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CONTENTS

Vulnerability to Natural Hazards and Climate Resilient Socio-economic Development in Bhola

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Abstract

Bhola is the largest island in Bangladesh that has been suffering directly and indirectly from natural hazards almost every year. These hazards are adversely affecting the socio-economic and environmental conditions of local communities, slowing down their overall development. Although natural hazard-induced damages are already identified in different sectors, the reduction of economic losses and deaths remain largely unaddressed due to poor understanding and practices among communities regarding resilience activities. Our study aims to understand the vulnerability to natural hazards and climate resilient socio-economic development in Bhola. The results found in this study suggest that cyclones are the main devastating natural hazard in this district, whereas other hazards such as flood and river bank erosion are also common. It is also found that most of the unions of Bhola Sadar upazila have been affected by cyclones. Casualties and damage were very high in Tazumuddin upazila and the highest migration occurred from Charfasson upazila. The results also suggest that most of the region has medium resilience to natural hazards. Among the six thematic areas used in this study to determine the levels of community resilience, "knowledge and education" scored the highest and "preparedness and response" scored the lowest. These results suggest that policy makers consider the need forbuilding a hazard resilient community in the coastal areas of Bangladesh.

Keywords: Adaptive Capacity, Bhola, Disaster, Hazard, Resilience

Introduction

Bangladesh is the largest deltaic country in the world, and its geographic location exposes its inhabitants to natural hazards such as cyclones, sea level rise, salinity intrusion, river bank erosion, land loss, and drought (A. U. Ahmed *et al.*, 2012; Rahaman *et al.*, 2021). These environmental stressors cause communities to be vulnerable by affecting their sustenance, livelihoods, recreation, and agricultural productivity, while damaging their homes and property and imposing long-term adversity on the country's socio-economic and environmental systems (Ayeb-Karlsson *et al.*, 2016).

Understanding vulnerability and the governance of resilience in the built environment are foundations for hazard resilient sustainable development. Community vulnerability can be gauged from adaptive capacity, whereas resilience reflects the capacity to manage existing and envisioned physical systems, as well as natural ecosystems, in a manner that can persist during extreme adverse events (IPCC, 2014). However, these two terminologies are not in opposition, but rather complementary in explaining in-depth depictions of these natural and built environmental systems (Adger, 2006; B. Ahmed *et al.*, 2016; Summers *et al.*, 2018).

Vulnerability as a concept originated from natural hazards studies in the beginning of the 18th century and was used to gauge the magnitude of the negative response of a system to a disaster (Janssen *et al.*, 2006). Vulnerability refers to the capacity to be wounded, i.e., the degree to which a system is likely to experience harm due to physical, social, and economic exposure to a hazard (Sharifi, 2016). It has been used as an interlinked concept, defined as a function that includes resilience, adaptability, susceptibility, marginality, fragility, and risk (Füssel, 2007). Vulnerability is also the combined representation of several factors such as exposure, susceptibility, and adaptive capacity. It is a function of the character, intensity, magnitude, frequency of casualties to which the system or community, or individual, is exposed, and is related to various other factors (Barbier, 2015; Rahman and Rahman, 2015).

Like vulnerability, resilience is also perceived in different ways within a system or for an individual. Both are considered as central points from which to govern and develop a framework to reduce and manage natural disaster risk. Resilience originates from ecological research fields used to demonstrate the capability of an ecosystem to absorb a hazardous event (Connor and Zhang, 2014). In disaster studies, resilience is defined as the ability to absorb, resist or accommodate adverse unpredictable shocks and stresses without significantly changing the basic structures of the exposed system or individual (Janssen *et al.*, 2006; Sharifi, 2016).

The application of the concept of resilience may depend on several factors: (1) types of activities; (2) for whom these may be implemented; (3) agents of decision-making and (4) the cultural context within which implementation occurs (Cote and Nightingale, 2012). How activities and institutions determine the political economy of climate change resilience is also important; this allows us to understand who will be benefited by resilience activities, power relations in implementing activities, and varying access to resources and concurrent inequality in society (Beymer-Farris *et al.*, 2012). Climate resilience should consider varying levels of climate impact, and the capacity of different social groups to respond to climate change. These factors of impact and response to climate change may include "levels of on-the-ground social inequality, rights and unequal access to resources, poverty, poor infrastructure, lack of representation and inadequate systems of social protection, planning and risk management" (Tanner *et al.*, 2015, p. 23).

Bangladesh is a multi-hazard prone country in the world due to its geographical location and the seventh most vulnerable country to climate related extreme weather events in the world (Eckstein *et al.*, 2019). Floods, cyclones, tidal surges, landslides, tornadoes, riverbank erosion, droughts, and earthquakes are very common hazards (Alam and Collins, 2010). Atmospheric disasters (e.g., tropical storms) and hydrologic disasters (e.g., flooding, drought, storm surges, salinization, sedimentation, and erosion) are a common annual phenomenon in this country. Also, 97.1% of its landmass and 97.7% of its population are susceptible to disasters (WB, 2015). Due to its geographical setting, low income, and dense population, the effects of natural calamities are more severe and makes it highly vulnerable and at risk (Alam and Collins, 2010; Brammer, 2014; Paul and Routray, 2010).

The physical and meteorological characteristics of the Bay of Bengal make it an ideal ground to form an average 16 tropical cyclones each year, which is 6-10% of global cyclone formations (Paul, 2009). Bangladesh is also highly vulnerable because of its 711 km long coastline with Bay of Bengal, and thereby expected to suffer a severe cyclone every three years (Hossain *et al.*, 2019; Tasnim *et al.*, 2015). Approximately 40% of global cyclonic storm surges occurred in Bangladesh in the past 60 years, mainly affecting the coastal zones (Haque *et al.*, 2012; Murty, 1984). According to Penning-Rowsell *et al.* (2013), there were 15 major cyclonic hazards that have struck the coastal zone of Bangladesh since 1960, of which nine struck the southeastern coast, four happened in the southwest, and two hit the central and eastern coasts. In the last 200 years, about 70 major cyclones struck Bangladesh, and 900,000 people died from these in the last 35 years. During the last 20 years, there was approximately USD 1.69 billion worth of losses due to climate induced disasters, amounting to 0.41 percent of national GDP (Eckstein *et al.*, 2019). Specifically, the estimated loss from the cyclone in 1970 was USD 63 million, cyclone Gorky in 1991 cost USD 2 billion, and the total losses due to Sidr in 2007 was USD 1.7 billion. In addition, excessive rainfall during the monsoon season led to the inundation of 20-25% of the landmass, and this ranged from 40-70% in extreme cases such as the flood in 1954, 1955, 1974, 1987, 1988, 1998, 2002, 2004, and 2007. Each of these flood events killed hundreds of people and caused untold damages to crops and property (Penning-Rowsell *et al.*, 2013).

The devastation that natural hazards cause depend on their characteristics i.e., hazard type, frequency, magnitude, etc., and the distribution of consequences varies by individual and community characteristics, i.e., proportion of women, elderly, infant, poor people, income, house type, etc., and national level characteristics, i.e., physical, social, economic response, and communication infrastructures (Hossain *et al.*, 2019; Islam *et al.*, 2016). Hazard resilient development has become a priority for long-term sustainability in built and natural ecosystems. In the context of Bangladesh, we can identify many factors affecting community resilience. These include networking relationships, social capital, and recovery mechanism (LaLone, 2012), as well as support from different organizations, planning, regulation, training, and governance (Burby *et al.*, 2000; Dasgupta *et al.*, 2014; Islam *et al.*, 2017; Manyena *et al.*, 2011). Moreover, some gaps continue to be found in the implementation of these frameworks for community resilience due to insufficient consideration of power, political interests, and a lack of systematic interactions among resources, actions, and learnings (Ashley and Carney, 1999). These gaps need to be addressed while exploring their interactions (Cote and Nightingale, 2012).

The coastal area of Bangladesh is different from the rest of the country not only because of its unique geo-physical characteristics, but also because of sociopolitical circumstances that often limit people's access to endowed resources, perpetuating their risk and vulnerabilities. Coastal hazards such as tropical cyclones and coastal erosion are regarded as the greatest threats to human life and security in many countries. Bangladesh is a predominantly agricultural economy, with an increasing population, while being one of the most prone to natural disasters (WB, 2015). The coastal zones of Bangladesh are naturally dynamic making them particularly vulnerable to hazards mentioned earlier. There are 19 coastal districts, covering 47,201 km^2 (32%) of the total landmass, and accommodating 36.8 million (28%) of the total population, of which 52% are poor, and have many infants, children, elderly, and females, who are comparatively more vulnerable than others (Islam, 2004; Islam, 2008; (Parvin *et al.*, 2008). Storm surges during cyclonic events and river erosion are the two major calamities causing the primary vulnerability in Bhola district.

Our study focuses on Bhola, a southern coastal district of Bangladesh. Bhola is particularly vulnerable to natural hazards (Fritz *et al.*, 2009). Historically, there have been many devastating cyclones in Bhola that caused severe casualties and loss of property. For example, in 1970, about 167,000 people died due to a cyclone and most of the casualties were in Tazumuddin upazila (Islam *et al.*, 2015). Most people in Bhola earn their livelihood by farming and fishing, and they live in the vulnerable areas. When natural disasters occur, they are the first to suffer (Hossain, 2018). Homesteads and agricultural crops are damaged, and fisheries are washed away. Development activities and infrastructure are also hampered and damaged. This is how the economic growth rate is adversely affected due to such disasters. Besides, the social situation of people living in the area is already difficult. Many of them are forced to live illegally on embankments and other vulnerable areas and do not have their own land to cultivate (Hossain *et al.*, 2008). Various initiatives have been taken to address these vulnerabilities and build community capacity to recover from disasters, and promote resilience (van der Vegt *et al.*, 2015). For example, attention has been given to the likelihood of vulnerability or risk, social structures, adaptation strategy, as well as the characteristics of natural and built environment. Including these factors in enhancing the resilience capacity of local community has been important for policy makers (Ahmed *et al.*, 2016; Islam *et al.*, 2017; Summers *et al.*, 2018; Uddin *et al.*, 2020).

In view of the above background, our study was conducted to identify the major environmental impacts of natural hazards in Bhola district, and to assess the climate resilient socio-economic growth and development there. The main questions to which we seek answers are (a) *What are the major natural hazards in Bhola district?* and (b) *Are the socio-economic and environmental development in Bhola hazard resilient?*

Methodology

Study Area

Bhola is a southern coastal district of Bangladesh situated between $21^0\ 51'38''$ to $22^0\ 51'40''$ N latitudes and $90^0\ 32'07''$ to $90^0\ 55'44''$ E longitudes, comprising an area of 3,737.21 km^2. It is 90 km long and 20 km wide. This island district consists of 67 unions under 7 upazilas, which are Tazumuddin, Burhanuddin, Bhola Sadar, Manpura, Charfasson, Lalmohan, and Daulatkhan (Islam *et al.*, 2015). Figure 1 shows that this island is in the delta of the Meghna River, while the Tetulia River flows on the western side, and the Shahbazpur channel flows from the eastern side.

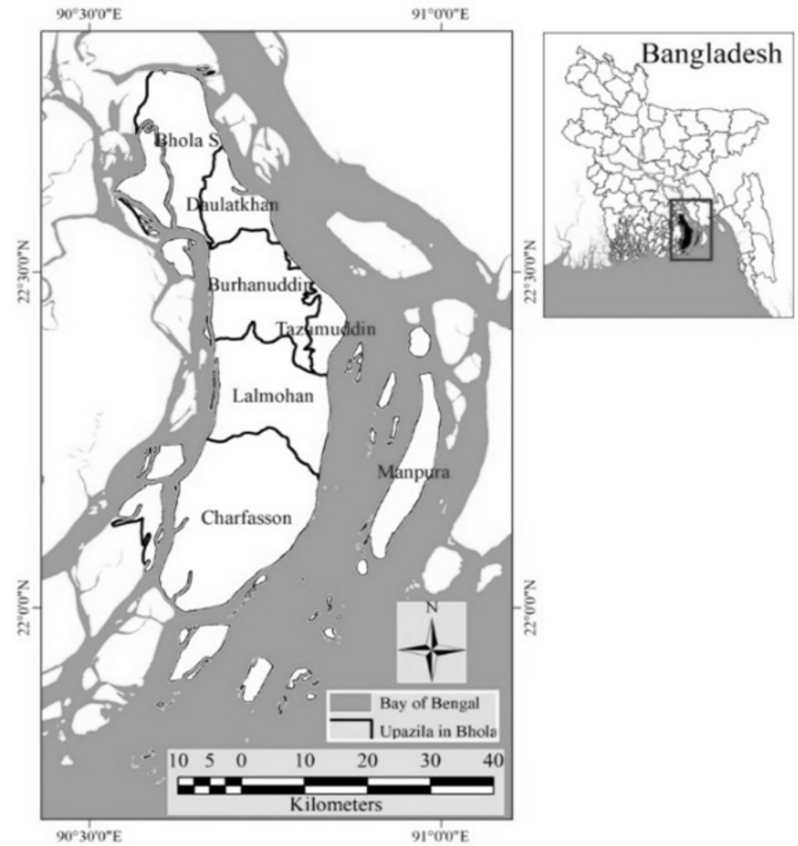

Figure 1: Upazilas of Bhola district

Study Design and Data Collection Methods

Our study used both primary and secondary data to analyze the socio-economic and environmental conditions of different upazilas of Bhola district. The study has two parts: firstly, analysis of historical hazard events along with their damages and casualties for vulnerability assessment, and secondly, understanding peoples' perception regarding resilient capacity.

Assessment of Vulnerability

The historical data on hazards casualties in Bhola during 1941-2019 have been used for the analysis of exposure in this area. Information regarding historical hazards that have occurred in this district was collected from EM-DAT (2015), Khan (1995), BMD (2015), DMIC (2015), IFRC (2015), pertinent books, journals, reports, articles, newspapers and available websites. In addition, data from Bangladesh Water Development Board (BWDB) of Bhola District Information office, reports on disasters, NGO publications were also used as data sources. The amalgamated data were classified into hazard types, number of strikes, magnitudes, frequencies, damages, and casualties. After this a normalization was used in Equation 1 to adjust the values of indicators of different upazilas into a common scale (UNDP, 2015). Then the exposures of an upazila to natural hazards were calculated by normalizing the total values in Equation 2.

$$U_x = \frac{X_v - X_{min}}{X_{max} - X_{min}} \text{ (If maximum value represents highest sensitivity)} \ldots\ldots\ldots\ldots (1)$$

$$U_x = \frac{X_{max} - X_v}{X_{max} - X_{min}} \text{ (If minimum value represents highest sensitivity)}$$

Where, U_x represents the normalized value of an indicator X for a spatial location U. X_v is the value of an indicator (V) for a specific location in relation to maximum *(X_{max})* and **(***X_{min}***)** values of all spatial locations for that indicator respectively. The exposure is calculated for each spatial location i.e., upazila for measuring vulnerability based on Equation 2.

$$Exposure_U = \sum NS_U + HM_U + HF_U + L_U + D_U \quad (2)$$

Where, U is the exposed upazila that is considered for analyzing exposures to natural hazards based on the number of total hazards occurring during 1941-2019 (NS_U); HM_U is the magnitude of the hazard; loss of property and infrastructures such as houses, and roads are indicated by HF_U; livestock is L_U and the number of people who died is D_U.

Subsequently, there were nine exposures, eight sensitivity, and seven adaptive capacity indicators selected from similar studies to analyze vulnerability to natural hazards, shown in Table 1. The values of indicators were collected from relevant sources and normalized in Equation 1, and vulnerability of upazilas in Bhola district was calculated using IPCC guideline (IPCC, 2014) shown in Equation 3.

Table 1: Selection of determinants

Determinants	Indicators
Sensitivity	- Proportion of people living in mud houses (%) - Proportion of people living in *jhupris* (%) - Population density (person/km^2) - Proportion of people living below the poverty line (%) - Proportion of disabled people (%) - Proportion of people working in agriculture (%) - Proportion of floating people (%) - Proportion of females (%)
Adaptive Capacity	- Literacy rate (%) - Per capita cyclone shelter - Proportion of people using hygienic sanitation (%) - Proportion of people using safe drinking water (%) - Proportion of people living in concrete houses (%) - Proportion of people above the poverty line (%) - Proportion of people employed (%)

$$V_U = \sum S_U - \sum AC_U \quad (3)$$

Where, V_U is the vulnerability of an upazila generated by subtracting the total normalized value of adaptive capacity (AC_U) from the total normalized sensitivity (S_U) value of upazila U.

Analysis of Resilience Capacity

Bhola consists of seven upazilas named above. After analyzing the vulnerability to natural hazards in these seven upazilas, a perception study was conducted to understand the community's knowledge of resilience, and how these are connected to considerations of social, economic, and infrastructural development activities. There were nine respondents from each upazila, i.e., a total 63 persons were interviewed. The sampled interviewees included students, teachers, private job holders, NGO workers, developmental engineers, doctors, government officials, journalists, and politicians.

Our study used GOAlies (GOAL) guidance manual for determining the levels of individual and community resilience developed by the International Humanitarian Agency (IHA, 2015). There are 15 consultation questions used from this manual under five thematic areas, namely governance, risk assessment, knowledge and education, risk management and vulnerability reduction, and disaster preparedness and response. These thematic areas are chosen based on physical characteristics of hazards, geomorphological chararcteristcs of the location, as well as socio-economic and infrastructural conditions of Bhola, as shown in Table 2. McCaul and Mitsidou (2016) used this guidance toolkit for analyzing the community resilience in Honduras.

Table 2: Thematic and focused area

	Thematic Areas	Questionnaire Features
Governance	Rights awareness and advocacy	Is the community aware of its rights and the legal obligations of government and other stakeholders that provide protection?
	Integration with development planning	Is Disaster Risk Reduction (DRR) seen by the community as an integral part of plans and actions to achieve wider community goals (e.g., poverty alleviation, quality of life)?
	Access to funding and partnerships	Are there clear, agreed, and stable DRR partnerships between the community and other actors (local authorities, NGOs, businesses, etc.)?
	Inclusion of vulnerable groups	Are vulnerable groups present in the community included/represented in community decision making and management of DRR?
	Women's participation	Do women participate in community decision making and management of DRR?
Risk Assessment	Local and scientific methods for risk awareness	Does the community use local knowledge and perceptions of risk as well as other scientific knowledge, data, and assessment methods?
Knowledge and Education	Dissemination of DRR knowledge	Are DRR knowledge and capacities being passed on to children formally through local schools and informally via oral tradition from one generation to the next?
	Knowledge and Education: Cultural attitudes and values	Do the community's cultural attitudes and values (e.g., expectations of help/self-sufficiency, religious/ideological views) enable it to adapt to and recover from shocks and stresses?
Risk Management and Vulnerability Reduction	Sustainable environmental management	Does the community adopt sustainable environmental management practices that reduce disaster risk and adapt to new risks related to climate change?
	Food and water supplies	Does the community have a secure supply of food and water and manage an equitable distribution system during disasters?
	Social protection	Does the community have access to social protection schemes to support risk reduction directly, through targeted DRR activities, and/or indirectly, through socioeconomic development activities that reduce vulnerability?
	Income and asset protection	Are household and community asset bases (income, savings and convertible property) sufficiently large and diverse to support disaster coping strategies, and are there measures to protect them against disasters?
	Infrastructure and basic services	Are the community's building infrastructure and basic services resilient to disasters (including being located in safe areas, using hazard-resistant construction methods and structural mitigation measures)?
	Land use and planning	Does the community's decision-making regarding land use and management take hazard risks and vulnerabilities into account?
Preparedness and Response	Emergency infrastructure	Are emergency shelters (purposely built or modified) accessible to community and with adequate facilities for all affected population?

The responses were recorded in Likert Scale from "no awareness (score 20)", "some awareness but takes no action (score 40)", "some awareness with improved capacity to act (score 60)", "good awareness occasionally (score 80)", and "good awareness with culture of safety (score 100)". The responses from low (20) to high (100) represents their hazard resilient knowledge and practices in the developmental activities.

These responses (scores) were transferred into a data worksheet for perception analysis. The responses of each group were then analyzed to scrutinize the level of knowledge and practices of selected groups. In addition, these responses were analyzed for each thematic area by using the relative importance index formula in Equation 4.

$$Relative\ Resilience\ Score_U = \frac{\sum(N_r \times C_v)}{N_q \times N} \quad \ldots\ldots\ldots\ldots (4)$$

Where, N_r is the frequency of responses to scale criteria i.e., no awareness to occasional good awareness, C_v is the value of the response specific criteria i.e., 20 to 100, N_q is the number of questions under those thematic areas, and N is the total number of respondents of this thematic area (i.e., 63). Table 3 presents the analyzed scores that were converted into five different categories (0-100) and interpreted based on the IHA (2015) guidance manual.

Table 3: Interpretation of responses on resilience (IHA, 2015)

Level (Score)	1 (0-20)	2 (21-40)	3 (41-60)	4 (61-80)	5 (81-100)
Category	Minimum Resilience	Low Resilience	Medium Resilience	Resilient	High Resilience
Response pattern in the questionnaire	No awareness	Some awareness but takes no action	Some awareness with improved capacity to act	Good awareness occasionally	Good awareness with culture of safety

Results and Discussion

By analyzing the historical hazards since 1941 to 2019 as well as the questionnaire survey, our study found that cyclones are the main natural hazard in Bhola district. They strike in 1–2-year intervals, with varying severity that results in very mild to severe destruction. Floods are found to be the second common natural hazard, recurring every 3-4 years and causing mild to moderate damage. However, not all upazilas of this district suffer from this hazard at the same time. Another hazard, riverbank erosion, found to occur every year in the upazilas, as elsewhere in the coastal area of the country, often causes severe destruction to land and property.

Exposure to Natural Hazards

A 10-year (2007-2017) analysis of exposure to natural hazards in this district confirms that cyclones are the primary natural hazard, followed by floods, and riverbank erosion. In Figure 2, normalization of casualties shows that most of the unions of Bhola Sadar upazila were affected by natural hazards, and that Manpura scored lower casualties than other upazilas. On the other hand, Tazumuddin upazila was found to be most exposed to casualties, the largest number of households being affected, and the land area, as well agricultural land damaged (0.2), livestock killed (1.0), and maximum roads and bridges impaired (1.0). Manpura, Charfasson, Burhanuddin (0.5), Lalmohan (0.0) and Daulatkhan (0.0) upazilas experienced the minimum casualties. Further, the natural hazards causing the largest number of displaced people was in Charfasson, and Figure 2 shows no one was found to have migrated from Daulatkhan upazila.

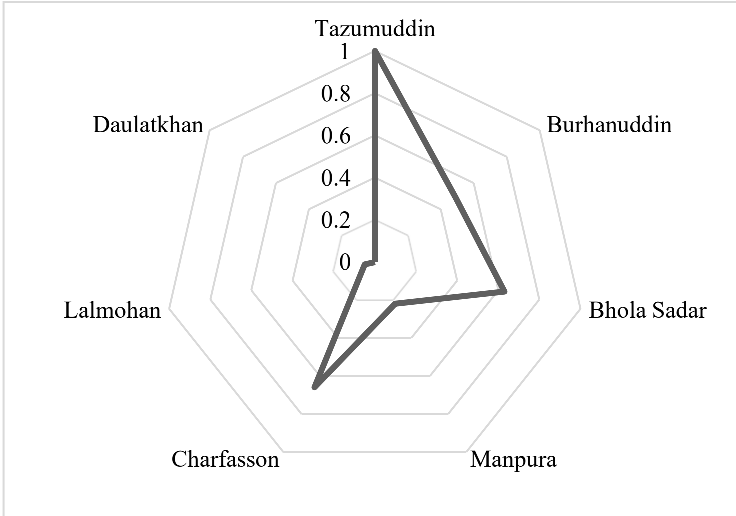

Figure 2: Exposure Score to Natural Hazards in Bhola District

Sensitivity

In terms of sensitivity, Table 4 presents the normalized value of sensitivity to show that among the seven upazilas of Bhola, Manpura has been more sensitive than other upazilas, while Charfasson has been less so.

Table 4: Normalized sensitivity scores to natural hazards at different upazilas

Sensitivity Indicators	Bhola Sadar	Burhanuddin	Char-fasson	Daulatkhan	Lalmohan	Manpura	Tazumuddin
Proportion of people living in mud houses	0.36	0.71	0.52	0.60	0.86	0.00	1.00
Proportion of people living in *jhupris*	0.00	0.04	0.24	0.09	0.03	1.00	0.14
Population density (km^2)	1.00	0.74	0.25	0.39	0.61	0.00	0.05
Proportion of people below the poverty line	0.00	0.15	1.00	0.48	0.00	0.67	0.58
Proportion of disabled people	0.43	0.57	0.71	0.71	0.14	1.00	0.00
Proportion of people dependent on agricultural profession	1.00	0.08	0.22	0.04	0.07	0.00	0.02
Proportion of floating people	1.00	0.04	0.17	0.09	0.21	0.00	0.00
Proportion of females	0.00	0.99	0.97	0.99	1.00	0.95	0.93
Proportion of aged people (>65 years)	0.91	0.45	1.00	0.76	0.67	0.91	0.00
Total normalized score	4.70	3.78	5.08	4.14	3.58	4.53	2.73
Normalization score based on total	0.84	0.45	1.00	0.60	0.36	0.77	0.00
Sensitivity rank	2	5	1	4	6	3	7

Adaptive Capacity

In terms of normalized adaptive capacity values, Table 5 shows that Manpura scored the lowest on this measure, while Lalmohan and Tazumuddin have been more adaptive.

Table 5: Normalized adaptive capacity scores to natural hazards at different upazilas

Adaptive capacity indicators	Bhola Sadar	Burhanuddin	Char-fasson	Daulatkhan	Lalmohan	Manpura	Tazumuddin
Proportion of literate people	0.32	0.39	0.32	0.00	1.00	0.13	0.21
Number of cyclone shelters	0.32	0.89	1.00	0.11	0.68	0.30	0.00
Proportion of people using hygienic sanitation	0.84	0.82	0.51	0.79	0.98	0.00	1.00
Proportion of people using safe drinking water	0.82	0.93	0.00	0.96	1.00	0.62	0.76
Proportion of people living in buildings (pukka houses)	1.00	0.55	0.35	0.60	0.35	0.00	0.25
Proportion of people above the poverty line	0.00	0.17	0.35	0.60	0.24	0.28	1.00
Proportion of people employed	0.93	0.38	1.00	0.20	0.57	0.00	0.12
Total normalized score	4.23	4.14	3.52	3.25	4.82	1.34	3.34
Normalization score based on total	0.8	0.8	0.6	0.5	1.0	0.0	0.6
Adaptive capacity rank	2	2	3	4	1	5	3

Vulnerability

From Figure 3, we can see that the vulnerability indicator shows that Manpura is the most vulnerable upazila, while Burhanuddin is the least vulnerable.

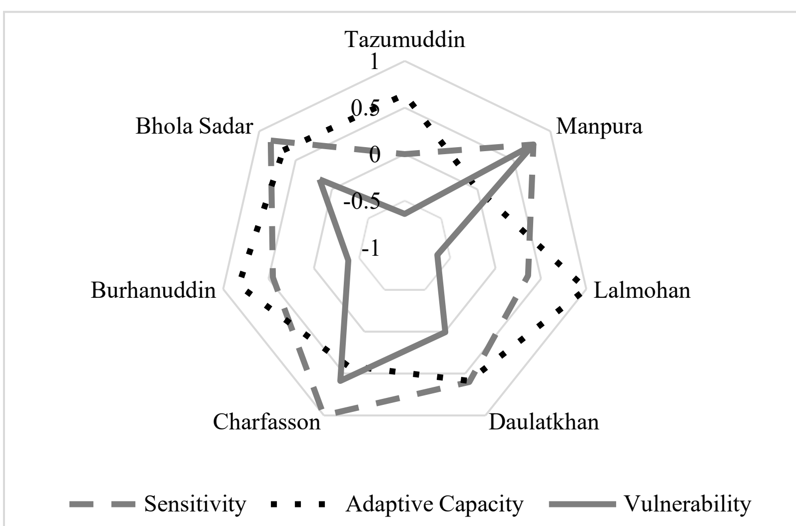

Figure 3: Vulnerability to natural hazards

Table 6: Vulnerability to natural hazards at different upazilas

Upazila	Sensitivity	Adaptive Capacity	Vulnerability	Rank
Manpura	0.77	0.00	0.77	1
Charfasson	1.00	0.41	0.59	2
Bhola Sadar	0.84	0.67	0.17	3
Daulatkhan	0.60	0.59	0.01	4
Burhanuddin	0.45	0.83	-0.38	5
Lalmohan	0.36	1.00	-0.64	6
Tazumuddin	0.00	0.64	-0.64	6

Table 6 shows that Manpura is ranked as the most vulnerable, while Lalmohan and Tazumuddin are ranked lowest in vulnerability. The degree of vulnerability is found to be determined by the adaptive capacity of each location. Even though Manpura has comparatively lower sensitive score than Charfasson, the lower adaptive capacity ranked it to be most vulnerable.

Addressing Hazard Resilient Socio-Economic and Environmental Development

For assessing the perceptions on the above issues, the sampled populations were selected to be interviewed using a semi-structured schedule at pre-appointed times. The interview questions were mostly open ended. Responses are presented in Figures six and seven.

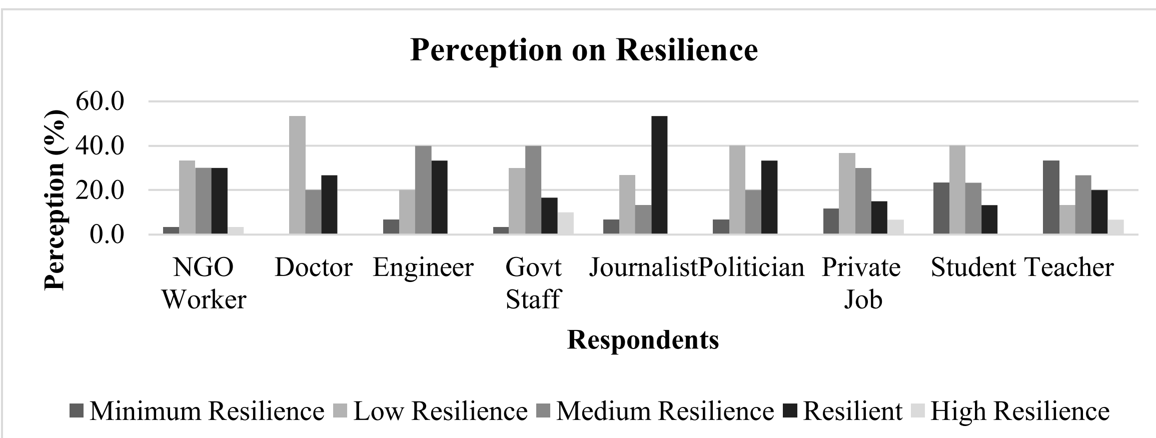

Figure 4: Perception of different groups of people regarding the resilience of Bhola

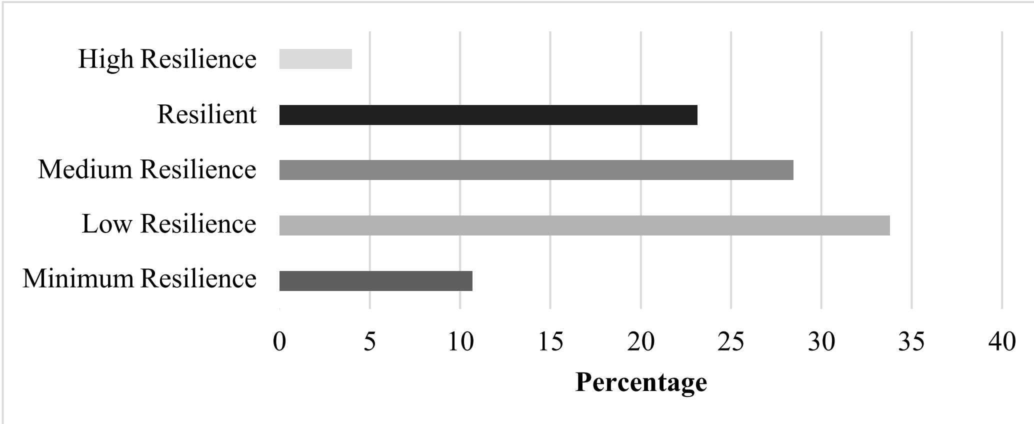

Figure 5: Overall knowledge and practices of resilience in Bhola

According to the above overall resilience score based on people's perception, it is found that most consider climate resilience regarding natural hazards to be low in Bhola, and very few people think it is high. A significant number of people also find it to be medium.

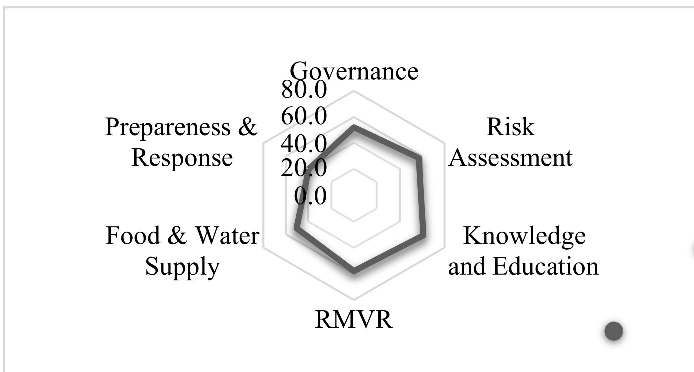

Figure 6: Resilience based on thematic areas of Bhola

There were six thematic areas on which the analysis of climate resilience in consideration of natural hazards in Bhola was conducted. Figure 8 shows that some of these values are resilient. From these scores, Table 7 shows that "knowledge and education" is resilient, and "preparedness and response" is low in resilience among the thematic areas.

Table 7: Resilience of different areas of Bhola district

Thematic Areas	Score	Category
Governance	52.0	Medium Resilience
Risk Assessment	57.3	Medium Resilience
Knowledge and Education	61.3	Resilient
Risk Management and Vulnerability Reduction	58.0	Medium Resilience
Food and Water Supply	50.7	Medium Resilience
Preparedness and Response	40.0	Low Resilience

An effective resilience framework comprises a complex but well-developed network of institutions where the government agencies, local governments, private sector, and NGOs participate to pursue a common and comprehensive goal. While this integrated network system has considerably reduced natural disasters induced casualties in Bangladesh over the years, the economic losses could not be contained in recent disasters. Table 7 seeks to explain the resilience categories of six sectors such as governance, risk assessment, knowledge and education, risk management and vulnerability reduction, food and water supply, preparedness and response which are involved in managing disasters.

This study finds that high resilience capacity exists in knowledge and education (score 61) and low resilience capacity exists in preparedness and response (score 40). In addition, Figures 6 and 7 show that most of the general people perceived their minimum and low resilience considerations regarding development activities. Therefore, a continued willingness and ability to learn and acquire knowledge and skills is important for community resilience in Bhola, particularly for dealing with future continuous adaptation and hazard resilient development. This is consistent with the literature (e.g., Adger, 2000). Hence, enhancing the resilience capability of community people at all sectors of Bhola may enable a positive response by improving practices related to saving lives and property.This has been shown in the case of a community which has transformed to high resilience during the onset and post-eventrecovery from Cyclone Aila, which, despite severely impacting the southwestern coast of Bangladesh, resulted in a relatively low number of fatalities (Panda *et al.*, 2011).

Conclusion

This study has been conducted to assess the knowledge and practices of hazard resilient socio-economic and environmental development in Bhola. It has revealed that cyclones are the common natural hazards in Bhola district, followed by floods and riverbank erosion. These were the most devastating for the socio-economic conditions of local people and were found to occur every 1-2 years. Analyzing the secondary data, it is found that Bhola Sadar was mostly affected by these natural hazards, whereas Manpura was found to be less affected compared to the other upazilas. Meanwhile, Manpura was found to be more vulnerable due to its lack of adaptive capacity, whereas Lalmohan and Tazumuddin had comparatively more adaptive capacity.

In the perception study, considerable differences were found among the understanding and practices of hazard resilient socio-economic developmental activities in Bhola. The overall resilience score shows that consideration of hazard resilient activities was very low, and this was likely portrayed in the perception scores. In addition, it was also found resilience in terms of "knowledge and education" is high whereas "preparedness and response" is low among the thematic areas queried.

This heterogeneity and ambiguity of the data in this study may be overcome through the collection of current data on sensitivity and adaptive capacity indicators, as they will provide a more reliable scenario of vulnerability of different upazilas of Bhola. However, this study may be useful for enhancing the knowledge and practices of hazard resilient development that will also eventually reduce the vulnerability of Bhola and other similar geographical locations.

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