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Review Article

Cyclone Vulnerability Reduction Management System in Bangladesh

Md Nur-Us-Shams[1*], Tasnuva Islam[2]

[1]Department of Engineering, University of Dhaka, Dhaka, Bangladesh;[2]Department of Electronics Engineering, Barisal Polytechnic Institute, Barisal, Bangladesh

ABSTRACT

Bangladesh is one of the densely populated countries in the world. Currently, 150 million people lives here. Out of them, 35 million people, representing 24% of the total population in coastal districts (Second Administrative Tertiary) named as coastal areas. This coastal area covers 46080 square kilometer area which is 32% of the country. In Coastal areas, Cyclone cause great loss in any country; especially in Bangladesh. It damages not only human lives; but also damage roads, embankments and houses. Here, a huge number of coastal people and islanders lost their lives and cannot get emergency shelter facilities during cyclones due to uneven distribution and locations of existing shelters. Also, most of the rural people have lack of emergency facilities and their residents are far from existing shelters. The capacities of these existing shelters have been analyzed and found that some shelters have sufficient capacity, some needed to be extended on existing locations, while some shelters could not be extended within their existing locations. For this reason, this paper focuses to analyze current cyclone vulnerability reduction management system in Bangladesh. Lastly, it shows a possible way to need more attention to minimize vulnerability reduction in Bangladesh.

Keywords: Cyclone; Vulnerability; Coastal area

INTRODUCTION

Natural disaster is a catastrophic event caused by natural processes on the earth. It can be happened anywhere of the world. Bangladesh, a small country with 147470 square kilometer land. It is one of the most disaster prone countries in the world. It faces extreme natural disasters, especially Cyclone, Tropical Floods, and Storm Surges [1]. It is a global hotspot for tropical cyclones. The topography is flat and with two-thirds of its land is less than 5 m. A severe cyclone inundates one thirds of coastal areas in every three years [2]. An average of 1-3 severe to moderate cyclonic storms hit in Bangladesh each year [1]. Currently, 35 million people live in coastal districts in Bangladesh. This huge number of coastal people settled at low elevated coastal areas. As a result, these people live with high risk during cyclones; particularly when high tides combine with storm surges [3].

Current disaster in Bangladesh

Bangladesh is a low-lying and deltaic country. It is universally known as highly vulnerable to climate-related disasters, particularly riverine and coastal flooding. The coastal morphology influences impact of natural hazards on coastal areas; especially, south, south eastern and south western areas. The natural hazards increase vulnerability of coastal dwellers and slow down social-economic development in Bangladesh.

Geographical features

Bangladesh is in the frontline of battle against climate changes. Considering last hundred year's information, approximately, 49% of the world total cyclone related deaths have been occurred in Bangladesh [4]. About 42% of disaster related death caused by tremendous cyclones at 16 coastal districts (Table 1 and 2) [5] .

Table 1: Geographical Informations in Bangladesh.

Description	Total land Area with Population Density		
	Unit	Total	Coastal Area
Land Area	Square Kilometer (sqkm)	147570	47201
Total Upazila	Nos	507	147
Total Union	Nos	4484	1351
Total Village	Nos	87928	17618
Population Density	Nos/sqkm	839	743

Correspondence to: Md Nur-Us-Shams, Department of Engineering, University of Dhaka, Dhaka, Bangladesh, E-mail: shams.lged@gmail.com

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Table 2: Stastical Information's of Coastal Districts.

District Name	Comparison of districts total land areas and coast area	
	District total land area (Square kilometer)	Corresponding coast area (Square kilometer)
Bagerhat	3959	2679
Barguna	1831	1663
Barisal	2785	~
Bhola	3403	3403
Chandpur	1704	~
Chittagong	5283	2413
Cox' Bazar	2492	2492
Feni	928	235
Jhalakathi	749	~
Khulna	4394	2767
Lakhmipur	1456	571
Noakhali	3601	2885
Patuakhali	3221	2103
Pirojpur	1308	353
Satkhira	3858	2371

LITERATURE REVIEW

Major hazards at coastal areas

Though Bangladesh is a small country; but it faces different types of natural hazards. Some hazards are man-made and some are natural. Man-made hazards can be minimized, but natural hazards are very difficult to control and mitigate [6]. So, overviews of natural hazards are summarized below to get a picture about how much emphasis would be needed on these areas (Tables 3 and 4).

Frequency of cyclones

The seasonal distribution of cyclones depends on seasonal variations of location of monsoon through. An interrelationship has been found between frequencies of cyclones in monsoon and post-monsoon periods. In Bangladesh, there are two peaks of tropical cyclones; one occur in May within peak season of pre-monsoon (April-May) and another one happen in October within the post-monsoon (October-November). Bangladesh experienced 66 cyclones; out of them, 36 cyclones have been identified as severe [6]. Several numbers of disastrous cyclones have been struck in 1822, 1876, 1961, 1965, 1970 and 1991 [7]. For this reason, the entire coastal areas classified into four coasts according to past hit directions and damaging impacts (Figure 1). Among the coasts, Chittagong-Cox's Bazar Coast experienced maximum hits by a frequency of 33.64% and it is affected more frequently than other coastal districts; whereas Noakhali-Patuakhali Coast affected by a frequency of 26.17% [8]. The details of tropical cyclones mentioned in Table 5.

Historical cyclones

The direct or indirect impacts from a cyclone can be divided into cost of destruction, cost of preparation, cost of the warning service, cost of assistance, loss in business revenue and losses to agriculture sectors. A numerous cyclones hit in four coast zones [9]. The following table showed an overall view of cyclones with their intensity from 1960 to 2017 (Table 6).

Table 3: List of major hazards.

Peril	Comparison of different types of hazards	
	Potential Severity	Relative Frequency
Tropical Cyclone	High	High
Flood	High	High
Severe Storm	High	Low
Extreme Temperature	Moderate	High
Drought	High	Moderate
Fire	Local	Moderate
Building Collapse	Local	Low
Landslide	Local	L:ow
Arsenic Contac\mination	~	~
Riverbank erosion	~	~

Table 4: Distribution of Disaster affected household by division and disater from 2009-14.

Peril	Disaster Affected Household (%)									
	Drought	Flood	Water Lodge	Cyclone	Tornado	Tidal surge	Thunderstorm	River Erosion	Landslide	Salinity
Barisal	1.41	5.24	3.91	78.31	0.91	31.51	3.72	4.35	0	0.85
Chittagong	10.61	32.03	34.39	30.96	1.8	13.51	8.39	7.01	0.8	5.3
Dhaka	19.89	51.89	18.68	0	3.88	0	17.69	6.42	0	0
Khulna	9.3	7.68	34.88	23.23	2.62	9.16	7.39	4.15	0	22.24
Rajshahi	25.39	48.47	0.65	0	7.51	0	20.4	3.39	0	0
Rangpur	23.99	41.74	0.68	0	12.3	0	23.53	6.87	0	0
Sylhet	16.51	69.97	2.57	0	1.3	0	31.84	1.95	0.02	0
Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local

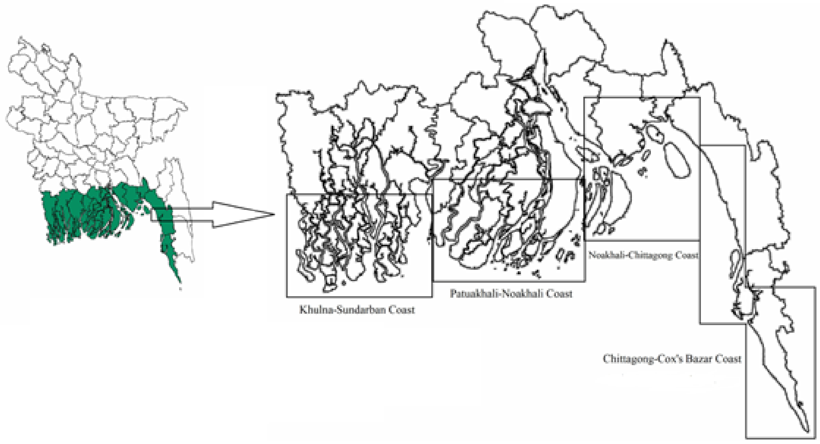

Figure 1: Four Coastal Zones in Bangladesh (Rectangle areas).

Table 5: Cyclone frequency at coastal areas.

Coast Name	Indicators name	
	Height (m)	**Frequency (%)**
Khulna-Sundarban Coast	0.61-4.55	21.5
Patuakhali-Noakhali Coast	0.60-13.64	26.17
Noakhali-Chittagong Coast	0.90-13.03	18.69
Chittagong-Cox's Bazar Coast	0.90-5.15	33.64

Table 6: Major Cyclones from 1960-2017 in Bangladesh.

Date of occurrence	Cyclone name and with its Intensity		
	Nature of Phenomenon	**Maximum Wind Speed (km/hr)**	**Tidal Surge Height (ft)**
11-10-1960	Severe Cyclonic Storm	160	15
31-10-1960	Severe Cyclonic Storm	193	20
09-05-1961	Severe Cyclonic Storm	160	08-Oct
30-05-1961	Severe Cyclonic Storm	160	Jun-15
28-05-1963	Severe Cyclonic Storm	209	08-Dec
11-05-1965	Severe Cyclonic Storm	160	12
05-11-1965	Severe Cyclonic Storm	160	08-Dec
15-12-1965	Severe Cyclonic Storm	210	08-Oct
01-11-1966	Severe Cyclonic Storm	120	20-22
23-10-1970	Severe Cyclonic Storm of Hurricane intensity	163	~
12-11-1970	Severe Cyclonic Storm with a core hurricane wind	224	Oct-33
28-11-1974	Severe Cyclonic Storm	163	Sep-17
10-12-1981	Cyclonic Storm	120	Jul-15
15-10-1983	Cyclonic Storm	93	~
09-11-1983	Severe Cyclonic Storm	136	5
24-05-1985	Severe Cyclonic Storm	154	15
29-11-1988	Severe Cyclonic Storm with a core hurricane wind	160	2-15.5

18-12-1990	Cyclonic Storm	115	05-Jul
29-04-1991	Severe Cyclonic Storm with a core hurricane wind	225	Dec-22
02-05-1994	Severe Cyclonic Storm with a core hurricane wind	220	05-Jun
25-11-1995	Severe Cyclonic Storm	140	10
19-05-1997	Severe Cyclonic Storm with a core hurricane wind	232	15
27-09-1997	Severe Cyclonic Storm with a core hurricane wind	150	Oct-15
20-05-1998	Severe Cyclonic Storm with a core hurricane wind	173	3
28-10-2000	Cyclonic Storm	83	--
12-11-2002	Cyclonic Storm	65-85	05-Jul
19-05-2004	Cyclonic Storm	65-90	02-Apr
15-11-2007	Severe Cyclonic Storm with a core hurricane wind (SIDR)	223	15-20
25-05-2009	Cyclonic Storm (MAILA)	70-90	04-Jun
16-05-2013	Cyclonic Storm (MAHASEN)	100	--
30-07-2015	Cyclonic Storm (KOMEN)	65	05-Jul
21-05-2016	Cyclonic Storm (ROANU)	128	04-May
30-05-2017	Severe Cyclonic Storm (MORA)	146	--

Current vulnerability reduction measures

The cyclones cannot be stopped; however, various effective measures have been initiated to reduce vulnerabilities of lives and properties in Bangladesh. As a part of vulnerability reduction strategy, Bangladesh adapted a long term disaster management and mitigation plan. The Government of Bangladesh (GoB) with associate agencies, different non-government bodies, international and UN agencies play a vital role for immediate response and subsequent rehabilitation activities of the affected people. It implemented awareness campaigns to disseminate information about cyclone warning signals and preparedness measures, discussions, posters, leaflets, film shows and demonstration performances. Also, GoB has given equal importance both on Non-Structural Mitigation Measures (NSMM) and Structural Mitigation Measures (SMM) for cyclone vulnerability reduction. The NSMM are forecasting and Early Warning System, public awareness. SMM are coastal embankments, earthen mounds (Killa) and cyclone shelters construction. The EWS conducted by Bangladesh Meteorology Department (BMD) to get weather forecasts and early warnings. Earlier, weather forecasting system used satellite imagery to monitor upcoming events. But only weather forecast systems are not able to accurately predict cyclone intensity, speed and direction. So, it is necessary to develop more accurate methods to get appropriate locations and time [10].

On the other hand, earth observation data helps to assess and develop model of climate changes, potentially allowing for development of sustainable risk management strategies. These advanced data develops early warning information which can be used for proactive management. Currently, an information and communication technology such as internet, GIS, GPS, Satellite and other electronic communications are used to get advance information. Also, high resolution of satellite images, radar and a network of densely spaced meteorological observatories are useful tool to predict or for issuing warning for vulnerability reduction planning [11].

However, due to an absence of central and common disaster preparedness plan, a miscommunication exists between different authorities. Also, bureaucratic hassles, confusion about legal framework make problems on immediate preparedness and initiative [12]. Also, there is a lack of communication network in the rural areas; specially, radio and television are not available at all villages and islands. So, villagers cannot get emergency news. As a result, rural people suffer more than urban people.

Inadequate integration and co-ordination: Government, the ministries with consecutive departments, agencies, NGOs, civil societies and private sectors, local and international development partners pursued a strategy to reduce overall disaster impact; however, there exist gaps between policies at national and local levels. These initiatives are less consistent and less harmonious. Also, the regional coordination is relatively weak [11]. Furthermore, a lack of communication has been practicing between universities or another research institutes and local government bodies. So, it is essential to develop a strong relationship among different research organizations and government implement bodies.

The SMM are coastal embankments, earthen mounds (Killa) and cyclone shelters. Their details shown below:

Hydraulic structures: GoB constructed different types of structures. In Bangladesh, 3400 Kilometer long drainage channels and 9000 Sluice Gates with regulators at different areas. These structures constructed for safety measures against inundation of tidal waves, storm-surges and floods. Also, 3,841 number Cyclone Shelters have been identified at different locations in 16 coastal areas [13]. These shelters help to save people during natural disasters.

Earthen embankment: First earthen embankments have been constructed in 1960 along coastlines and islands in Bangladesh. Currently, 13000 km long Earthen Embankments exist against inundation [14]. Out of 13000 km long embankments, only 4000 km of coastal embankments along coastline and islands. Nearly 4600 km exist along bank of big rivers and rest 4,400 km of low-lying embankments along small rivers, haors and canals.

Though a huge length of Earthen Embankments constructed; however, construction and maintenance of this huge length is very expensive. Rain water splash, water seepage and water flow through old embankments and fail its internal strength due to irregular maintenance. So, these structures cannot stand against high tides effectively. Furthermore, the embankment built to protect high tide approximately six feet; as a result, most cases, the tidal waves overtopping the embankments and inundate nearby coastal areas. Lastly, there are no identified policies for routine maintenance of these existing embankments (Figure 2).

Figure 2: Location of earthen embankment at coastal zones. **Note:** (——) Embedment

Killa is an earthen mound. It is constructed by raising ground level above the normal ground. There are 190 Killa have been identified at different islands in Bangladesh. Out of these 190 killa, only 156 number constructed by Bangladesh Red Crescent Society in early seventy and rest 34 number constructed by Local Government Engineering Department (LGED) after the cyclone in 1991 to protect domestic animals, particularly cows, goats and buffalos.

Killa is usually rectangular in plan, varying with sizes from 24.4 m × 18.3 m. Naturally, it is located far from human settlement; as a result, people are not willing to walk a long distance to keep their cattle's. Also, due to rare use and lack of routine maintenance leads to weak slopes and growing of long grasses [15]. Also, killa needs approximately 20000 square meters of lands; most cases it is difficult to find large lands in local areas. So, GoB planned not to build killa due to the scarcity of lands [16].

GoB and other agencies constructed 132 multi-purpose cyclone shelters after devastating cyclone in 1970. The shelter locations prioritized at the existing union councils (the lowest administrative tier in Bangladesh) [15]. It is two storied building where upper floor used as shelter.

Currently, 3841 no of cyclone shelters have been identified at 16 coastal districts in Bangladesh. As a result, death toll reduced from 500,000 (year 1970) to 190 (year 2009) [17]. It makes an attempt to explore why relatively less people lost their lives during cyclone in 2007. Most of the studies identified that a network expansion of multipurpose cyclone shelters with an early warning system and its timely dissemination brought these success [18]. As a result, this vulnerability reduction strategy has been widely credited and proposes to increase the capacities of new cyclone shelters for the coastal areas (Figure 3) [19].

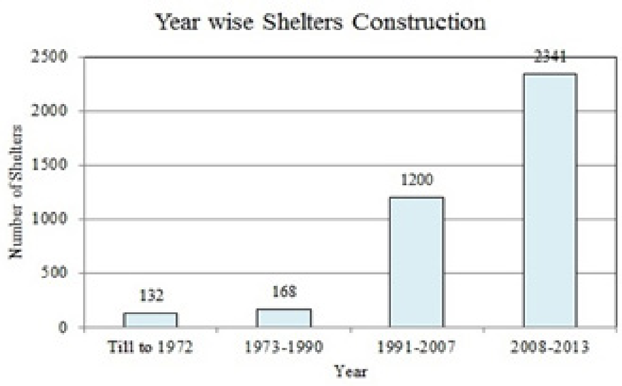

Figure 3: Yearwise Cyclone shelters construction history.

Bangladesh Ministry of Food and Disaster Management (MoFDM) is playing a vital role for cyclone risk mitigation and management. A spatial distribution of these existing shelters location has been shown in Figure 4.

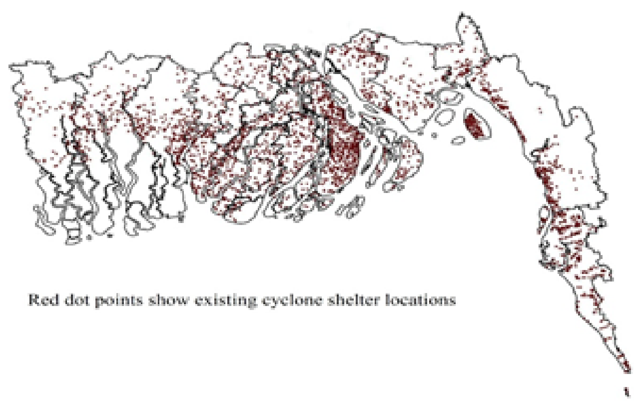

Figure 4: Geospatial locations of existing cyclone shelter locations at coastal areas.

Though a huge number of Cyclone Shelters have been constructed; however, these can accommodate only 27% of coastal population [14]. A survey conducted by Comprehensive Disaster Management Program (CDMP) for analysis the performances of these shelters in 2013; it summarized that shelter capacities is not enough for these huge number of coastal people. Also, shelter number is not adequate for coastal people [18,19]. Furthermore, due to flooding and inaccessible transportation system, only two out of every five cyclone shelters are usable during cyclone. As a result, a majority of people are still uncovered and living with risks.

On the other hand, the distribution of existing cyclone shelters is highly uneven [20]. Only three districts have a capacity to accommodate twenty five to fifty percent of its population. Most cases, each shelter can accommodate only 10-20 percent of its population and some cases less than 10 percent only. Also, the locations of existing cyclone shelters are far from local community. So, the local people are reluctant to go far cyclone shelters.

Furthermore, the structural conditions of existing cyclone shelters are conducted by Schmidt hammer Test and Windsor Pin Test. Though structural designs and amenities of those shelters are different, but result initiated an issues. It depicts that 67% cyclone shelters are usable, 24% used as primary schools, 7% is not usable and 2% will need to abandon immediately due to lack of proper maintenance. Also, some cyclone shelters constructed very close to the river bank and it makes another issue for instability due to river bank erosion problems in Bangladesh.

However, another study identified that 56% (2,151 Nos.) shelters locate in high risk areas, 24% (922 Nos.) are locate at risk areas, 9% (346 Nos.) situate at low risk areas and rest 11% (423 Nos.) are safe areas. Also, 8% of shelters are currently vulnerable in terms of inundation risk maps. So, it is an issue to determine suitable locations to construct additional 7000 number of cyclone shelters in Bangladesh.

On the other hand, there is no identified financial heads in national budget for restoration and maintenance of existing cyclone shelters in Bangladesh. As a result, proper maintenance cannot be ensured properly. So, different development partners have been expressing their concerns for proper maintenance and appropriate management. After all, reviewing different literatures and current reports, it has been summarized that an inappropriate locations, lack of sufficient accommodations and structurally poor conditions are major problems of existing cyclone shelters at the coastal areas in Bangladesh. So, it is necessary to more emphasis these identified problems.

There are different approaches have been initiated to improve these problems. One possible way is to find suitable locations to increase more coverage area of vulnerable people. An appropriate location can improve this problem by analyze population distribution, road network and shelter capacity, using Geographic Information System (GIS). The GIS integrates geographic features with tabular data to assess and better understand of real problems by using simple code and storing data in a computer, allowing further modification and extension. It can be used to determine preferable locations by applying different scenarios. However, an identification of populated area is a complex task at villages and islands in developing countries. Due to time constraints and data limitation, only catchment area delineation, shelter capacity and road network can be considered for selecting newp shelter locations.

DISCUSSION AND CONCLUSION

Cyclone shelter plays one of the suitable roles for disaster risk management measure. In Bangladesh, number of the existing cyclone shelters is insufficient at coastal areas. Also, they are not properly located, designed and maintained. On the basis of the new concept of disaster management, it is essential to construct cyclone shelter in coastal areas. It can improve not only as an evacuation space for affected people, but also it would be consider as a community development center throughout the whole year. So, an additional initiative would be needed to select more accessible and suitable locations to construct new cyclone shelters at coastal areas in Bangladesh.

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