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Research Article

Natural Disaster Risk Assessment in the Coastal Area of Bangladesh: A Study on Cox's Bazar Paurashava

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ABSTRACT

Bangladesh is recognized worldwide as one of the most vulnerable countries to natural disasters, is still struggling to benefit its wider population from the current economic growth and social welfare. Issues like global warming and climate change are putting all the development works into great challenge. In order to overcome these challenges, intensive research on disaster risk reduction programmes are required. This paper works as a basis of such intensive research where combining the socio-economic factors and geographical factors, a combined risk index of a coastal area (Cox's Bazar Paurashava) has been identified. The study tried to establish some parameters regarding hazard, vulnerability and resiliency of the community in terms of the urban area of the coastal zone. In this way, this study focused on the non-spatial pattern as well as spatial factors of the community like roads and cyclone shelters. In terms of non-spatial risk, it has been derived that weak socio-economic status plays the most dominant role for a family to become vulnerable to natural disaster along with poor infrastructure systems, less chance of access to information etc. which also intensify the vulnerability of the community. Information regarding natural disaster risk assessment of the study area were collected through questionnaire survey and field observation. Members of professionals like professors and officials of disaster management department were selected for key informants' interview to get some concept, parameters, standards regarding preparing Natural Disaster Risk Assessment Index (NDRAI). In this study, all the factors have been considered together for quantifying the risk of the community. In this way, this research prepared different local map on the basis of hazard, vulnerability and resiliency condition of the people. This study also prepared spatial risk map, non-spatial risk map and final risk map. Thus, this study will certainly help to prioritize government and non-government interventions according to the risk category during emergencies.

Keywords: Disaster; Hazard; Vulnerability; Resiliency; Spatial; Non-spatial

INTRODUCTION

Over the course of the last century, natural disasters are estimated to have killed as many people as the two World Wars combined (Cohen and Werker). Over the period 1980-2016, about 10,500 reported natural disasters have resulted in about 2.4 million deaths and have caused around $2.9 trillion worth of direct economic damage (EM-DAT). In 2017 alone, about 350 natural disasters claimed the lives of close to 10,000 people and caused economic losses of about $317 billion dollars (EM-DAT) [1,2]. Notably, recent empirical evidence suggests that those most affected by natural disasters are the world's poorest individuals (SMRC). In fact, 93% of all-natural disaster deaths since 1980 happened in developing countries (EM-DAT), despite the geographical distribution of both frequency and intensity of hazards not being concentrated to these (Kahn, Strömberg) [3].

Bangladesh is a low-lying deltaic country in South Asia, which is formed by the Ganges, the Brahmaputra and the Meghna rivers (DMB, 2010). Bangladesh is located at the interface of two quite different settings. To the north of the country lie the Himalayas foot plain and the Khasi-Jainta hills, and to the south are the Bay of Bengal and the Indian Ocean. Those different settings control, modify, and regulate the climate of the country (Ali). Geologically it is a part of the Bengal Basin, which is built up by sediments washed down from the highlands on three sides of it. It is bordered

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on the west, north and east by India, on the southeast. The total length of the land border of Bangladesh is about 4,246 km, of which 93.9% is shared with India and the rest with Myanmar. There are 57 cross-boundary rivers, of which 54 are shared with India whereas other three rivers with Myanmar and Bangladesh is the common lower riparian zone of all these trans-boundary rivers. There are more than 310 rivers and tributaries which have made this country a land of rivers [4].

The coastal area represents an area of 47,201 km^2, which is about 32% of Bangladesh's total geographical area. In terms of administrative consideration, 19 districts out of 64 are considered as coastal districts (BBS, MoEF). About 10% of the country is 1 m above the mean sea level, and one-third is under tidal excursions (Ali). The country has a coastline of about 710 km along the Bay of Bengal [5,6].

MATERIALS AND METHODS

Background of the research

Bangladesh is recognized worldwide as one of the most vulnerable countries to natural disasters and to the impacts of global warming and climate change (SDC, DOE). Almost every year, Bangladesh experiences one or more disasters- such as tropical cyclones, storm surges, coastal erosion, floods, and droughts- resulting in massive loss of life and property and hampering the development activities (Ali). "In 2004, the United Nations Development Programme (UNDP) ranked Bangladesh the number one nation at risk for tropical cyclones and number six for floods" (Luxbacher and Uddin). Rapid global warming has caused fundamental changes to Bangladesh's climate and as a result million are suffering (DOE). It is therefore necessary to understand its hazard, vulnerability in terms of population and sectors at risk and its potential for adaptation to climate change (DOE) as shown in Figure 1.

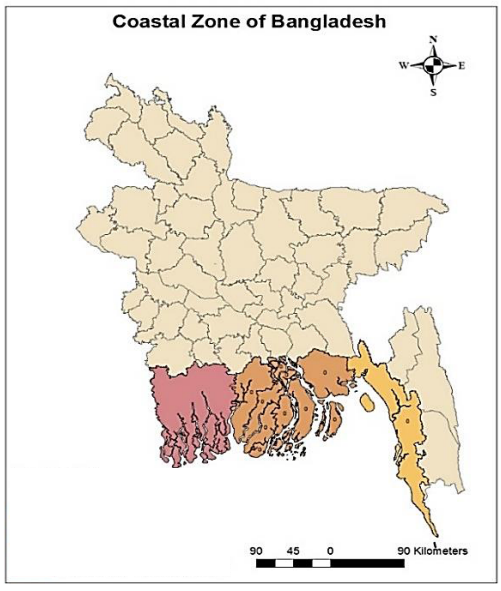

Figure 1: Coastal Zone of Bangladesh. **Note:** (▭) Eastern Coastal Zone; (▭) Central Coastal Zone; (▭) Western Coastal Zone.

In recent times the coastal areas Bangladeshi are sensitive to sea level rise, changes in the frequency and intensity of storms increases in precipitation and warmer ocean temperatures. The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) projects a global sea level rise in different RCP 's of 26 to 82 cm during the end of the 21st century (IPCC) which would threaten the survival of coastal cities and entire island [7-13].

Problem statement

The most common and most devastating disasters in Bangladesh come from natural hazards. This is driven by Bangladesh's geographic position; it is the Himalayas' drainage basin and lies at the top of the Bay of Bengal (MoWR). These geographic features essentially push large amounts of water into the country from both the north and south. Additionally, the agricultural tradition and rapid development in some areas of the country leave large portions of the population and the economy vulnerable to natural hazards. The coastal belt of Bangladesh is hit by cyclonic storms and associated storm surges regularly causing loss of human lives and livestock and severe devastation of crops and property. The main cause of loss of lives is storm surge (BUET-BIDS). Scientists of Bangladesh believe that because of sea level rise coastal Bangladesh has already experienced the worst impacts especially in terms of coastal inundation and erosion, saline intrusion, deforestation, loss of bio-diversity and agriculture, and large-scale migration (DOE). Many renowned scholars have asserted that climate change is one of the major challenges for human being in the 21st century. Increase of global temperature, rainfall changes, sea level rising, occurrences of extreme weather events such as flood, cyclone, drought etc. demonstrate climate change in the world (Paul). In this regard, assessment of disaster risk should be prepared for reduction the risk of natural disaster. So, my research tries to prepare a disaster risk assessment index based on hazard, vulnerability and resilience capacity of the people in the coastal area of Bangladesh [14-18].

Conceptualization

Natural Hazard is a natural event which has an adverse socio-economic impact on the human being. Alternatively, an extreme natural event such as cyclone, earthquake or flood that is not caused by human beings. Natural hazards can be identified into three broad groups such as atmospheric hazards caused by atmospheric process, exogenic hazards caused by the earth surface process and endogenic hazards caused by internal earth process [19,20].

A natural hazard is a relevant condition for a disaster to occur. However only when hazards intersect with exposed, vulnerable elements at risk will a disaster occur and cause humanitarian, economic and ecological effects. Natural hazards thus are triggering disaster events [21]. However, the final consequences will be determined by the elements at risk and their degree of vulnerability within a social structure. Thus, natural disaster risk can be said to be defined by three factors: hazard, elements at risk, and vulnerability. According to IPCC, the following criteria can be used to define a large disaster:

- More than 100 casualties

• Economic damage in excess of 1% Gross National Product (GNP)

• More than 1% of an impacted country's population harmed.

Research design

This research was conducted by using qualitative and quantitative approach. Both qualitative and quantitative data are necessary for finding the final outcome of the research. The main focus of the research is to assess disaster risk of the people in the coastal area of Bangladesh. So, it is necessary to have a clear idea about coastal areas. Qualitative part of this research helped to gain that idea. Quantitative approach was used to assess disaster risk. Literature review focuses on the issues of natural disaster and its impact, determinants of natural disaster, natural disaster risk assessment model- Crunch model and release Model, hazard assessment, vulnerability assessment, capacity assessment, disaster risk assessment. An individual opinion survey was undertaken by means of a structed questionnaire. In this research survey, an individual was chosen as a sampling unit. 96 individuals were taken for collecting data. By using Rao software, sample size is fixed. Purposive sampling technique was used to collect the data from individuals [22]. There are 12 wards in cox's Baazar paurashava and eight respondents are surveyed for collecting data from each ward of the Paurashava. After collecting data, Key Informants Interview were carried out to capture more information about disaster risk and its assessment criteria. Officials and GIS specialist from the department of disaster management and academician of a specific field disaster management were involved in this interview. They just give their opinion to fix the criteria, scale of disaster risk, level of disaster risk and provide different information about vulnerable people and their livings. From their opinion and conceptualization, I formulated a function which led me to the assessment process. In this research, Risk has been categorised into two segments as Non-Spatial Risk and Spatial Risk [23].

So, the mathematical expression of Non-Spatial Risk (NSR) is the following,

NSR=Hazard Score+Vulnerability Score–Capacity Score

On the other hand, Spatial Risk (SR) factors are those exclusively rely on the the geographic location and spatial distribution of social elements over the community. Therefore, spatial risk has been calculated based on the proximate location of settlement from the road side and existing cyclone shelter [24].

Finally, these two risks have been combined giving equal weight and a final risk index has been prepared. The equation of combined risk is:

Combined Risk, (R)=(Non-Spatial Risk+Spatial Risk)/2

After identifying parameter and variable, I need to give value for measuring the disaster risk assessment. The weight of the value was given on the basis of some consideration [25]. This idea was taken from the Disaster Crunch Model considered assessment level after getting measurement calculation on the score from 1 to 5. They categorised three assessment level where 2.5-2.8 was considered as low, 2.81-3.35 was considered as medium and 3.36-3.75 as high. After putting weightage, analyzing the collected information and data related to the research work had been begun. Thus, disaster risk level has been categorized in the following manner:

Study area

Bangladesh is considered as one of the most vulnerable countries in the Global Climate Risk Index (CRI) developed by Germanwatch which informs countries' exposure and vulnerability to climate-related risks. Almost all the districts of Bangladesh are affected by the natural disaster however, the districts of coast line areas affected mostly in comparison to the other districts of the country. While the Cox's Bazar district is the worst affected district among the 19 coastal districts of country [26]. There are 8 Upazilas under Cox's Bazar district. Being flowed beside the Bay of Bengal, with 3 isolated, the district is mostly concern of natural disaster like cyclone, tidal surge, flash flood, river and canal erosion, water logging, heavy rainfall etc (DMB) as shown in Figure 2.

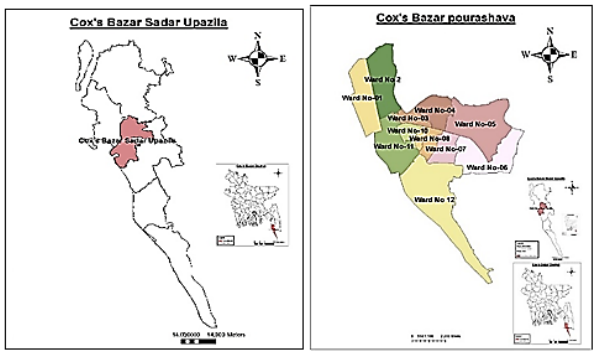

Figure 2: Global Climate Risk Index.

Natural disaster risk assessment analysis

This analysis focuses the socio-economic condition of the study area and the hazard, vulnerability and resiliency assessment in the context of natural hazard like cyclone and flooding. The detailed analysis of different variables regarding Natural Disaster Risk Assessment Index (NDRAI) are given below:

Socio-economic condition

In my study, it is found that the respondents of Cox's Bazar Paurashava are middle aged where almost 50% respondents are within 30-60 aged and 50% people have graduation degree. So it might be told that Cox's Bazar Purashava has large educated people as shown in Figure 3.

It is also found that agriculture (40%) and business (30%) sector are dominant occupations in Cox's Bazar Paurashava. It is noticed that maximum people have bank savings account. As a tourist area, people makes lots of transaction through banking channel [27-31].

Hazard condition

Hazard condition of Cyclone can be easily measured through cyclone frequency, intensity and magnitude of loss and damage of the people.

Hazard score

In order to calculate the hazard score, relevant hazard assessment criteria have been set according to the frequency of the hazard, intensity of the hazard and magnitude of the hazard as shown in Table 1 and Figure 4.

Hazard category

After getting score for individual ward, I can identify them as different level hazardous situation on the basis of scale. These are given below in Table 2 and Figure 5.

Vulnerability score

Similar method has been used to calculate the vulnerability score. Following criteria has been considered to calculate the vulnerability score as shown in Table 3 and Figure 6.

Capacity assessment

The capacity of the community refers to the resilience factors causing the risk of cyclone to be reduced. For the current study, the availability of protection system into the community, access to information and savings have been considered in order to calculate the capacity score as shown in Table 4 and Figure 7.

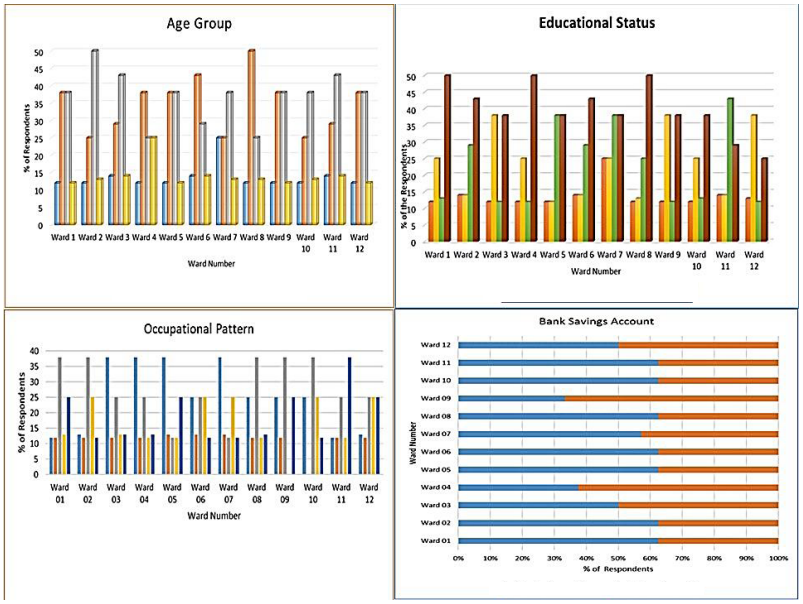

Figure 3: Socio-Economic Condition.

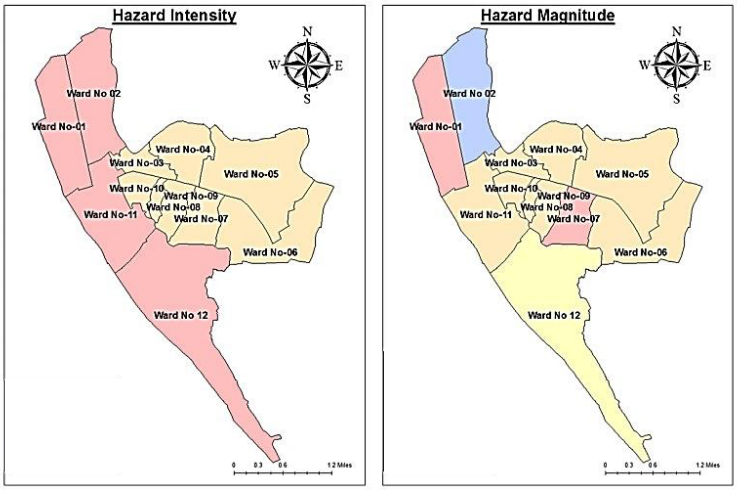

Figure 4: Intensity of the Hazard and Magnitude of the Hazard.

Table 1: Hazard Category.

Criteria	Scale of Scoring (1 to 5)	Cox's Bazar Paurashava Ward Number											
		1	2	3	4	5	6	7	8	9	10	11	12
-Frequency	Both Cyclone and Flood/Tidal Surge Occurs in Every Year=5 Cyclone or Flood/Tidal Surge Occurs in Every Year=4 Cyclone or Flood/Tidal Surge occurs in 1 Year Gap=3 Cyclone or Flood/Tidal Surge occurs in 2-3 Years Gap=2 Cyclone or Flood/Tidal Surge occurs in over 5 years Gap=1	3	3	3	3	3	3	3	3	3	3	3	3
-Intensity	10 feet tidal surge and 200 km wind speed=5 10 feet tidal surge or 200 km wind speed=4 5 feet tidal surge or 150 km wind speed=3 Below 5 feet tidal surge or 100 km wind speed=2 Little Flooding or below 100 km wind speed=1	5	5	3	3	3	3	3	3	3	3	5	5
-Magnitude	Loss of Human life and Property value BDT 20,000=5 Human life injured and loss of Property value BDT 20,000=4 Loss of Human life or Property Value BDT 20,000=3 Loss of Firms and Agro Industry=2 Minimum Destruction=1	2	1	3	3	3	3	2	3	3	3	3	4
	Average	3.3	3	3	3	3	3	2.6	3	3	3	3.6	4

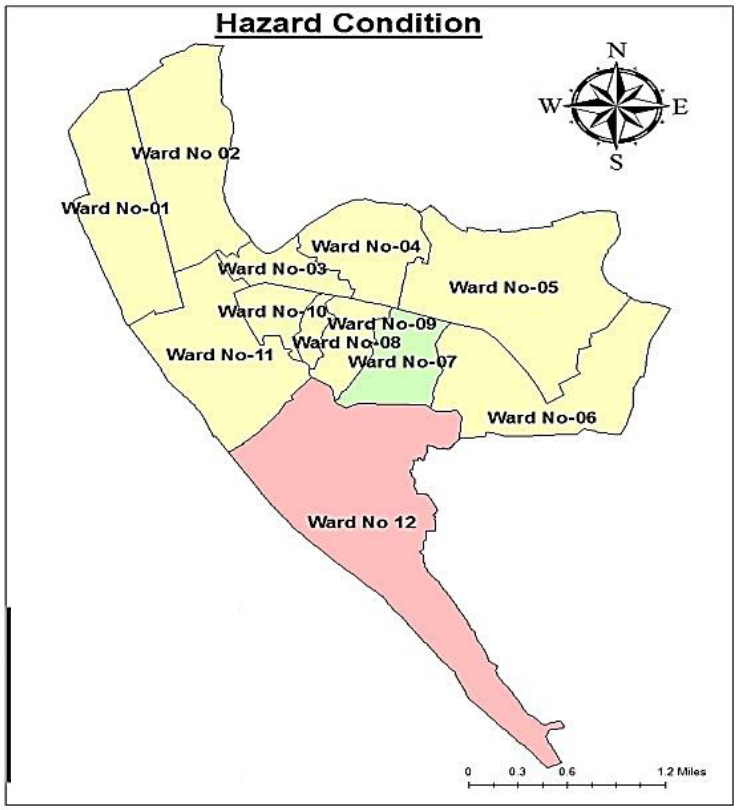

Figure 5: Intensity of the Hazard Condition. **Note:** (▭) Modern Hazardous; (▭) High Hazardous; (▭) Severe Hazardous.

Table 2: Vulnerability Score.

Ward Number	Hazard Score	Hazard Category
Ward-01	3.3	High Hazardous
Ward-02	3	High Hazardous
Ward-03	3	High Hazardous
Ward-04	3	High Hazardous
Ward-05	3	High Hazardous
Ward-06	3	High Hazardous
Ward-07	2.6	Moderate Hazardous
Ward-08	3	High Hazardous
Ward-09	3	High Hazardous
Ward-10	3	High Hazardous
Ward-11	3.6	High Hazardous
Ward-12	4	Severe Hazardous

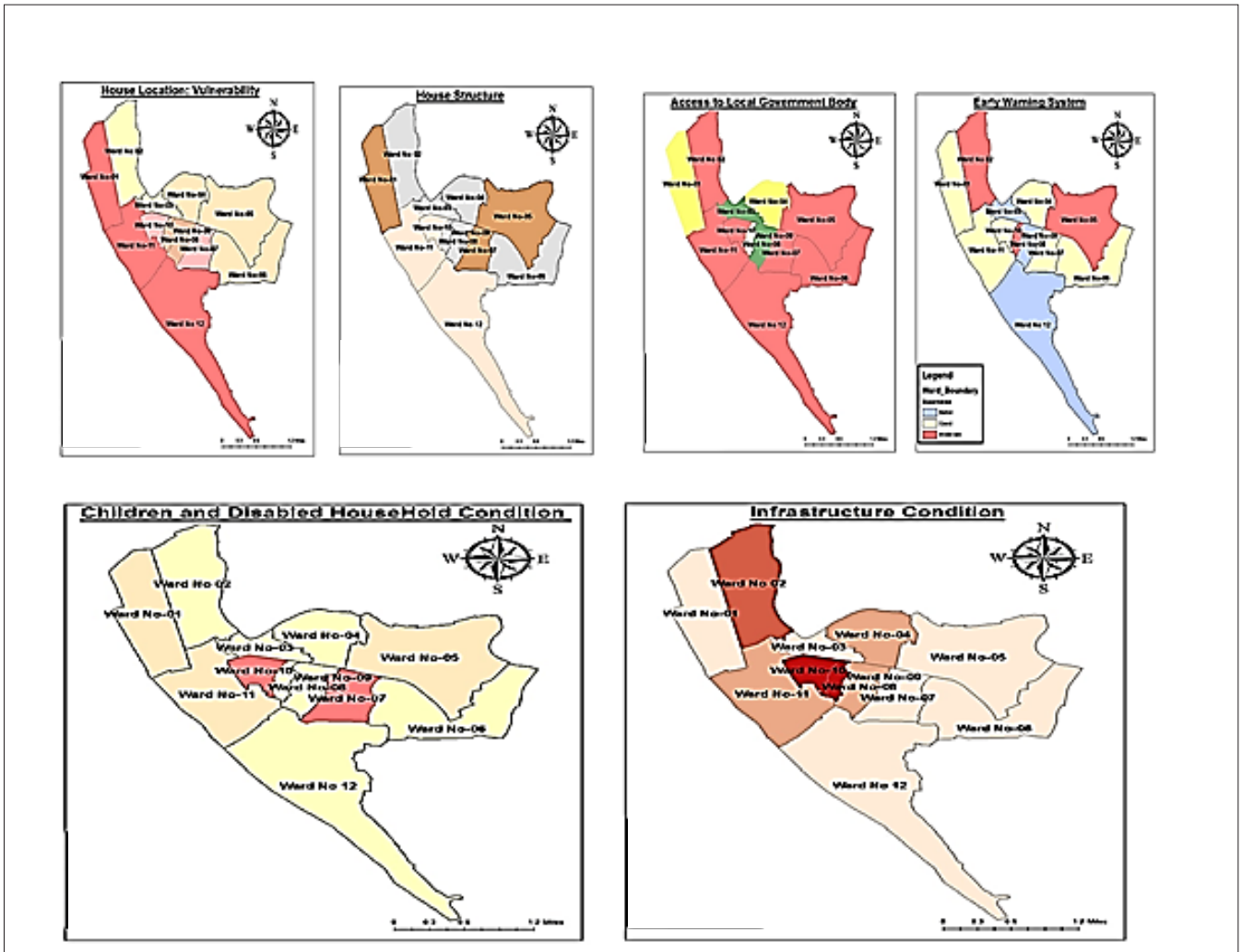

Figure 6: Intensity of the Hazard and Magnitude of the Hazard.

Table 3: Capacity Assessment Index.

Criteria	Scale of Scoring (1 to 5)	Cox's Bazar Paurashava Ward Number											
		1	2	3	4	5	6	7	8	9	10	11	12
-House location within 1 km. sea or river	More than 80% house=5 From 60%-80%=4 From 40%-60%=3 From 20-40%=2 Below 20%=1	5	4	4	3	3	3	2	2	1	2	5	5
-Income Source	Agriculture=5 Fishing=4 Business=3 Informal Job=2 Public and Private Job=1	3	3	5	5	5	3	5	3	3	3	2	3
-Structure of House	Mud/Bambo=5 Tin=4 Tin and Brick=3 Brick=2 Others=1	3	4	4	4	3	4	3	4	4	2	2	2
-Access to local Government	More than 80%=1 From 60%-80%=2 From 40%-60%=3 From 20%-40%=4 Below 20%=5	4	3	2	4	3	3	3	2	1	3	3	3
-Early Awareness	More than 80%=1 From 60%-80%=2 From 40%-60%=3 From 20%-40%=4 Below 20%=5	2	3	1	2	3	2	2	1	3	2	2	1
-Children and Disabled Person	More than 80% house=5 From 60%-80%=4 From 40%-60%=3 From 20%-40%=2 Below 20%=1	3	4	4	4	3	4	5	4	4	5	3	4
-Efficient Infrastructure	More than 80%=1 From 60%-80%=2 From 40%-60%=3 From 20-40%=4 Below 20%=5	2	1	2	3	2	2	2	3	4	4	3	2
-Age	Above 70=5 Below 10=4 10-15=3 16-30=2 30-60=1	1	1	1	2	1	1	1	2	1	1	2	1
-Education	More than Graduate=1 HSC=2 SSC=3 Below SSC=4 Illiterate=5	1	1	3	1	2	1	2	1	3	1	2	3
-More than One Earning Member	More than 80% house=1 From 60%-80%=2 From 40%-60%=3 From 20-40%=4 Below 20%=5	3	5	3	4	4	3	3	3	4	5	3	3
-Safe Drinking water	More than 80% house=1 From 60%-80%=2 From 40%-60%=3 From 20-40%=4 Below 20%=5	4	4	3	2	3	2	3	2	3	2	4	2
Average		2.8	3	2.9	3.1	2.9	2.6	3.1	2.4	2.8	2.7	2.8	2.6

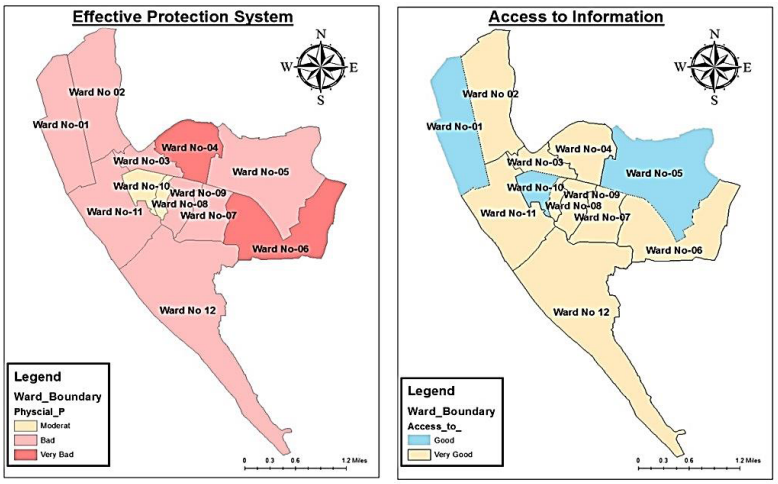

Figure 7: Calculate the capacity score.

Capacity category

After getting score for individual ward, I can identify them as different level hazardous situation on the basis of scale. These are given below in Table 5 and Figure 8.

Non-spatial risk assessment index

Based on the previous calculation of Hazard Score, Vulnerability Score and capacity Score, total Non-Spatial risk has been calculated by the following equation, NSR=(Hazard Score+Vulnerability Score–Capacity Score) as shown in Table 6 and Figure 9.

Spatial risk assessment index (srai)

Spatial Risk Index for each ward has been calculated based on two major criteria which are distance from pucca road and distance from cyclone shelter as shown in Table 7 and Figure 10.

Spatial risk category

The calculation of spatial risk score has been provided in the following calculation table. On the basis of calculation, I can identify the risk ward as shown in Table 8 and Figure 11.

Final risk index

From the calculation of Non-Spatial Risk Index and Spatial Risk Index, a combined final risk score has been calculated for each ward using the following formula and it has shown in Table 9 and Figure 12.

Combined Risk Index, R=(Non-Spatial Risk Index+Spatial Risk Index)/2

Table 4: Capacity Category.

Criteria	Scale of Scoring (1 to 5)	Cox's Bazar Paurashava Ward Number											
-Physical Protection System	More than 80% house=1 From 60%-80%=2 From 40%-60%=3 From 20-40%=4 Below 20%=5	4	4	4	5	4	5	4	4	3	3	4	4
- Savings and Assets	More than 80%=1 From 60%-80%=2 From 40%-60%=3 From 20-40%=4 Below 20%=5	2	2	3	4	2	2	3	2	4	2	2	3
-Access to Information	More than 80% house=1 From 60%-80%=2 From 40%-60%=3 From 20-40%=4 Below 20%=5	2	1	1	1	2	1	1	1	2	1	1	1
Average		2.6	2.3	2.6	3.3	2.6	2.6	2.6	2.3	3	2	2.3	2.6

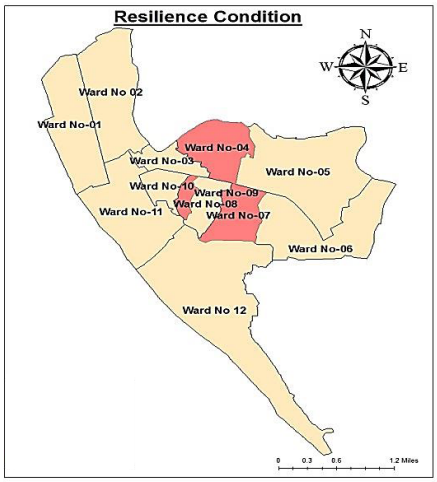

Figure 8: Resilience Condition of Different Wards. **Note:** (▭) Moderate Capacity; (▭) High Capacity.

Table 5: Non-Spatial Risk Assessment Index (NSRAI).

Ward Number	Capacity Score	Capacity Category
Ward-01	2.6	Moderate Capacity
Ward-02	2.3	Moderate Capacity
Ward-03	2.6	Moderate Capacity
Ward-04	2.3	Moderate Capacity
Ward-05	2.6	Moderate Capacity
Ward-06	2.6	Moderate Capacity
Ward-07	2.6	Moderate Capacity
Ward-08	2.3	Moderate Capacity
Ward-09	3	High Capacity
Ward-10	2	Moderate Capacity
Ward-11	2.3	Moderate Capacity
Ward-12	2.6	Moderate Capacity

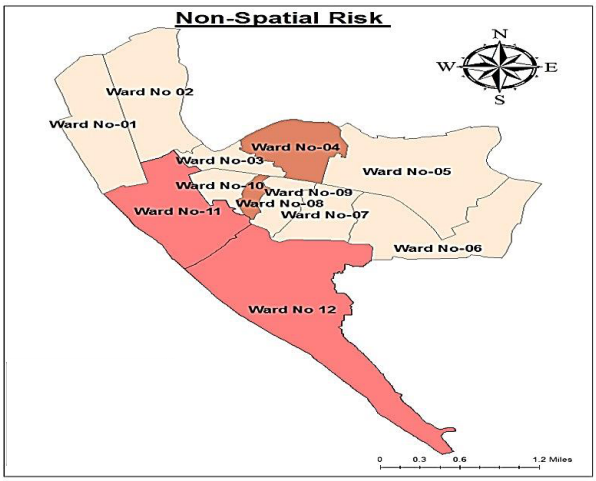

Figure 9: Non-Spatial Risk of Different Wards. **Note:** (▭) Moderate Risk; (▭) High risk; (▭) Severe Risk.

Table 6: Spatial Risk Assessment Index (SRAI).

Ward	Hazard (H)	Vulnerability (V)	Capacity (C)	H+V-C	Risk Category
Ward-01	3.3	2.8	2.6	3.5	High Risk
Ward-02	3	3	2.3	3.7	High Risk
Ward-03	3	2.9	2.6	3.3	High Risk
Ward-04	3	3.1	3.3	2.8	Moderate Risk
Ward-05	3	2.9	2.6	3.3	High Risk
Ward-06	3	2.6	2.6	3	High Risk
Ward-07	2.6	3.1	2.6	3.1	High Risk
Ward-08	3	2.4	2.3	3.1	High Risk
Ward-09	3	2.8	3	2.8	Moderate Risk
Ward-10	3	2.7	2	3.7	High Risk
Ward-11	3.6	2.8	2.3	4.1	Severe Risk
Ward-12	4	2.6	2.6	4	Severe Risk

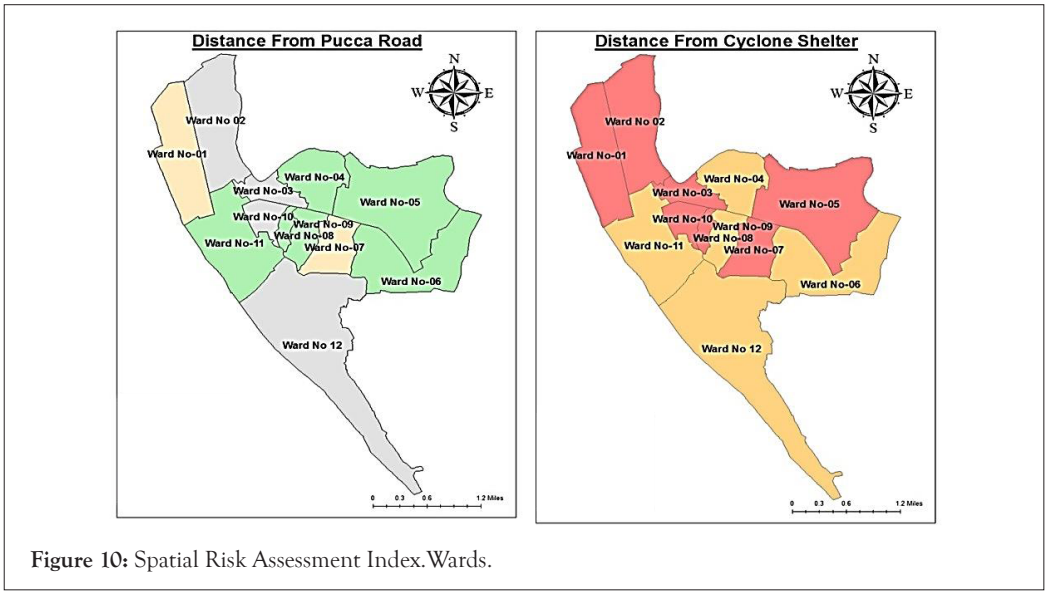

Figure 10: Spatial Risk Assessment Index.Wards.

Table 7: Spatial Risk Category.

Criteria	Scale of Scoring (1 to 5)	Cox's Bazar Paurashava Ward Number											
		1	2	3	4	5	6	7	8	9	10	11	12
-Distance from Pucca road	More than 3 km. from house=5 From 2-3 km.=4 From 1-2-1 km.=3 From .5-1 km.= 2 Below .5 km.=1	3	1	1	2	2	2	3	2	2	1	2	1
-Distance from cyclone shelter	More than 3 km. from house=5 From 2-3 km.=4 From 1-2– 1 km.=3 From .5 -1 km.= 2 Below .5 km.=1	3	3	3	2	3	2	3	2	3	3	2	2
Average		3	2	2	2	2.5	2	3	2	2.5	2	2	1.5

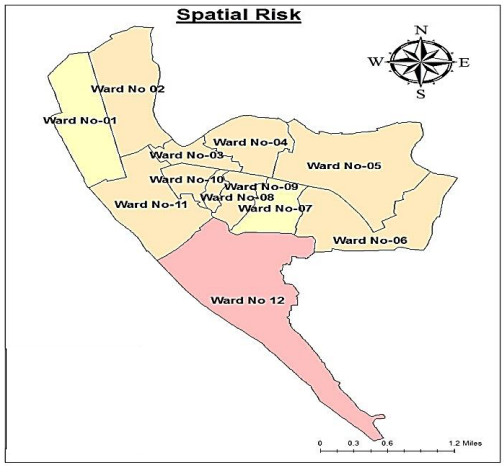

Figure 11: Spatial Risk Category. **Note:** (▬) Low Risk; (▬) Moderate Risk; (▬) High Risk

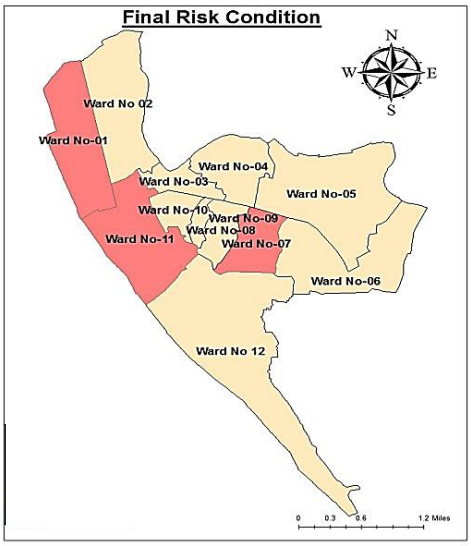

Figure 12: Calculation of Final Risk Index. **Note:** (▬) Moderate Risk; (▬) High Risk.

Table 8: Final Risk Index.

Ward	Non-Spatial Risk Index (NSRI)	Spatial Risk Index (SRI)	Final Risk Index=(NSR+SR)/2	Risk category
Ward-01	3.5	3	3.25	High Risk
Ward-02	3.7	2	2.85	Moderate Risk
Ward-03	3.3	2	2.65	Moderate Risk
Ward-04	2.8	2	2.4	Moderate Risk
Ward-05	3.3	2.5	2.9	Moderate Risk
Ward-06	3	2	2.5	Moderate Risk
Ward-07	3.1	3	3.05	High Risk
Ward-08	3.1	2	2.55	Moderate Risk
Ward-09	2.8	2.5	2.65	Moderate Risk
Ward-10	3.7	2	2.5	Moderate Risk
Ward-11	4.1	2	3.05	High Risk
Ward-12	4	1.5	2.75	Moderate Risk

Major findings

From the Above calculation of hazard Score, this study found three types of hazardous condition out of five hazardous condition. Ward–One, Two, Three, four, Five, Six are high hazardous prone area where ward–Eleven and twelve are severe hazardous prone area. Ward–Seven is comparatively less hazardous area than others. According to the level of scale, it is moderate hazardous prone area in this study.

In the calculation of Vulnerability scale, this study identified that two types of vulnerable condition are seen in the study area. Three Wards of the Cox's Bazar Paurashava (Ward–Two, Four and Seven) are more vulnerable to natural hazard. Their socio-economic conditions are weak than others wards. On the other hand, others Nine Wards (Ward–One, Three, Five, Six, Eight, Nine, Ten, Eleven and twelve) are comparatively less vulnerable to natural hazard.

In terms of resiliency, Ward–Nine has most resilient condition to natural hazard. All of the wards except nine are moderate resilient condition to natural disaster.

After getting hazard, vulnerability and resiliency score, this study can calculate Non-Spatial Risk condition on the basis of hazard, vulnerability and resiliency. From the Non-Spatial Risk calculation, this study found three types of disaster risk. Ward–Eleven and Twelve are severe risk prone area. Ward–One, Two, Three, Five, Six, Seven, Eight and Ten are high risk prone area in terms of Non-Spatial Risk. Ward–Four and Nine are considered as moderate risk prone area.

Spatial Risk Assessment Index is also prepared after finding non-spatial risk. Basically, Spatial Risk Index is prepared based distance from pucca road and distance from cyclone shelter. In this way, this study found three types of risk. Ward–One and Seven are high risk prone area. Ward–Twelve is less risk prone area. Ward–Two, Three, Four, Five, Six, Eight, Nine, Ten, eleven are moderate risk area in terms of spatial condition.

So According to the Above calculation, Final Risk Index is formulated combining Non-Spatial Risk and Spatial Risk Index. In this regard, this study identified two types of risk at last. Three wards (ward–one, eleven and seven) out of twelve of Cox's Bazar Paurashava has been resulted as a high risk area of natural disaster like cyclone, flood, storm surge, Tsunami whereas nine Wards (Ward-Two, Three, Four, Five, Six, Eight, Nine, Ten and twelve) of the Paurashava has been categorized as moderate risk area [32-34].

DISCUSSION AND CONCLUSION

Natural disaster risk of coastal communities of Bangladesh is basically a function of their vulnerability in terms of weak socio-economic structure and existing poor infrastructure development. Along with the lack of consciousness and haphazard development, the present form of institutional structure within coastal communities and lack of access of the people in the development process is also the cause of high degree of vulnerability.

The methodology used in this study is very effective to identify the socio-economic and spatial factors. Different types of indicators and parameters are formulated in terms of hazard, vulnerability, resiliency of the people and spatial factors in respect of their settlement. A Natural Disaster Risk Assessment Index (NDRAI) is developed from the different indicators which are related with hazard, vulnerability, resiliency etc. This index shows different levels of risk on the basis of categorizing the risk level. This study shows, about three wards out of twelve wards in the paurashava are into a high-risk category because of their socio-economic and geographical location.

The methodology can be used in the other coastal district or country based on the context and considering different relevant factors such as local area characteristics, selection of necessary vulnerability indicators, resiliency indicators, availability of data, study objectives, study area etc. It is also recommended that appropriate hazard, vulnerability, capacity indicators should be identified for risk assessment in the other areas of the country.

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