Vulnerability Assessment to the Natural Disaster in the Coastal Areas of Bangladesh: A Case Study on Cox's Bazar Paurashava

Ashraf Uddin Fahim[1]
Sania Sifat Miti[2]

Abstract

Bangladesh is recognized as one of the most vulnerable countries to the natural disaster worldwide. As Bangladesh is densely populated country, it is struggling to benefit its wider population from the current economic growth and social welfare. Different issues like global warming and climate change are putting all the development works into great challenges. In order to overcome these challenges, intensive research on disaster risk reduction programs are required. This paper works as a basis of such intensive research where socio-economic factors and geographical factors are identified to assess the vulnerability of Cox's Bazar Paurashava and a combined vulnerable index has been formulated. The study tried to establish some parameters regarding vulnerability of the community of the urban areas of the coastal zone. Different local maps on the basis of social vulnerability, economic vulnerability and physical vulnerability of the area have been prepared. This will help to prioritize government and non-government interventions according to the vulnerability category during critical conditions of any disaster period.

Key words: Social Vulnerability, Economic Vulnerability, Physical Vulnerability, Vulnerability Assessment Index.

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 & Werker, 2008). 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, 2016). 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, 2018). Bangladesh is recognized as one of the most vulnerable countries to the natural disasters and to the impact of global warming and climate change (SDC, 2010). Almost every year Bangladesh experiences one or more natural disasters such as tropical cyclones, storm surge, coastal erosion, flood, drought etc. It is a low-lying deltaic country in South Asia which is formed by the Ganges, the Brahmaputra and the Meghna rivers (DMB, 2010). There are more than 310 rivers and tributaries which have made this country a land of rivers (DMB, 2010). The coastal area represents an area of 47, 201 sq. km which is about 32% of the total geographical areas of Bangladesh. In terms of administrative consideration, 19 districts out of 64 are considered as coastal districts (BBS, 2011). The most common and most devastating disasters in Bangladesh come from natural hazards. This is driven by the geographic position of Bangladesh as it is in the Himalayas'

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[1] Lecturer, Department of Urban and Regional Planning, Pabna University of Science and Technology, Pabna, Bangladesh. E-mail: fahim.urp@pust.ac.bd
[2] Associate Professor, Department of Urban and Regional Planning, Jahangirnagar University, Dhaka-1342, Bangladesh. E-mail: miti@juniv.edu

drainage basin, the Bengal Basin which is built up by sediments washed down from the highlands on three sides of it and lies at the top of the Bay of Bengal. The coastal belt of Bangladesh is hit by cyclonic storms and associated with storm surges regularly causing loss of human lives and livestock and severe devastation of crops and property (BUET-BIDS, 1993). Approximately 76% of the total loss of human lives from cyclone storms has occurred in India and Bangladesh (IPCC, 2007). UNDP (2004) has identified Bangladesh to be the most vulnerable country in the world to tropical cyclones. The poor socio-economic conditions of coastal inhabitants also contribute to the increasing vulnerability of inhabitants to cyclones and storm surges (Paul et al., 2010). Therefore, the increasing trend of cyclones will certainly affect the livelihoods of vulnerable populations living in low-lying coastal areas of Bangladesh (Islam, 2008). If global warming causes any increase in cyclone activity, the situation in Bangladesh and India is likely to further worsen. In this regard, there should be Vulnerability Assessment procedures to identify the vulnerable areas to disaster. This will help to take necessary actions during or before any natural disaster or hazard according to the level of vulnerability of the areas to the disaster and thus will help to reduce the risk of various natural disasters. So, this research tries to identify the parameters for assessing the vulnerability of the people and develop a Natural Disaster Vulnerability Index (NDVI) of the people in the coastal area of Bangladesh.

Conceptualization

Any natural event that has an adverse socio-economic impact on human being is called Natural Hazard. 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 (ADPC, 2000). According to IPCC (2012), the following criteria can be used to define a large disaster:

a) More than 100 casualties;

b) Economic damage in excess of 1% gross national product (GNP); and

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

According to ADPC (2000), there are different dimensions of vulnerability:

a. Physical Vulnerability: this relates to the susceptibility to damage of engineering structures such as house, dams or roads.

b. Social Vulnerability: The ability to cope with impacts on the individual level.

c. Institutional Vulnerability: Referring to the existence and robustness of institutions to deal with and respond to natural disaster.

d. Economic Vulnerability: The economic or financial capacity to finance losses and return to a previously planned activity path. This may relate to private individuals.

Research Design

This research is conducted by using both qualitative and quantitative approaches. The main focus of the research is to assess vulnerability of the people in the coastal areas of

Bangladesh. So, it is necessary to have a clear idea about coastal areas. Qualitative part of this research has helped to gain that idea. Quantitative approach is used to assess the vulnerability. An individual opinion survey has been conducted with the help of a structured questionnaire. In this survey, an individual has been chosen as a sampling unit. 144 individuals are taken for collecting data. By using Rao Software, sample size is fixed. Purposive Sampling Technique is used to select samples from the population. There are 12 wards in Cox's Bazar Paurashava and eight respondents have been surveyed from each ward. After collecting data, Key Informant Interviews have been carried out to gather more information about vulnerability and its assessment criteria. Officials and GIS specialists from the Department of Disaster Management under the Ministry of Disaster and Relief in Bangladesh and academicians of related fields have been involved in these interviews. They provide different information about vulnerable people and their livelihood and their opinions are used to fix the factors, scale of vulnerability, and level of vulnerability. From these expert opinions and various literatures, a function has been formulated to assess the vulnerability of the people of coastal areas. As vulnerability is the function of physical, social, institutional and economic vulnerabilities, the ultimate vulnerability should be the average of these four. So, the equation stands as:

Vulnerability score (Ultimate/Final) = (Physical Vulnerability + Social Vulnerability + Institutional Vulnerability + Economic Vulnerability)/4

In this study, institutional vulnerability is not considered because of the lack of information. So, in this paper vulnerability is classified into three dimensions:

1. Physical vulnerability: It includes road distance to house and cyclone shelter, house location from river and sea and effective protection system.

2. Social Vulnerability: It includes age, educational status, occupation, early warning system, access to local government, children and disabled person, safe drinking water and access to information.

3. Economic Vulnerability: It includes income, bank saving accounts and earning member.

The distribution of factors and Chi-quare Test are employed to understand respondents' basic characteristics. All statistical analysis like table and Pearson Correlation Matrix are performed using SPSS 21. Arc GIS 15 is used for preparing different Maps. The Chi-square (χ^2 value) Test was performed with the studied variables at a significant level $p < 0.05$ with 95% confidence interval.

Chi-square test shows the relationship of the variables of the factors. When the value of the p value is less than 0.05, the relationship of the variables of the factors is significant. The Table-1 shows the distribution of the factors of the vulnerability assessment with chi-square value. Maximum respondents are from 17 to 40 age ($\chi^2 = 143.167$, df=2, p=.000). The p-value of .000 signifies that the difference between the age distributions is statistically significant. There are two factors (Savings and Earning member) which have value of p more than .05. This p value signifies that the observation data of two factors of the vulnerability are not statistically significant. Thus, distribution of all the factors of the vulnerability assessment was showed with their p value in Table-1.

Table 1: Distribution of the factors of Vulnerability Assessment (N=144)

Factors	Variable %	χ2 value	df	p value
Age (F1)				
	11-16 = 1.4 17-40 = 78.6 41-59 = 20	143.167	2	.000
Occupation (F2)				
	Official Work = 1.4 Business = 42.1 Informal Activities = 20.7 Agriculture = 23.4 Fishing = 12	66.764	4	.000
Education (F3)				
	Graduate = 37.2 HSC = 26.9 SSC = 22.1 Below SSC = 11 Illiterate = 2.1	54.819	4	.000
Effective Early Warning (F4)				
	Yes = 65.5 No = 34.5	14.694	1	.000
Access to Local Government (F5)				
	Yes = 37.2 No = 62.8	9.000	1	.003
More than Two Children (F6)				
	Yes = 69 No = 31	23.361	1	.000
Safe Drinking Water (F7)			1	.012
	Yes = 70 No = 30	6.250	1	.012
Access to Information System (F8)				
	Yes = 80 No = 20	51.361	1	.000
House Location within 1 km. Sea or River (F9)				
	Yes = 66 No = 34	14.694	1	.000
House Structure (F10)				
	Brick = 30.7 Tin and Brick = 31.7 Tin = 36.8	46.611	3	.000

Physical Protection System (F11)			
Yes = 30 No = 70	23.361	1	.000
Distance from Pucca Road (F12)			
Above K.M. = 28 2-3 K.M. = 44.1 1-2 K.M. = 22.8 .5-1 K.M. = 3.6 Below .5 K.M. = 1.4	92.597	4	.000
Distance from Cyclone Shelter (F13)			
Above K.M. = 28 2-3 K.M. = 44.1 1-2 K.M. = 22.8 .5-1 K.M. = 3.6 Below .5 K.M. = 1.4	105.444	4	.000
Savings and Assets (F14)			
Yes = 53 No = 47	.444	1	.505
Earning Member (F15)			
Only One = 44 More than One = 56	2.250	1	.134
Income Class (F16)			
0-7000 = .7 7001-12000 = 22.5 12001-18000 = 42.2 18001-25000 = 26.3 Above 25000 = 8.3	75.931	4	.000

Source: Field Survey, 2019 and Prepared by Authors, 2020

Pearson Correlation Matrix (PCM) is applied in this study to show the relationship of the studied factors of the vulnerability indicators of the people to natural disaster in the coastal areal of Bangladesh (Table 3). A strong significant positive correlation is found between F1 and F3, indicates the relation between age and education. Besides, between F2 and F3 also shows strong positive correlation which illustrates the relationship between education and occupation. There is also a positive correlation between occupation and income class. On the otherhand, there are two negative correlation between access to local government and income class and safe drinking water.

After identifying variables of 16 factors, each variable of the vulnerability then scored from 5 to 1 scale that represents severe vulnerability to less vulnerability. The weight is given following the Disaster Crunch Model (Venton and Hansford, 2006).

Waliuzzaman, *et al*. (2016) 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. Based on this, the vulnerable index of this study has been categorised in the following manner. In this research, five levels of vulnerability are considered for more specification of vulnerable area.

Table 2: Vulnerability assessment level

Scale	1-2.2	2.2-2.50	2.51-3.00	3.01-3.50	3.51-4.99
Level	Lower	Low	Moderate	High	Severe

Source: Waliuzzaman, et al. (2016); Field Survey, 2019 and Prepared by Authors, 2020

Table 3: Pearson Correlation Matrix of the factors of vulnerability (Significant Values >0.2)

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16
F1	1															
F2	-.160	1														
F3	**-.249****	**.478****	1													
F4	.021	.161	.127	1												
F5	.041	-.209*	-.181*	.132	1											
F6	-0.86	.196*	-.133	-.020	.035	1										
F7	-.041	-.042	-.162	.198*	.128	.092	1									
F8	.022	-.025	-.013	.041	.103	-025	.125	1								
F9	.108	-.081	-.046	.052	.072	-.116	-.162	-068	1							
F10	.139	-.047	-.098	-.007	-.178*	.089	.055	-.029	.011	1						
F11	.144	-.001	-.087	-.076	.090	-.105	.063	.025	-.076	-.017	1					
F12	.134	-.067	.078	.049	.186*	.075	-.106	.043	-.051	-.033	.012	1				
F13	.067	.077	.015	-.170*	-.200*	.054	-.027	.091	-.40	.009	-.016	.196*	1			
F14	-.047	.161	.101	-.092	.014	-.131	-.111	.045	-.122	.045	.040	-.020	.012	1		
F15	.041	-.086	-.060	-.017	.069	-.159	-.116	.024	.013	-.066	.128	.111	.168*	.189*	1	
F16	-.175*	**.273****	.398**	-.057	**-.231****	.129	**-.220****	-.084	.074	-.015	.011	-.126	-.199*	.065	-.097	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Source: Field Survey, 2019 and Prepared by Authors, 2020

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 (Waliuzzaman, *et al*. 2016). Almost all the districts of Bangladesh are affected by the natural disasters but the districts of coast line areas affected mostly in comparison to the other districts of the country. Cox's Bazar District is the worst affected district among the 19 coastal districts of country. There are 8 Upazilas under Cox's Bazar District. Being flowed beside the Bay of Bengal, Most concerned natural disasters of the study area are cyclone, tidal surge, flash flood, river and canal erosion, water logging, heavy rainfall etc (DMB, 2010).
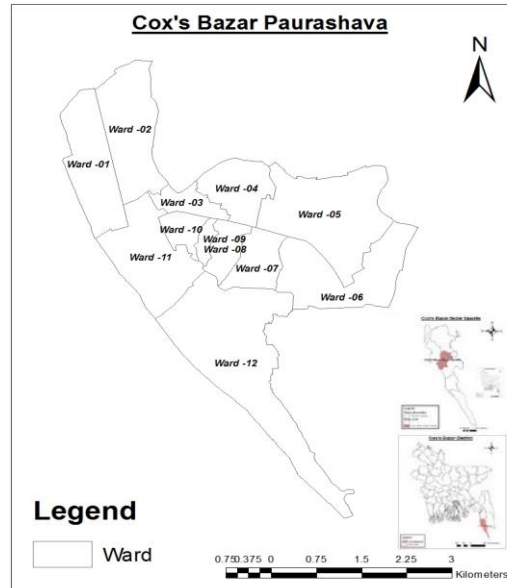
Figure 1: Map of the study area

Source: Field Survey, 2019 and Prepared by Authors, 2020

Socio-Economic Condition

In this study, it is found that 50% respondents of Cox's Bazar Paurashava are within age limits 30-60 and 50% respondents have graduation degree. So it might be told that Cox's Bazar Purashava has large educated people. It is also found that agriculture (40%) and business (30%) sectors are dominant occupations in Cox's Bazar Paurashava. It is noticed that maximum people have bank savings account. As a tourist area, people make lots of transaction through banking channel.

Vulnerability Assessment Analysis

As physical, social and economic vulnerabilities to natural disaster are considered in this study as dimensions of vulnerability, the final vunerability has been found by summing up these three.

Physical Vulnerability Assessment

In order to calculate the physical vulnerability score, five (5) assessment criteria have been set: 1) house location from sea and river, 2) structure of house, 3) physical protection system, 4) distance from major road and 5) cyclone shelter. If the criterion "house location within 1 km. from sea and river" is found, the score for this criterion is considered five (5) which means the vulnerability to the natural disaster is higher considering the distant respondents. This scale of score goes from 5 to 1. The highest vulnerability has been denoted as 5 and the lowest is 1. Same as this criterion, score are provided to the other four (4) criteria.

Table 4: Physical vulnerability score

Criteria	Scale of Scoring (1 to 5)	Physical Vulnerability Score for each ward											
		1	2	3	4	5	6	7	8	9	10	11	12
House location within 1 km. from 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
Structure of House	Mud/Bamboo = 5 Tin = 4 Tin and Brick = 3 Brick = 2 Others = 1	3	4	4	4	3	4	3	4	4	2	2	2
Physical Protection System	Below 20% = 5 From 20-40% = 4 From 40% - 60% = 3 From 60%-80% = 2 More than 80% house = 1	4	4	4	5	4	5	4	4	3	3	4	4
Distance from *Pucca* Road)	Above 3 km. from house = 5 From 2-3 km.= 4 From 1-2 km. = 3 From 0.5-1 km. = 2 Below 0.5 km. = 1	3	1	1	2	2	2	3	2	2	1	2	1
Distance from cyclone shelter	Above 3 km. from house = 5 From 2-3 km.= 4 From 1-2 km. = 3 From 0.5-1 km. = 2 Below 0.5 km. = 1	3	3	3	2	3	2	3	2	3	3	2	2
Average		3.6	3.2	3.2	3.2	3	3.2	3	2.6	2.8	2.6	3	2.8
Vulnerability Level		S	H	H	H	M	H	M	M	M	M	M	M

*M=Moderate; H=High; S=Severe

Source: Prepared by Authors, 2020; Field Survey, 2019

From Table 4, it is found that Ward No. 1, 2, 11 and 12 are very close to the Bay of Bengal. On the other hand, ward number – three, four, five, six are very close to the *Bakkhali* River. Maximum household of Ward No. 5, 6, 7, 8, 9 and 10 are far from the sea and the river. So, it can be said that Ward No. 1, 2, 3, 4, 7, 12 are most risky areas due to closeness to the sea and river.

From the survey data, it is found that most of the dwelling unit uses Tin as their structural material. Above 50% respondents in every ward except Ward No. 10, 11 and 12 reported that they use tin and bricks as their construction materials for housing. On the

other hand, about 50% respondents in the Ward No. 10, 11 and 12 reported that they build houses using bricks, cement and stones. So, it can be said that a significant number of households in the study area are vulnerable to cyclones due to lack of strong structural materials.

Recently Cox's Bazar Paurashava has been inundated by flooding. Maximum household of the study area have reported that they have faced water logging in monsoon now-a-days. It is going to be a daily phenomenon in Cox's Bazar Paurashava. It is found that 62% - 80% respondents of every wards reported that they are now affecting through water logging. There is no effective water protection system through which water can be released to the outside of the embankment or dam during rain.

From the field survey (2019), it is seen that almost 38% respondents of Ward No. 2, 3, 10 and 12 reported that they are living close to the *Pucca* road and it is within 500 meters from the *Pucca* road. Moreover, 38% respondents of Ward No. 4, 8, 9, 11 and 12 told that they are living between 1 km. to 0.5 km. distant from *Pucca* road. Maximum respondents of Ward No. 1 and 7 added that they are living within 1-2 km. from *Pucca* road. As the distances of houses increase from the *Pucca* road, it can be risky for those who have vulnerable housing structure and have to take shelter on any permanent structure like roads, shelter house etc.

In coastal region, cyclone shelter is very important. People of different ages could stay in here during any kind of natural disaster like cyclone. So, it is very important matter to establish in that point where it can serve lots of people to stay here during disaster. 38% respondents of Ward No. 4, 6, 8, 11 and 12 told that they are living between 1 km. - 0.5 km. from cyclone shelter. But Maximum respondents 38% of Ward No. 1, 2, 3, 5, 7, 9 and 10 added that they are living within 1-2 km. from cyclone shelter (Field Survey, 2019).
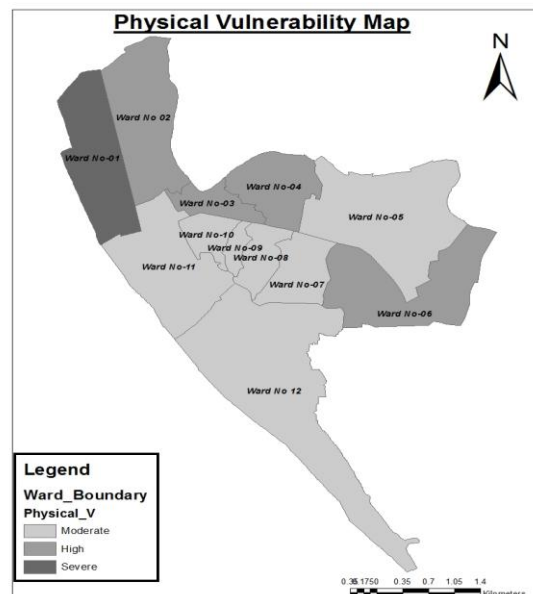

Figure 2: Physical vulnerability map of the study area

Source: Field Survey, 2019 and Prepared by Authors, 2020

Using Vulnerability Assessment Level (Table 2), three level of physical vulnerable conditions are found in the study area and they are:

1. Moderate vulnerable area,

2. Highly vulnerable area and

3. Severe vulnerable area.

Ward No. 5, 7, 8, 9, 10, 11 and 12 are moderate vulnerable and Ward No. 2, 3, 4 and 6 are highly vulnerable area. Ward No. 1 is severe vulnerable than all other wards.

Social Vulnerbility Assessment

Social vulnerability includes certain demographic and social characteristics that make particular communities more vulnerable than others. Unlike biophysical vulnerability or other exposure indicators, social vulnerability or sensitivity is an important hazard type or threat source. In other words, it is a pre-existing condition or an inherent property of individuals or existing communities, irrespective of the natural hazard of interest (Cutter & Finch 2008).

In order to calculate the social vulnerability score, eight assessment criteria have been selected which are: age, occupation, education, early warning system, access local government, number of children, safe drinking water and access to information. Table 4 shows social vulnerability of each wards of the study area using those eight selected criteria with the help of a scale of scoring ranging from 5 to 1.

Table 5: Social vulnerability score

Factors	Scale of Scoring (1 to 5)	Cox's Bazar Paurashava Ward Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Age	Maximum People Age Above 60 = 5 Maximum People Age Below 10 = 4 Maximum People Age Between 11 - 16 = 3 Maximum People Age Between 41 - 59 = 2 Maximum People Age Between 17 - 40 = 1	1	1	1	2	1	2	1	2	1	1	1	1
Occupation	Fishing = 5 Agriculture = 4 Informal Activities = 3 Business = 2 Official Job = 1	2	2	4	4	4	2	2	2	2	2	3	3
Educational Status	Illiterate = 5 Below SSC = 4 SSC = 3 HSC = 2 More than Graduate = 1	1	1	3	1	2	1	2	1	1	1	2	1

Factors	Scale of Scoring (1 to 5)	Cox's Bazar Paurashava Ward Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Early Warning System	Below 20% = 5 From 21-40% = 4 From 41% - 60% = 3 From 61%-80% = 2 More than 80% house = 1	2	3	1	2	3	2	2	1	3	2	2	1
Access to Local Government	Below 20% = 5 From 21-40% = 4 From 41% - 60% = 3 From 61%-80% = 2 More than 80% house = 1	4	3	2	4	3	4	4	4	5	3	3	3
More than 2 children	More than 80% House = 5 From 61%-80% House = 4 From 41% - 60% House = 3 From 21-40% House = 2 Below 20% House = 1	3	4	4	4	3	4	5	4	4	5	3	4
Safe Drinking Water	Below 20% = 5 From 21-40% = 4 From 41% - 60% = 3 From 61%-80% = 2 More than 80% house = 1	4	4	3	2	3	2	3	2	3	2	4	2
Access to Information System	Below 20% = 5 From 21-40% = 4 From 41% - 60% = 3 From 61%-80% = 2 More than 80% house = 1	2	1	1	1	2	1	1	1	2	1	1	1
Average		2.3	2.3	2.3	2.5	2.6	2.2	2.5	2.1	2.6	2.1	2.3	2
Vulnerability Level		L	L	L	L	M	L	L	Lr	M	Lr	L	Lr

*Lr=Lower; L=Low; M=Moderate

Source: Field Survey, 2019 and Prepared by Authors, 2020

From Table 5, it is seen that most of the respondents of this study are between the age of 17 to 59. Majority of the population of ward three, four and five are engaged in agriculture; ward eleven and twelve have more informal activities and ward one, two, six, seven, eight, nine and ten have business as their major occupation. Educational status of the study area is quite satisfactory. Majority of the respondents are literate within the study area.

Effective early warning reduces the risk of any disaster like cyclone or flood. So, if warning system can be well circulated within the mass people, the losses and damages will be reduced massively. Table 4 represents disaster warning conditions in the study area. It is found from the field survey (2019) that almost 70% respondents receive disaster early warning from concerned agencies. It is also found that the main sources of disaster warning are government agencies, news media, army/police, community-based organization/club etc. Community based organizations are the main sources of disaster warning in the study area followed by government agencies (Field Survey, 2019).

Cox's Bazar Paurashava authority has played amazing role to mitigate the disaster risk. It is found that the respondents of only Ward No. 3 have easy access to local government body because the location of local government authority is very close to them (Field Survey, 2019). But others live at a distant from the local government authority which makes them more vulnerable than the close one.

It is seen that 70% respondents of Ward No. 2, 3 4, 6, 8, 9 and 12 have more than two children in their house. On the other hand, range between 41-60% respondents of Ward No. 1, 5 and 11 told that they have also over two children in their own houses. It is clear from the table that more than 80% houses of Ward No. 7 and 10 have more than two children. This percentage varies between 40% to 80% in the rest of the wards (Field Survey, 2019). That is to say, maximum households of the study area have more than two children. They also have some disabled and old aged people in their houses which make them more vulnerable during natural calamities.

Maximum households of the study area have reported that they have safe drinking water other than ward number one, two and eleven where only 20% to 40% households have access to safe drinking water. According to the respondents of the survey, the salinity in water is increasing rapidly (Field Survey, 2019). Maximum households of the study area have reported that they are using mobile phone, radio, television to know the information about the natural calamities. In recent years, they are informed about any matters regarding climate or disaster through these technologies which ease their life to handle and cope with these calamities.

Figure 3: Social vulnerability map of the study area

Source: Prepared by Authors, 2020
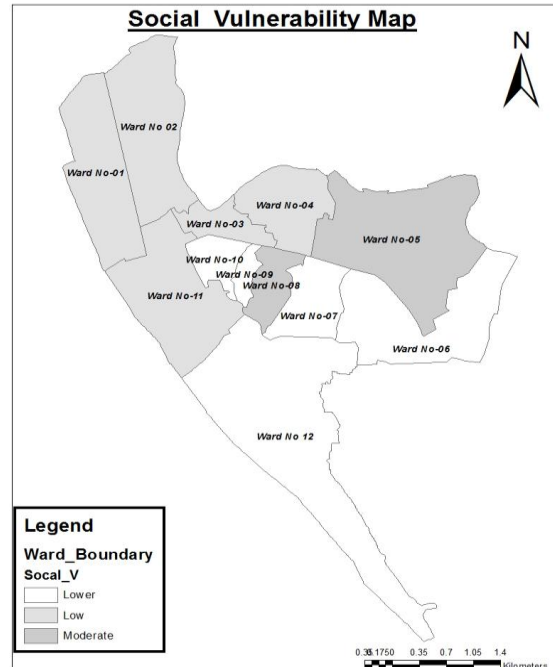
From the above calculation of Social Vulnerability Score, this study found three types of socially vulnerable condition out of five vulnerable condition using Vulnerability Assessment Level of Table 2 and they are:

1. Lower vulnerable area
2. Low vulnerable area
3. Moderate vulnerable area

Ward No. 8, 10 and 12 are lower vulnerable area; Ward No. 1, 2, 3, 4, 6, 7 and 11 are low vulnerable area and Ward No. 5 and 9 are moderate vulnerable area according to the Vulnerability Assessment Level (Table 2).

Economic Vulnerability Assessment

Economic vulnerability composed of some significant criteria factors which are income; savings and assets; and earning member more than one. These criteria factors are more relevant to the vulnerability of the people in the coastal area. High income, good saving condition and more than one earning member are very important to reduce the economic vulnerability to natural disaster in the coastal area. These factors make people more resilient to minimise the damage of natural disaster.

Table 6: Economic vulnerability score

Criteria	Scale of Scoring (1 to 5)	Number of people in each ward											
		1	2	3	4	5	6	7	8	9	10	11	12
Income	0 -7000 BDT = 5 7000 – 12000 BDT = 4 12000 – 18000 BDT = 3 18000 – 25000 BDT = 2 25001 Above = 1	3	3	2	3	2	3	4	3	3	3	2	3
Savings and Assets	Below 20% People = 5 From 20-40% People = 4 From 40% - 60% People = 3 From 60%-80% People = 2 More than 80% People= 1	2	2	5	5	4	2	4	2	4	2	2	3
Earning Member More than One	Below 20% = 5 From 20-40% = 4 From 40% - 60% = 3 From 60%-80% = 2 More than 80% house = 1	3	5	4	5	5	3	3	3	4	5	3	3
Average		2.6	3.3	3.6	4.3	3.6	2.6	3.6	2.6	3.6	3.3	2.3	3
Vulnerability Level		M	H	S	S	S	M	S	M	S	H	L	M

*L=Low; M=Moderate; H=High; S=Severe

Source: Field Survey, 2019 and Prepared by Authors, 2020

Table 6 describes that about 75% respondents from Ward No. 1, 2, 4, 6, 8, 9, 10 and 12 earn BDT 12000-18000 monthly. Almost 62.5% respondents from Ward No. 3, 5 and 11 earn BDT 18000-25000 monthly. On the other hand, most of the respondents (75%) from Ward No. 7 earned BDT 7000-12000 monthly (Field Survey, 2019).

In terms of savings and assets, most of the respondents from Ward No. 1, 2, 6, 8, 10, 11 and 12 have savings in different banks and financial organizations. Tendency of savings of the respondents from Ward No 3, 4, 5, 7 and 9 is not remarkable.

Maximum households of the study area have only one earning member. Where less than 20% respondents of Ward No. 2, 4, 5 and 10 have more than one earning member in their families. As the study area is located at the side of beach, different types of business are growing for tourism purpose.
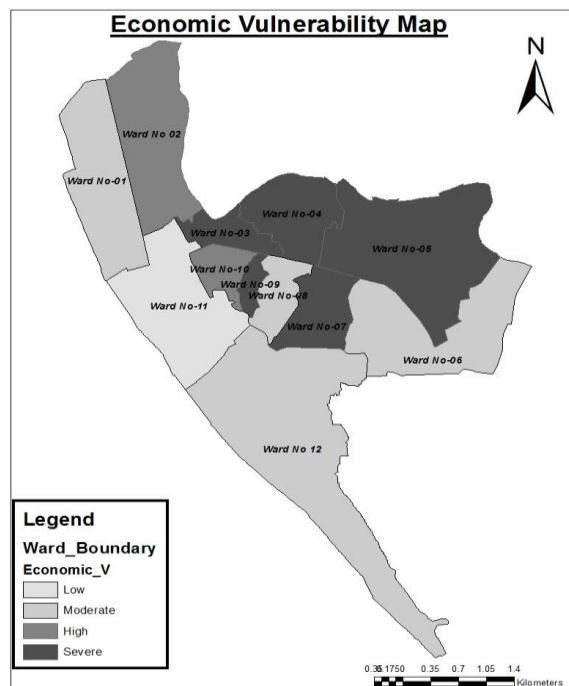

Figure 4: Economic vulnerability map of the study area

Source: Field Survey, 2019 and Prepared by Authors, 2020

While assessing economic vulnerability, this study identifies that four types of economic vulnerability level are seen in the study area using Vulnerability Assessment Level of Table 2 and they are:

1.   Low vulnerable area

2.   Moderate vulnerable area

3.   Highly vulnerable area

4.   Severe vulnerable area

Only one ward of the Cox's Bazar Paurashava (Ward No. 11) is low vulnerable area in terms of economic condition among all the other wards of the study area. Ward No. 1, 6, 8 and 12 are moderate vulnerable area. And Ward No. 2 and 10 are highly vulnerable area. On the other hand, Ward No. 3, 4, 5, 7 and 9 are severe economically vulnerable area.

Vulnerability Assessment Index (VAI)

From the calculation of, physical vulnerability, social vulnerability and economic vulnerability, a combined final vulnerability score has been calculated for each ward using the following formula:

Combined Vulnerability Assessment Index, R = (Social + Physical + Economic)/3

Table 7: Vulnerability index of the study area

Ward	Physical Vulnerability	Social Vulnerability	Economic Vulnerability	Vulnerability Score	Vulnerability Category
Ward - 01	3.6	2.3	2.6	2.8	Moderate
Ward – 02	3.2	2.3	3.3	2.9	Moderate
Ward – 03	3.2	2.3	3.6	3.03	High
Ward – 04	3.2	2.5	4.3	3.3	High
Ward – 05	3	2.6	3.6	3.06	High
Ward – 06	3.2	2.2	2.6	2.66	Moderate
Ward – 07	3	2.1	3.6	2.9	Moderate
Ward – 08	2.6	2.1	2.6	2.4	Low
Ward – 09	2.8	2.6	3.6	3	Moderate
Ward – 10	2.6	2.1	3.3	2.66	Moderate
Ward – 11	3	2.3	2.3	2.53	Low
Ward - 12	2.8	2	3	2.6	Moderate
Average	3.017	2.283	3.20	2.82	--
Vulnerabil-ity Level	**High**	**Low**	**High**	**Moderate**	--

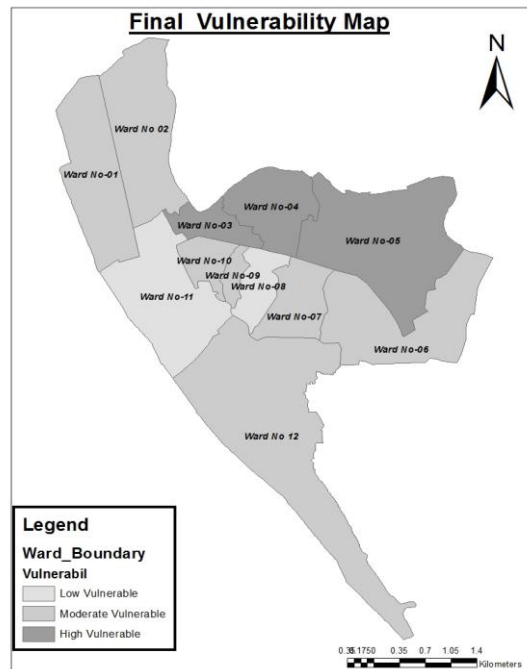Source: Field Survey, 2019 and Prepared by Authors, 2020

Figure 5: Vulnerability map of the study area

Source: Prepared by Authors, 2020

So According to the above calculation, Vulnerable Index is formulated combining physical, social and economic vulnerability. In this regard, this study identifies three types of vulnerability finally. Three wards (Ward No. 3, 4 and 5) out of twelve wards of Cox's Bazar Paurashava have been resulted as a high vulnerable area of natural disaster like cyclone, flood, storm surge, Tsunami; whereas seven wards (Ward No. 1, 2, 6, 7, 9, 10 and 12) of the Paurashava have been categorized as moderate vulnerable area. Two wards (Ward No. 8 and 11) are identified as low vulnerable area.

On the other hand, comparing the three types of vulnerability of twelve wards of the study area, physical and economic vulnerabilities of the study area are high and the social vulnerability is low and combinedly, the study area is moderately vulnerable according to the Vulnerable Assessment Level (Table 2).

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.

The methodology used in this study is very effective to identify the socio-economic and physical factors which are responsible to make the study area vulnerable to disasters. This study shows, about three Wards out of twelve wards in the paurashava are into a highly vulnerable category because of their socio-economic conditions and geographical location. This Vulnerability Assessment Index can help the study area to categorize the

vulnerable areas with their vulnerability level to the disaster. The more vulnerable area to a disaster, the more risky area to the disaster. So, this index can help to identify the areas which need prior concern during or before any natural hazard and based on this categories, the concerned authorities can take measures to the most required areas.

The methodology can be used in the other coastal districts or countries 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 etc. It is also recommended that appropriate physical, social and economic indicators should be identified for vulnerable assessment in the other areas of the country.

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