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Living with the Risks of Cyclone Disasters in the South-Western Coastal Region of Bangladesh

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Abstract: Bangladesh is one of the most disaster prone countries in the world. Cyclone disasters that affect millions of people, destroy homesteads and livelihoods, and trigger migration are common in the coastal region of Bangladesh. The aim of this article is to understand how the coastal communities in Bangladesh deal with the continuous threats of cyclones. As a case study, this study investigates communities that were affected by the Cyclone Sidr in 2007 and Cyclone Aila in 2009, covering 1555 households from 45 coastal villages in the southwestern region of Bangladesh. The survey method incorporated household based questionnaire techniques and community based focus group discussions. The pre-event situation highlights that the affected communities were physically vulnerable due to the strategic locations of the cyclone shelters nearer to those with social supreme status and the location of their houses in relatively low-lying lands. The victims were also socio-economically vulnerable considering the high rate of illiteracy, larger family size, no ownership of land, and extreme poverty. They were mostly day labourers, farmers, and fishermen. Post-event situation reveals that the victims' houses and livelihoods were severely damaged or destroyed. Most victims were forced to shift their occupations (e.g., from farmers to fishermen), and many became unemployed. They also became heavily dependent on micro-credits and other forms of loans. A significant number of people were displaced and migrated to large urban agglomerations in search of livelihoods to maintain their families back in the affected villages. Migration was primarily undertaken as an adaptation strategy.

Keywords: cyclone; community vulnerability; migration; disaster; Cyclone Aila; Cyclone Sidr; climate change; Bangladesh

1. Introduction

Disasters are primarily triggered by the combination of natural hazards and the presence of a vulnerable group of people. Globally, it is well established that there is a lack of knowledge, consciousness, relevant government responsibilities, and appropriate resources to tackle the devastations of natural hazards. Despite spending large budgets to prevent, predict, and protect vulnerable communities from socio-natural disasters, a developed country like the United States also responds to hurricanes impacting its coastal regions and cities with staggering helplessness [1].

Accordingly, it is interesting to analyse similar scenarios for developing countries, where some aspects of disaster risk reduction (DRR) are unplanned. It is important to find out how the social and cultural conditions of a country can be adjusted to cope with a disaster and to identify which of these adjustment measures will be socially acceptable. This article is going to focus on these issues based on empirical examples from the cyclone-affected coastal region of Bangladesh.

Bangladesh is ranked as the world's fifth most disaster prone country. Its topographic and geo-physical location has made it vulnerable to various natural hazards, particularly to extreme climate-induced disasters [2]. Flooding, cyclones, tidal waves, and river erosion etc. are the most common climatic hazards that affect millions of people every year in the country with varied scale [3,4]. About 44 million people live in the coastal zone that makes Bangladesh one of the most vulnerable and exposed countries to cyclone disasters in the world. A catastrophic tropical cyclone is likely to hit the coastal region of Bangladesh almost every three years. The tropical cyclones cause casualties and damages and sometimes are responsible for cascading disasters [5,6]. It has been argued that cyclone hazards are natural, but disasters are man-made [7–10]. It is now possible to track the speed and direction of cyclones and warn the coastal communities well in advance, but still thousands of coastal families continue to be adversely affected by cyclones in Bangladesh. The absence of sufficient critical infrastructure and institutional support from the individual to the community level is a major issue, though Bangladesh has improved significantly in the field of disaster preparedness and prevention in recent years [6]. However, there is a dearth of proper implementation of policies, which requires an extensive investigation of how a coastal community in Bangladesh perceives, reacts, and adapts to a cyclone disaster. This study will investigate some research questions such as which actions had the victims taken before, during, and after the cyclone event; what measures they had taken in order to recover from the damage; and what social and economic changes were observed in the region etc. The aim of this article is particularly focused on these questions that exacerbate the understanding of what makes people vulnerable to cyclone disasters, and it will analyse the pre and post event responses and the socio-economic and institutional aspects of the cyclone affected communities. This study considers the approach of an acceptance-based policy formulation and implementation instead of a need-based support and service to combat disasters [11].

This study scrutinizes some highly vulnerable cyclone-affected villages located in the southwest coastal districts of Bangladesh. It focuses on two extreme climatic events, namely Cyclone Sidr in 2007 and Cyclone Aila in 2009, to analyse how the coastal society deals with the increasing livelihood pressure that emerged after cyclone disasters. It focuses on the real-life experiences, perceptions, and reactions of the cyclone victims in the selected villages. This article contributes to an understanding of the social dynamics following cyclone disasters in coastal Bangladesh by addressing the following three research questions:

(a) How did the communities perceive (pre-event) cyclone disasters?
(b) What were the activities (post-event) undertaken by the affected communities to recover from the cyclone disasters?
(c) What changes took place at individual and household level?

It covers the methods adopted by the people in the community to recover from the losses, the types of external assistance and interventions available during the response period, the consequences of those interventions, and the changes on the overall transformations in livelihood pattern and lifestyle at the community level.

2. Literature Review

The tropical cyclone is one of the most common hazardous events in coastal areas [12]. In general, coastal areas are densely populated with an increasing trend toward conflicts due to a scarcity and unequal use of resources [13]. The unpredicted effects of climate change and globalization are causing the spatial separation of specialized business and unrest within the communities. People in coastal

areas utilize a variety of complementary livelihood options. Examples include a community forest in Sri Lanka and fishing and farming in Fiji, Bangladesh, and India. These multiple options have been weakened due to the growing importance of wage employment and competition of resources with absentee commercial interests [14].

Depending on the level of vulnerability and household experience, storms impact assets and livelihoods differently and people react differently [15–21]; for example, Shameem and colleagues argued that the repeated adverse impacts of climatic stressors on livelihood activities of fishermen in Bangladesh shape their perception of climatic risks [20]; Sultana and Mallick created an atlas of locally adopted strategies after the Cyclone Aila in 2009 [19]; Paul and Rashid described the indigenous adjustment processes of cyclone disasters in coastal Bangladesh, particularly mentioning the indigenous housing pattern. They also exemplified the strategies adopted by agriculture and coastal fisheries in the face of climate change [21].

Social relations and structures of domination influence the new array of livelihood options [3,22,23]. Families caught in disasters may have new problems created by the aftermath. Once the emergency period has passed, life must still go on. The household budget changes radically. For a period during relief and recovery, the poorest households may have lost everything and will be dependent largely on social networks amid aid from outside sources (as in Bangladesh following cyclones in 1991, 2007, and 2009; in Andhra Pradesh in 1977; Orissa in 1999; in Myanmar following Cyclone Nargis in 2009; and in the cases of Hurricane Katrina, and the Tsunami in Indonesia in 2004). In case of Bangladesh, cyclone shelters were built [24]. However, poorer social groups found themselves in a weaker position in terms of rebuilding their livelihood systems and their recovery was difficult [25–27]. The factors of disaster management are critically controlled and influenced by the poverty and social conditions of victims [4]. The social power relations are also vital in coastal risk mitigation and disaster preparedness planning in Bangladesh, which was defined as "social supremacy" [3]. Land-assets, monthly income, and investment in residential house construction data of the interviewee households were incorporated to develop the "social supremacy index" (SSI) [3], which shows how a specific social group perceives and reacts to the disaster management activities. This SSI indexing approach is adopted in this analysis.

Vulnerability depends on the interaction of the socio-economic and natural factors of a region [14,28–30]. For example, the increasing trend of salinity intrusion, tropical cyclones, and land-use change severely affect access to livelihood assets at the household and community levels [17,30,31]. Planners, investors, politicians, and people in the community must agree on common ground to implement necessary infrastructural improvements in any locality [32]. Accordingly, this study intends to analyse the household situation of a sample of coastal people during cyclones, with an eye to challenges being faced by the coastal communities. It is evident that people living in the coastal region are susceptible because they live in a dynamic estuarine environment facing numerous natural hazards. These threats affect different aspects of human life and limit the livelihood choices of local people [4,33]. Moreover, climate change scenarios forecast an increasing frequency and intensity of cyclones [34–36]. It calls for the examination of socially, culturally, politically, and economically acceptable preventative measures.

3. Methodology

This research is dependent on empirically gathered data and based on a stratified random sampling surveying method. This research reflects the diversity of the socio-economic conditions of the entire coastal region. During the fieldwork, a total of 1555 households were randomly selected for standardized questionnaire surveying. In addition, this research included community based qualitative tools like case-study interviews and focus group discussions for extracting relevant information from the cyclone-affected villages. The methodological process is illustrated in Figure 1. Statistical analyses were performed using the SPSS software (IBM Corporation, Armonk, NY, USA).

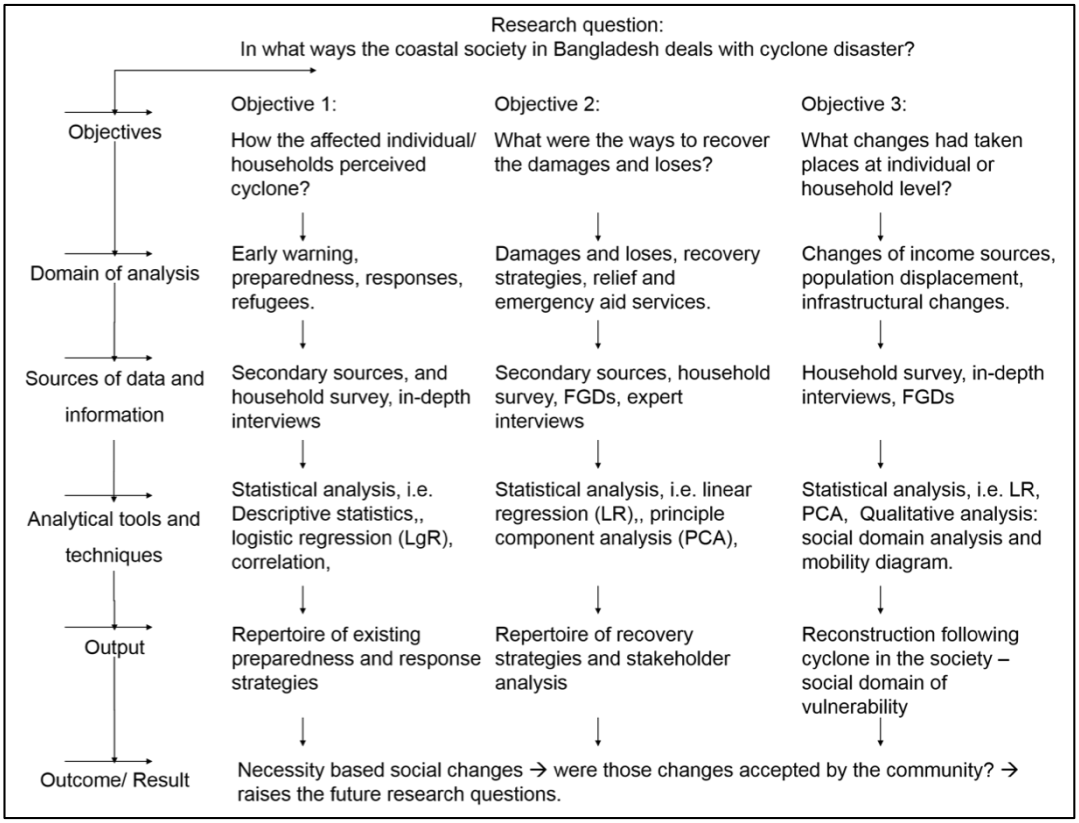

Figure 1. Methodological flowchart of the study.

3.1. Study Area

The southwest coastal region of Bangladesh is a hub of diversified and creeping problems, for example cyclones [3,34], social transformations and migration [33,37], salinity [31], the cascading effect of climate change impacts [23], upstream water withdrawal [38], shrimp farming, and land use change [39] and coastal polders [5]. This research focuses specifically on the region hit by Cyclone Sidr and Cyclone Aila, covering the districts of Khulna, Bagerhat, and Satkhira (Figure 2). These three districts were inundated and heavily damaged by both cyclones. The coastal zone covers 19 out of 64 districts in Bangladesh (Figure 2). It is located in close proximity to the Bay of Bengal. The zone constitutes 32% unoccupied land and 28% population (i.e., projected about 44 million in 2016) of Bangladesh. This coastal zone forms the lowest landmass (in cases 0–30 cm MSL), part of a delta of the extended Himalayan drainage ecosystem, and is exceedingly prone to multiple threats like cyclones, storm surges, floods, tsunamis, and climate change [6,40].

3.1.1. Devastation of Cyclone Sidr

On 15 November 2007, Cyclone Sidr (Figure 3) struck the southwest coast of Bangladesh with winds up to 240 km per hour, accompanied by tidal waves up to five meters high and surges up to 6 m in some areas. The cyclone caused 3363 deaths, 1001 still missing, 55,282 injured people, 1.5 million damaged or destroyed homes, and 2.5 million acres of damaged farmland that affected about 8.9 million people. The total damage and losses caused by Cyclone Sidr was calculated to be US$ 1.7 billion [6,41].

3.1.2. Devastation of Cyclone Aila

Cyclone Aila hit 14 districts of southwest coastal Bangladesh on 25 May 2009 with wind speeds of up to 90 km per hour. The cyclone killed 236 people, injured more than 7000, damaged or destroyed

more than 500,000 houses, damaged 6000 km of roads, caused more than 17,000 km of embankments to collapse, completely destroyed 275 primary schools, damaged 1942 schools, and affected a total of about 4.8 million people [6,42].

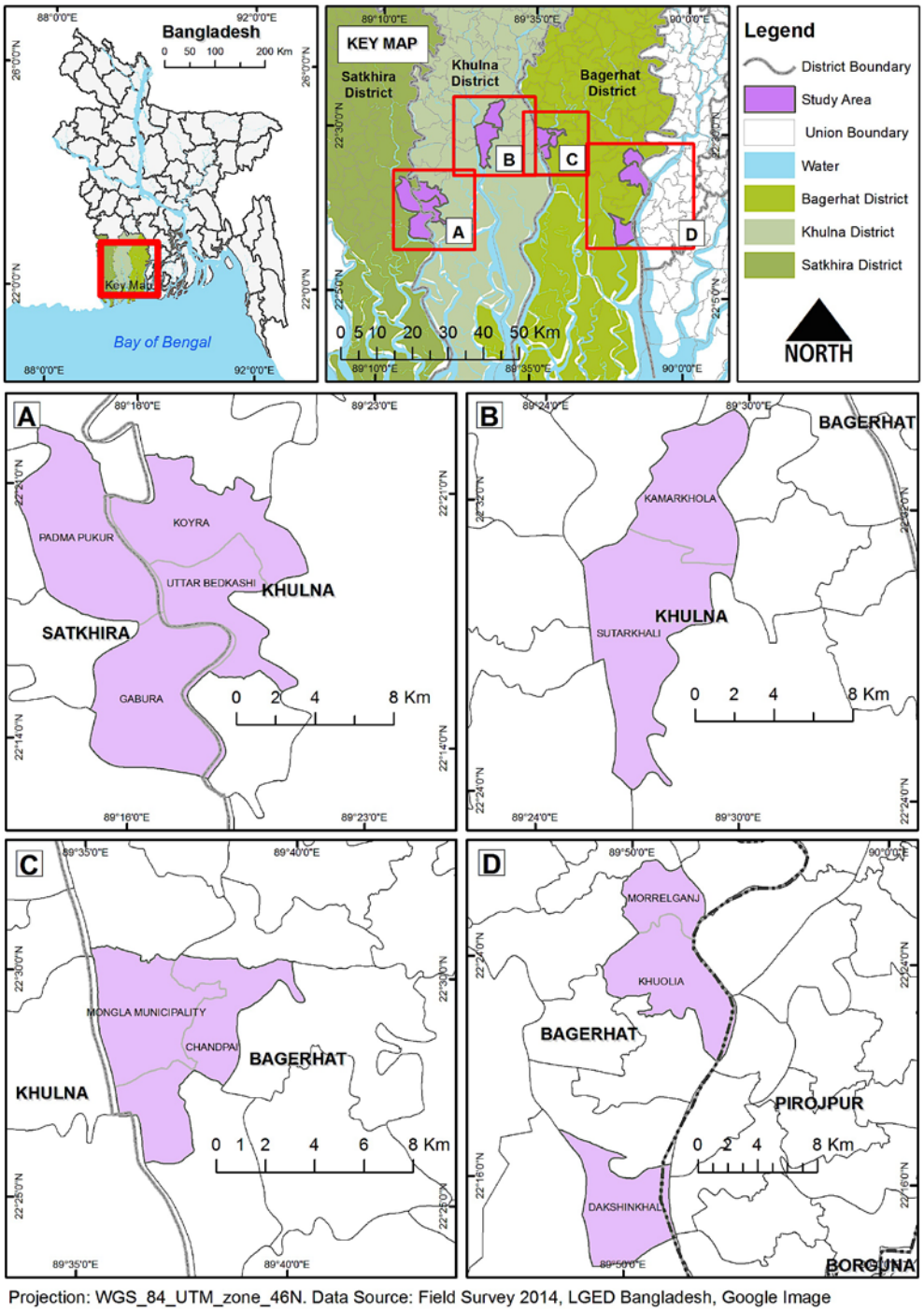

Figure 2. Study area, the southwest coastal region of Bangladesh. (**A**) Padmapukr, Gabura, Koyra and Uttar Bedkashi Union; (**B**) Kamarkhola and Sutarkhali Union; (**C**) Mongla Municipality and Chandpai Union; (**D**) Morelgonj Municipality, Khaulia and Sharankhola Union.

Figure 3. An aerial view of the damage to villages and infrastructure following Cyclone Sidr on the southern coast of Bangladesh. Source: The US Marine Corps, 24 November 2007 [43].

3.2. Data Collection

3.2.1. Household Based Questionnaire Surveying

Data on the damages and losses due to Cyclone Sidr in 2007 and Cyclone Aila in 2009 shows that the districts of Khulna, Satkhira, and Bagerhat were severely affected; therefore, these three districts were selected as the study area. Based on the level of destruction and damages due to Cyclone Sidr, the sub-districts, Mongla, Morelgonj, Sharankhola, Dacope, Koyra, and Shyamanagor, were selected. After this spatial scaling, the severely affected unions (which are the smallest electoral unit in Bangladesh) and villages were identified (Figure 2A–D). A total of 45 villages in 11 unions were selected for this empirical study. Statistical scaling was then applied to determine the total sample of the respective union. The sample size was calculated with the total number of households. Population data was collected from respective upazila (that is the sub-district) statistics offices. The concept of Sachs and Hedderich (2006) was used to determine the sample size [44]. This method of sample size determination was chosen because it permits up to 10% error probability (Equation (1)). A representative sample size for each union was then calculated based on the total number of households of the respective union.

$$n = \frac{N}{1 + a^2 \times N} \tag{1}$$

here, "n" is the number of samples, "N" is the number of households, and "a" is the error probability. Taking into account the probability of error of one percent of the sample sizes, 1555 households were calculated. This represents 3.05 confidence intervals at a 99% confidence level on the basis of 25,782 total households in the selected 45 sample villages. A proportional allocation method (Equation (2)) was applied for the village-wise sample size determination.

$$n_1 = n \times \frac{N_1}{N} \tag{2}$$

where, n_1 = selected sample number for one village, n = total sample size, N_1 = number of households of a respected village, and N = total number of households. For example, in Ward-2 of Mongla municipality, the sample size was = $\{(147 \times 1610)/3320\} = 71.28 \approx 71$; and in Ward-7, the sample size was = $\{(147 \times 1710)/3320\} = 75.71 \approx 76$. Similarly, the sample size for other villages was counted.

Rural settlements in Bangladesh are mostly clustered and oriented following an access road [45]. Hence, the households located along the roadside were primarily selected for surveying. If there was no respondent for a selected house, the next available respondent's house was selected. The questionnaire consisted of one general section and three specific sections. Section one put together the adaptive measures and strategies undertaken by the respondents; section two collected their opinion on disaster

risk management operations and future plans; section three dealt with specific socio-demographic conditions before and after the cyclone; and the general section collected information on the demographic characteristics of the respondents. The questions related to the cyclone were aimed at examining the extent and nature of the cyclone's impacts on life and livelihood, including the aftermath of inundation. The questionnaire was translated into the local language (i.e., Bengali), and the medium of communication between the interviewers and interviewees was in Bangla. Each interview lasted around 30 min. The standard national level ethical regulations were followed and consent from the people in the community was gathered before conducting the interviews.

In total, two rounds of pre-testing were performed to finalize the household questionnaire, including two days of discussion sessions with the local experts and stakeholders from the Coastal Research Foundation of Khulna District, Bangladesh.

3.2.2. Focus Group Discussion

To accumulate in-depth community information, a total of 20 focus group discussions (FGD) were carried out. On an average, each FGD session lasted around three hours. The rules followed during the FGD sessions were as follows: (a) the participant size was kept reasonable, i.e., minimum 6 to maximum 12 local people; (b) there was a homogeneity maintained in profession and gender among participants (i.e., if the session was conducted with male farmers, then all of them were chosen with similar characteristics and similar age groups); (c) one protocol writer, one moderator, and one organizer were present during the sessions; (d) the sessions were recorded using audio devices with prior permission from the participants to prepare transcriptions; and (e) the collected information and diagrams (i.e., mobility maps) were reproduced by the interviewers and shared with the participants. Under FGD, "mobility mapping" was conducted to depict where the victims took shelter during the cyclone. The participants were asked to relate the information with respect to their movement, such as decision-making roles and access to resources and empowerment. Mobility maps were prepared to help the community members to identify the movement patterns and to document that information for baseline survey purposes.

3.2.3. In-Depth Interviews/Case Study

The in-depth interviews covered the impact of the cyclones on different occupational groups, coping mechanisms during and after the cyclones, and information regarding household activities during normal and extreme-events timeframes. The respondents were also asked about the effectiveness of relief and rehabilitation programs organized by different government and non-governmental organizations (NGOs). Efforts were taken to understand how the programs were being implemented and accepted by the local population, and possible improvements that could be made. The respondents were also asked about their migrated family members. A snowball sampling method was applied to find other migrants. Several group discussion sessions portrayed the migrants' livelihood changes and their network and social structure in new settlements. On average, each interview lasted around two hours and a total of 21 case studies were conducted.

3.2.4. Geographic Survey

To depict the contour level of the coastal region, digital elevation model (DEM) imaging was collected from the Survey of Bangladesh. Global positioning system (GPS) technology was used to identify the real-world position of the respondents' houses. The relevant shapefiles for mapping purposes were collected from the Local Government Engineering Department (LGED), Bangladesh.

3.2.5. Construction of Social Supremacy Index (SSI)

Mallick and Vogt [3] have developed and employed the concept of the "Social Supremacy Index" (SSI) to describe the societal structure of rural Bangladesh. This index incorporates three aspects: first, income is a generally accepted indicator of an individual's material wealth and accordingly their

capacity to react to disruptions. Second, the residential building is a key attribute of social prestige. The dwelling's quality is a sign of social supremacy as well as social status. Accordingly, those who have or strive for a supreme social status invest capital in house construction. Third, the extent of land ownership by the individual is also an indicator of power in the rural society of Bangladesh.

These selected three indicators are then weighted according to the index value as is presented within the bracket in Table 1. Then each surveyed household was indexed according to those index values, and, accordingly, those households that were recorded an index value of 9 are considered here as the "social supreme". Similarly, those that were marked as an index value in between 5 and 8 were termed the "mostly deprived group" because those groups are rarely considered in all types of development debates, whereas, those households that scored an index value in between 3 and 4 are denoted here as the "mostly prioritized group" because they have received the utmost attention from all development projects, either relief works or construction works. Although it does indeed lead to a slightly higher degree of motivation compared to the less educated, the "socially supreme" education level is neglected here as it does not imply a gain in manipulation power in the rural areas, as long as those in this category lack wealth and well-constructed houses (Table 1). Using this SSI, this paper portrays the socio-spatial relationships amongst the respondents and their proximity to cyclone shelters.

Table 1. Social supremacy index (SSI).

Level at Society	Indicators for Selection	Remarks
Decision makers/ "Socially supreme" (higher income group/ Local elite/ powerful/ pressure group).	Monthly income more than 120 USD (3) House construction cost/investment is more than 450 USD (3) Land size more than 0.4 Hector (3)	Education level is negligible, as without wealth and well-constructed houses, education has no decision making power in rural Bangladesh; Occupation level is important, whether they are in business or job.
Mostly deprived group in decision making process (middle income group).	Monthly income 30–120 USD (2) House construction cost 300–450 USD (2) Land size 0.2–0.4 Hector (2)	
Mostly prioritized group during any procession to gain benefit for the decision makers (low income group).	Monthly income less than 30 USD (1) House construction cost less than 300 USD (1) Land size less than 0.2 Hector (1)	

Source: Adopted from Mallick and Vogt [3].

4. Results and Discussion

4.1. Socio-Economic Profile of the Respondents

Table 2 summarizes the socio-demographic information extracted from the 1555 households surveyed. Most of the respondents were Muslim (90.2%) and the rest were Hindu (9.8%). The average age of the respondents was reported to be 45 years (minimum 17 and maximum 86 years). About 35.5% of the respondents were illiterate, only 12.3% attended more than 10 years of schooling, and 52.3% had less than 10 years of schooling. The average household size of the sample was 5 members. About 60% of the households had a family size between 5 and 10 members. Only one-fourth of the respondents had more than 0.5 acres of land. Years of schooling is an important determinant which correlates with the ability to cope with the adverse impacts of cyclones; for example, those who were educated also possessed quality and durable housing facilities ($r = 0.322$, $p < 0.001$). However, their education could not help them increase their accessibility to safe drinking water (i.e., negative association between accessibility to drinking water and residential house cost ($r = -0.115$, $p < 0.001$)) and years of schooling ($r = -0.275$, $p < 0.001$); because drinking water crisis was a problem related to natural environment rather social differences. About 90% of the households used to get their drinking water from ponds, sand filtered tube-wells, filtered pond-water in the house, or rainwater harvested from monsoons.

Table 2. Socio-demographic statistics of the respondents.

Parameter	Indicators	Value (%)
Religion	Islam	90.2
	Hindu	9.8
Gender	Male	82.9
	Female	17.1
Age category of respondent	Dependent Type 1 (those under 24 years old)	6
	Employable	88.4
	Dependent Type 2 (those are above 60)	5.6
Family size	Small family (≤4 members)	37.5
	5 to 10 members in family	60.5
	More than 10 members	2.0
Entitlement to land	Landless (who have less than 50 decimal of land)	74.5
	Non-landless (who have more than 50 decimal of land)	25.5
Years of schooling	Illiterate	35.4
	Less than 10 years of schooling	52.3
	More than 10 years of schooling	12.3

Source: Fieldwork conducted by the first author from 2009–2010.

Table 3 depicts the socio-economic characteristics of the respondents. Most of the households were engaged in agriculture-related activities to support their livelihoods. Approximately 37.7% of the respondents surveyed were day laborers. The distribution of respondents across occupations was not representative of the range of livelihoods in that region. Relatively more fishermen and farmers were interviewed, but due to the changes in livelihoods following the cyclones, most of the respondents identified themselves as day laborers. A wide gap was found in monthly income before (0.34) and after (0.24) cyclone disasters, which was calculated using Gini-coefficient calculations. Almost 80% of the population live below the poverty line if daily income is considered less than 2 US$ (1 US$ = 70 Bangladeshi Taka as on during the fieldwork). However, lower poverty levels were positively correlated with the years of schooling ($r = 0.138$, $p < 0.001$).

Table 3. Occupational pattern and economic capacity of the respondents.

Parameter	Indicators	Value (%)
Pattern of occupation	Agricultural production	20.2
	Fishing/shrimp farming	16.8
	Day labour/no specific income source	37.7
	Official job/services	1.7
	Business	5.5
	Unemployed (including student)	10.8
	Housewife	7.3
Income inequality (Gini Coefficient)	Before cyclone	0.34
	After cyclone	0.24
Level of poverty	Absolute poor (monthly income ≤ US$ 30)	12.5
	Poor (monthly income varies between US$ 31 to US$ 60)	69.1
	Non-poor (monthly income ≥ US$ 60)	18.4

Source: Fieldwork conducted by the first author from 2009–2010.

Table 4 describes the categories of residential houses; 2% of the houses were considered "built", i.e., made of brick and cement only (wall, roof, and floor are made of brick and cement). Around 50% houses were "non-built", i.e., made of totally organic materials, and the rest of the houses were "semi-built", i.e., made of both organic and inorganic materials, for example tally/Golpata (roof)

(Golpata is a local term for "Nipa Palm", which is scientifically known as *Nypa fruticans*) and mud (both wall and floors). Only 7.8% of the households had adequate floor space per capita (greater than or equal to 4.97 square meters), and only 12.5% of the houses had a plinth (platform upon which the structure rests) height of 1.5 m. Most of the respondents (72.2%) spent around US$ 400 to US$ 650 to construct their residential houses. However, the quality of residence depends on entitlement to land ($r = 0.322$, $p < 0.001$), which also correlates with poverty level ($r = 0.569$, $p < 0.001$) and years of schooling ($r = 0.131$, $p < 0.001$).

Table 4. Housing characteristics.

Parameter	Indicators	Value (%)
Categories of residential house	Non-built	59
	Semi-built	39
	Built	2
Per capita floor area ratio	Inadequate floor area ratio ($\leq$4.97 m^2 floor space per capita)	92.2
	Adequate floor area ratio ($\geq$4.97 m^2 floor space per capita)	7.8
Plinth level (meter)	Less than 1 m	49.3
	1.00–1.50 m	38.1
	More than 1.5 m	12.5
Cost of residential house construction	$\leq$US$ 400	15.4
	US$ 400 to US$ 650	72.2
	$\geq$650 USD	12.4

Source: Fieldwork conducted by the first author in 2009–2010.

4.2. Pre-Event Situation

The pre-event state describes the preparedness and perceptions of the cyclone victims. This section analyses the proximity to the nearest cyclone shelter (CS) and its relationship with the social supreme to understand whether any discrimination was present. The survey data represents the composition of the group surveyed as 3% social supreme, 18% mostly prioritized, and 79% from the deprived class according to the SSI.

Based on the field surveying and the analysis of the GIS maps, it was found that 45% of the social-supreme, 39.5% of mostly prioritized, and 38.8% of deprived group reside within a 500 m radius from a cyclone shelter (CS). Around 25%, 60%, and 90% of the residents live within the range of a 0.5 km, 1 km, and 1.5 km radius of a CS, respectively [46]. The Multi-purpose Cyclone Shelter Policy 1992 considered that people living within a 1.5 km radius of a CS will be able to take refugee during a cyclone [24]. However, studies claim that the nearness to the cyclone shelter and the place of taking refugee during a cyclone is positively correlated [4,32,41]. Subsequently this study considered a 500 m radius of a CS to understand the locational suitability of the same. It shows that 39% of the total sample is located within the 500 m radius of a cyclone shelter. Seemingly the social supreme class had relatively better access to a cyclone shelter than others; the reason of such discrimination is not a planning failure, rather it can be explained by the traditional social structure and system in rural Bangladesh. For instance, the construction of a CS requires a large-sized plot of land that cannot be easily acquired from a poor household. Sometimes it is also difficult to get an allocation of government owned fallow land (known as Khas land in Bangladesh) for the construction of a CS. Consequently, the social supreme class sell (or even donate) their land for the construction of a CS, and thus letting themselves be located closer to a CS.

In case of this study area, it is recommended that the houses near to the coastal areas should be built at least 4 m above the mean sea level. The generalized assumption is that dwellings located in higher grounds are less likely to be affected by storm surges [47]. After analysing the DEM, it was found that the average elevation of the dwellings is only 3.5 m [46]. This makes the houses highly

vulnerable to cyclones and storm surges. It that means before the occurrence of the cyclone event, most of the houses were already in a (physically) vulnerable situation.

4.3. Preparedness and Confronting Disasters

Improved early warning systems are now available in Bangladesh, but many people still do not know how to interpret the warnings. It is evident that almost everyone received an early warning (though 78% received a warning 6 h before the cyclone), but one third of them were not able to understand the early warning message. Nur Mia of Majer Char village at Sharankhola upazila said, "*what does it mean by signal 6, signal 7, signal 8 or extreme signal 10? I do not know, all are the same to me—when should I go back home? It was very difficult to understand*".

The existence of an effective early warning system is important in order for the local inhabitants to take preparations before the cyclone strikes. From the survey results, it was found that approx. 75% of the respondents got the warning in time, but only 30% of them took necessary measures, e.g., 53% of them tied-up their roofs with a tree and the remaining respondents kept food in safer places. However, the timing of the alert is critical for adequate preparation. Field data show that 77.6% of the respondents were not in a position to take any measures to prepare, as they received a warning only 6 hours before the cyclone made landfall. In addition, family size and structure are also important factors for preparedness. Data show that evacuation was difficult for families that had children and elderly family members and for families with more than 10 members. Only one-fifth of the total respondents failed to reach the cyclone shelters. In many cases, the respondents were not expecting the cyclone to hit so suddenly, and many even failed to estimate the severity of the disaster. For example, one respondent said that it came all of a sudden, and another respondent was shocked to see how quickly the water level had gone-up to a meter in several minutes. The people failed to perceive the intensity and magnitude of the cyclone disasters [46].

To understand why the vulnerable people did not leave even after receiving early warnings, FGDs were conducted among different communities. The data show that most cyclone shelters are located far from respondents' houses. Alternatively, people have easy access to friends/neighbours' houses, nearby elevated places (i.e., embankments), religious buildings, other taller buildings; rooftops, school buildings, and so on. Most of the respondents' professions were either day-labourer or farmers and it was important for them to stay close to their houses or place of work. Keeping these issues in mind, most of the inhabitants assumed that they could still take measures up until the cyclones and storm surges hit. Due to some local and cultural norms, women also had some restrictions on taking refuge at cyclone shelters. Moreover, women take care of the family resources, for example they preserve food, grains, fuel, etc. and sometimes are the last person of the family to leave the house to seek distant shelters. Therefore, women take refuge in cyclone shelters less often than men. These were found to be the main obstacles hindering them from relocating to the nearest cyclone shelters on the eve of the cyclones, even after getting warnings well in advance.

4.4. Post-Event Situation

After a cyclone, victims must overcome the consequences, trauma, and damages. It is not always possible for them to cope, as there can be no adequate resources left. Different government, humanitarian, and private organizations provided relief after the cyclone, but the measures taken for emergency assistance were unevenly distributed in terms of space and needs. Political and social status and the distribution of power play roles in this regard. Interestingly, at first, emergency relief projects were delivered to places where the activities could be publicized by the media (i.e., near existing hotels and guesthouses). In such preferential areas, donors competed, while victims living in the peripheral regions (i.e., the priority areas) hardly got any emergency assistance. Most affected people had to find alternative livelihood sources and reconstruct their houses. Table 5 shows how after the cyclones, people changed the materials they used for home construction; i.e., one third of the respondents used Golpata after the cyclones, whereas before the cyclones around half of the respondents used Tally

(mud-made materials) for the roof. Similarly, after the cyclones they switched to bamboo and wood walls (52%) instead of mud walls (83%). There was no significant change in floor construction.

Table 5. Housing construction materials.

Particulars	Materials	Before Cyclone	After Cyclone
Roof construction	Bamboo/ woods	1.5	0
	Golpata	19.5	33.1
	Tally	47.1	28.8
	Corrugated Iron (CI) sheet	31.3	37
	Brick/Concrete	0.6	1.1
Wall construction	Bamboo, woods	10.0	52
	Mud	83.0	25.7
	Golpata	0.5	7.1
	CI Sheet	0.4	5.7
	Brick/Concrete	6.2	9.5
Floor construction	Mud	93.4	92.1
	Brick/Concrete	6.6	7.9

Source: Fieldwork conducted by first author in 2009–2010.

Over the years, the various institutions, NGOs, and organizations distributed around US$1.4 billion to support the Cyclone Sidr and Aila victims [6]. In many cases, it was found that the relief was distributed by giving priority to religious, social, and political aspects among the communities. For example, the respondents believe that 75% of the politicians mismanaged the relief goods and the distribution was uneven. The social supreme class also got advantage in getting the relief. In other cases, some victims were selective in choosing the right kind of help from the donors, like waiting for getting a better quality of house from a particular NGO (the Muslim Aid) by ignoring the help from the other NGOS claiming that the quality of the house was not good enough [46].

4.5. Alternatives to Adapt to Adverse Situations

4.5.1. Changes in Occupation

This section explores how people cope after catastrophic disasters. Seventeen percent of the respondents sold their crops, cattle, or jewellery, and 14% of them changed their occupation, such as the farmers who shifted their occupation to fishermen since the agricultural lands were heavily inundated after the cyclones. Waterlogging or regular inundation after the cyclones forced people to change their occupation or income sources. For example, those who were dependent on rice cultivation could not produce rice as long as their farmland was under saline water. Those who did not change their occupation were forced to borrow money from local moneylenders or even worked as day-labours in various reconstruction and rehabilitation programmes. Due to the long-term stagnation of saline water on the paddy fields, people had to wait at least 2 years to restart paddy cultivation. As a result, they moved to the nearby cities for alternative income sources and others engaged in fishing. Another cluster (21.5% of the respondents) was found to be unemployed and they choose to migrate to nearby cities for jobs.

Secondly, those who were mostly dependent on the Sundarbans forest (e.g., honey collectors or fishermen) also changed their occupation, because they lost their fishing boats and nets. Due to massive destruction in the Sundarban forests, the locals could not continue their profession and they migrated to find work. Similarly, the groups who were dependent on shrimp farming had to diversify their income sources, as their shrimp-farms were totally washed out and they could not regain their capital [19,32]. Consequently, they were mostly displaced from their communities and moved to nearby cities [48].

4.5.2. Micro-Credit as an Alternative

The results show that 80% of the households took loans from NGOs and other different sources. Respondents also discussed micro-credit from NGOs as an alternative to regain their capital and continue their previous profession, but the repayment system was too strict. About 18.4% of the respondents had enough savings and assets to survive the aftermath of the disaster. Thus, living on their own savings was one possible option for them. Furthermore, people with more damage were prone to take loans. Field observations show that a big share of the respondents was repaying the credit loans taken from various institutions or relatives or neighbours.

4.5.3. Migration as an Alternative

Migration was evident in the aftermath of the cyclone disasters. About 34% of the households reported that at least one of their family members left the village. The high-income groups (particularly the social supreme) were less likely to migrate or be displaced. However, some lower income groups (privileged) also managed to avoid migration. They got additional donations from different government/NGO relief schemes or support from other influential families. In general, humanitarian relief programs dealt with activities related to the supply of food, water, health care, and sanitation, etc. But those programs did not provide long-term solutions to issues like migration and displacement. Ms. Kolpona Gorami of Gabura Union (utopian name applied here) reflected as follows:

"*We are Hindus and my husband was a farmer. We have 0.5 hectares of land. After Cyclone Aila, my husband made contact with our ward member (Muslim) to get some relief food. The ward member promised to provide food if we agreed to give him US$1.5 for each distribution. My husband agreed and we got relief two times, each consisting of 10 kilos of rice, 1 litre of oil, 500 grams of salt, 2 kilos of potatos, 1 kilo of lentils, 5 litres of water, and 5 packets of oral saline. The third time, the ward member refused to give us relief goods though we agreed to fulfil his requirements. He suggested my husband to go to Satkhira (the district town) and rent a rickshaw to pull. We have a small piece of land here, and we do not want to move away, though the land was under saline water due to storm surges. Later, the ward member and some of his rich Muslim friends asked my husband to sell our land and migrate to India. We did not agree and the member denied helping us anymore. Finally, my husband moved to Satkhira and now he pulls a rickshaw there. But gradually it is getting more difficult for me to continue our family expenses with the money sent by my husband. My husband is planning to come back home if the government can repair the embankment. Then he will try to start farming again. We are now under serious pressure to sell our land. But I have decided to stay here till my last breath and do not want to lose our land. The overall situation is very complicated*" [33].

This interview portrays many aspects of the cyclone victims in rural Bangladesh; religious identity, political influence in decision-making, fragile governance, the relationship between relief work and migration, land grabbing motives, social networking, and the hardship of finding a new livelihood after a hazardous event. It has also been identified that the poorer and vulnerable people of the community migrated after Cyclone Sidr in 2009 [49]. Accordingly, this study attempted to find the factors of vulnerability. Data shows that the cyclone-induced losses and damages had a direct impact on the movement decision ($r = 0.079$, $p < 0.001$) and the opportunity of diversified income also pulled people to move towards nearby cities ($r = 0.031$; $p < 0.002$). These findings signify the environmental push and address the economic pull of migration theory. Factors like accessibility to community services, involvement with micro-credit institutions, availability to loans, and income-expenditure patterns were evident in deciding migration [46,50]. Micro-credit consequences were also analysed through in-depth interviews. One of the migrants who took his family to Khulna city now works as a rickshaw-puller and lives in a slum close to the Khulna main railway station, explained his hardship [4]:
"*My father left 2 hectors of land for me and my brother in Gabura. I used to produce rice, but since the early 1990s I started shrimp farming. This was the beginning of my bad luck; gradually I lost my capital. Then I borrowed US$700 just before Cyclone Aila to invest in a shrimp farm. Unfortunately, Aila washed out my farm; no fish was there, only water and water. Can you tell me, how I can repay the loan? I came to Khulna with*

my family members to avoid the NGO supervisor, from whom I borrowed the loans. But eventually he got my current address. Now I don't know where we shall move next!" [4].

The lessons from this interview depict the consequences of shrimp farming and also the hardship of dealing with the consequences of micro-credit. After the cyclones, the local victims were also being forced to migrate to the bigger cities (e.g., Dhaka and Chittagong) in search of income. Notably, this influx of population is causing multi-hazard problems in those cities, such as the expansion of urban built-up areas, encroaching water bodies [51], water logging, urban heat island effect [52], air pollution, fire hazards, and urban landslides [53], ultimately degrading the living standard and hindering the sustainable development goals. The government of Bangladesh is planning to generate the "Delta Development Plan 2100". It will take into account the past, present, and future scenarios of hazards and disasters along with the legal and policy frameworks and the institutional arrangements of Bangladesh. The findings of this research can be helpful in the formulation further policies for the delta plan.

5. Conclusions

Disasters and calamities should not be viewed simply as fundamental interruptions to social and political life, but as variant manifestations of pre-existing processes and power relations. The victims of Cyclone Sidr and Cyclone Aila moved away because of a lack of resources, including financial and social capital and social protection, as well as the non-availability of income-generating alternatives. Their inability to preserve their assets and resources during their struggle against the cyclone made post-disaster recovery difficult. This research focuses on the preparedness, response, and recovery phases of the communities living with the risks of cyclone disasters in the southwest costal districts of Bangladesh. A total of 1555 cyclone-affected households from 45 villages in the Khulna, Bagerhat, and Satkhira districts were surveyed that were devastated by Cyclone Sidr and Cyclone Aila. The goal of this research was to understand how vulnerable communities deal with the catastrophic cyclone disasters in coastal Bangladesh.

To achieve the research questions, a number of participatory rural appraisal techniques, household based questionnaires, expert opinion surveying, focus group discussions, and case studies were performed to collect primary data from the affected communities. Results show that the affected communities were physically vulnerable (before the cyclones struck) due to the strategic locations of the cyclone shelters nearer to the social supreme class and the location of their houses in low-lying lands. They were also socio-economically vulnerable considering the high rate of illiteracy, less education, larger family size, landlessness, and the extreme rate of poverty. They were mostly day labours, farmers, and fishermen. Their houses were characterized as mostly non-built, low cost, and having inadequate floor area ratio. After the cyclone, their houses and livelihoods were severely destroyed. A significant change in housing patterns was observed, such as people starting to build the houses using Nipa Palm instead of tally. The walls were mostly constructed using bamboo or wood instead of mud. Most people shifted their occupations, such as from farmers to fishermen, and many became unemployed. The victims also became dependent on micro-credits and loans. A significant number of people were displaced and they migrated to cities in search of a livelihood and to maintain their families in the affected villages. It proves migration has been undertaken as a tool for adaptation.

Rebuilding after a disaster provides significant opportunities to initiate development programs [54]. For example, a self-help housing program to rebuild housing destroyed by a cyclone teaches new skills, strengthens community leadership, and explores new reconstruction technologies. Furthermore, development programs can be designed to decrease the susceptibility to disasters and their negative consequences, e.g. housing projects constructed under building codes designed to withstand high-winds result in less destruction during the next tropical storm. There is an urgent need for inter-departmental coordination, building rural infrastructure, proper operation and maintenance arrangements, design criteria for drainage capacity, and the establishment of a local water management committee. Dialogue should also be maintained with community-based organizations to ensure they have proper disaster management activities. It is recommended that in the future they should carry out

relief and rehabilitation work more effectively by ensuring equity. The strength and quality of physical planning practices in any country ensure the country's capacity to minimize the loss from natural hazards [55]. The focus of DRR research should also take into consideration the physical planning aspects of reducing risks and analyse the possible adjustments at a social and cultural level. This will ensure innovative, cost effective, and equitable ways of reducing disaster losses to promote sustainable development practices and make communities more resilient. This study provides a synthesized picture of coastal conditions during cyclones and hints at issues that need to be addressed for the sustainable well being of coastal communities in Bangladesh.

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