures – in fact it was the poor maintenance of such regulators in the original embankments established in the 1960s that cause widespread flooding when they became clogged by the 1980s. Monitoring and maintenance in turn requires continued government and donor interest as well as participation of the local population far beyond the original lifetime of the project. This point is echoed by the project director of the Coastal Embankment Rehabilitation Project who observed "The Operation and Maintenance (O&M) component appears to have been relegated. Political and institutional support from national to local level has been in favor of rehabilitation instead of preventative maintenance. The project's sustainability is apparently seriously deficient" (M.S. Rahman, 2002). Structural adaptations therefore need to be matched by efforts to facilitate financial and institutional adaptation – sustained interest on the part of the government and donors, and the participation of local populations to help monitor and maintain infrastructural projects.

The Bangladesh case study also highlights the importance of the trans-boundary dimension in addressing climate change adaptation. The effect of water diversion as a result of the Farakka barrage on dry season flows and salinity levels in the Sundarbans was in fact comparable (if not higher) than the impact that might be experienced several decades later as a result of climate change. Adaptation to climate change might therefore not just be local but might require cross-boundary institutional arrangements such as the Ganges Water sharing treaty to resolve the current problems of water diversion. Finally, climate change risks should also not distract from aggressively addressing other critical threats, including shrimp farming, illegal felling of trees, poaching of wildlife, and oil pollution from barge traffic, that might already critically threaten the fragile ecosystems such as the Sundarbans even before significant climate change impacts manifest themselves.

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