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Changing Profile of Cyclones in the Context of Climate Change and Adaptation Strategies in Bangladesh

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Abstract: Bangladesh **-** a disaster-prone country of South Asia - is considered to be one of the most vulnerable countries in the world due to the adverse impacts of climate change such as sea level rise, increased salinity intrusion, short term excessive rainfall and extreme heat etc. Apart from direct impact of climate change, it has a long history of confronting with higher levels of tropical cyclones, which is now changing its pattern. It is a poor country with one third of its population living under the poverty line. This poverty scenario is often further exacerbated by the disastrous repercussions of cyclones almost every year jeopardizing the country's development activities. This paper sheds light on the profile of tropical cyclones that have swept Bangladesh over the last five decades. More specifically, it analyze the changing profile of cyclone in terms of frequency of occurrence, intensity, area of landfall, and height of storm surge based on an analysis of official cyclone data of the last 50 years that landfall in Bangladesh. It reveals that though the frequency of cyclone occurrence is reducing but their intensity is increasing day by day. Consequently, based on the analysis and overall observations of the study, the article attempts to furnish some structural, non-structural and policy recommendations both for rural and urban settings. For doing this it focus on the rural and urban adaptations strategies that can fit into the institutional development policy guide line to minimize adverse impact of cyclone in the context of its changing profile.

Keywords : Bangladesh, Climate Change, Rural Adaption, Tropical Cyclone, Urban Adaptation

1. INTRODUCTION

Bangladesh, a disaster prone flat lands, situated in the confluence of three mighty river system - Ganges, Bramaputra and Megna, making it most susceptible to various natural hazard like flood, cyclone and river erosion (Khan & Rahman, 2007: 360). About 10 million people are impacted by one or more natural hazard annually (Ernst, et al., 2007: 1). The country which is already susceptible to natural disaster is going to face additional challenges of climate change not only through its direct impact like sea level rise, salinity intrusion, extreme precipitation and temperature but also indirect impact by shaping the natural disaster like cyclone's frequency and intensity. For instance Bangladesh experienced the lowest temperature in winter in early 2013 within four decades (Releifeweb, 2013). However, tropical cyclones is the prime natural disaster face by Bangladesh almost every year causing huge damage to people's life and property. UNDP (2004:3) identified Bangladesh as most exposed country to tropical cyclone with and with an average of four cyclone striking every years. Cyclone *Sidr* of 2007 incurred an estimated damage of $1.7 billion in the coastal area which is 2.6% of total GDP (Economics of Adaptation to Climate Change: Bangladesh, 2010:2). The damages from cyclones result from not only the strong wind speed but also the storm surges they induced. Moreover, unique geographical location, high population density and low per capita income are the main structuring factors that contributing to increase its vulnerability.

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However, the profile of cyclone is changing in term of severity and frequency. Several studies support the changing profile ranging from local scale to global scale. A recent study revealed that the frequency of tropical cyclones and storm surge is likely to increase due to the increase greenhouse gasses (GHG) than in a control run by using a regional climate model and a storm surge model for the Bay of Bengal (Unnikrishnan, 2011:329).

Kerry Emanuel's study found a highly positive correlation between the hurricane power dissipation and tropical sea surface temperature. He developed an index showing the potential harmfulness that a hurricane can cause based on the lifetime of the cyclone and total dissipation of power, where he discovered that this index is increasing significantly since the mid-1970s. But study was done in case of Atlantic and Pacific region not in case of Bangladesh or south Asia (Emanuel, 2005:686).

By using secondary sources Md. Sarwarevaluated the impacts of one meter sea level rise that is going to adversely affect vast coastal are and flood prone zone of Bangladesh. It will also affect the livelihood options of coastal community and natural environment. He anticipated a total damage of Sundarban, the most important ecosystem of the country, with one meter sea level rise. It also focused on the reshaping of adaptation and mitigation measures in changing circumstances of climate change (Sarwar, 2005:2). But no such study was done in the context of tropical cyclone.

The in-depth study discussed the likely impact climate change on cyclone, coastal erosion and strom surge. It predicted that, the increase of sea surface temperature between 2-4°C due to climate change will lead to increase the tropical cyclone's frequency and intensity in Bay of Bengal. It anticipated an increase in Sea Surface Temperature could have energized the weaker (dead) cyclones and the not-taken-into-account short-lived cyclones, making them more persistent and thus increasing the number of cyclones hitting a country around Bay of Bengal (Ali, 1999:109). But this study was done in 1999. So another research is in great need to evaluate his prediction as well forecast for future.

From the perspective platform, the forth assessment report of IPCC projects that cyclone frequency and severity will increase in next 21st century making Bangladesh the most vulnerable country (IPCC, 2007: 46). The extreme vulnerability of Bangladesh is due to its geographical and geomorphological position as well as it socio economic condition to absorb the stress of natural calamity. Due to the funnel shape of southern part, naturally there is greater propensity of tropical cyclone to landfall in Bangladesh on regular basis. From socio-economic standpoint, Bangladesh has a population of 156 million with a population density of 1060 per square kilometre (Bangladesh Bureau of Statistics, 2014). Moreover, the per capita income in Bangladesh is US$1061 and more than a third (31.5%) of its population still lives in poverty; the majority of whom live in rural areas, risk prone locations and urban slums (World Bank, 2011). This huge population density and acute poverty increases the exposure and reduce the adaptive capacity both in rural and urban area.

On macroeconomic aspect about 17.5% of the country's GDP comes from agriculture, which makes the country's economy relatively sensitive to climate variability and change (Bangladesh Economy Profile, 2013).

So it is beyond discourse that Bangladesh is going to face added adverse impact of climate change in addition to its existing vulnerability to natural disaster like cyclone, coupled with its changing pattern. Therefore, to cope with the anticipated challenges it is extremely important to understand the changing pattern of cyclone to future policy guideline as well as necessary adjustment of existing intervention. This study will provide that insight on this changing pattern of cyclone that can help policy maker to formulate and implement policies in effective way.

2. HISTORICAL TREND OF CYCLONE FORMATION IN BAY OF BENGAL

The disastrous impact of cyclone is measured not only by the severity of the cyclone but also from the loss and damage to human life and its property. As sea surface temperature is one of the main criteria for forming cyclone, there is an increasing number of cyclone anticipated due to global warming. But the harshness of cyclone is much more important than number of cyclone for Bangladesh. In relation to that out of 508 cyclone that formed in Bay of Bengal, 17% of made their landfall in Bangladesh over last 100 years. Compare to other cyclone hotspot countries, the frequency of cyclone is not unusual in Bangladesh. But it faced one extreme cyclone in every three years leaving its catastrophic footsteps. From 1877 to 1995 Bangladesh was hit by 0.93 % of world's total tropical cyclone (Ali, 1999: 111). But it doesn't mean that Bangladesh is in risk free zone due to the impact it generate in past years. About 53% (16 out of 35) of the cyclones that claimed more than 5,000 lives took place in Bangladesh (Government of the People's Republic of Bangladesh, 2008: 3) (Table 1).

Table 1: Deaths Associated with Noteworthy Tropical Cyclones in the World

Year	Location	Death	Year	Location	Death
1584	Bangladesh	200,000	1937	Hong Kong	11,000
1737	India	300,000	1941	Bangladesh	7,500
1779	India	20,000	1942	India	40,000
1780	Antilles	20,000	1960	Bangladesh	5,149
1822	Bangladesh	40,000	1960	Japan	5,000
1833	India	50,000	1961	Bangladesh	11,468
1839	India	20,000	1963	Bangladesh	11,520
1854	India	50,000	1963	Cuba-Haiti	7,196
1864	India	50,000	1965	Bangladesh	19,279
1876	Bangladesh	100,000	1965	Bangladesh	12,000
1881	China	300,000	1970	Bangladesh	500,000
1895	India	5,000	1971	India	10,000
1897	Bangladesh	175,000	1977	India	10,000
1900	Texas, USA	6,000	1985	Bangladesh	11,069
1906	Hong Kong	10,000	1988	Bangladesh	5,708
1912	Bangladesh	40,000	1989	India	20,000
1919	Bangladesh	40,000	1991	Bangladesh	138,000
1923	Japan	250,000	**Total = 35, Bangladesh= 16, India= 11**		

Source: (Government of the People's Republic of Bangladesh, 2008: 3)

In addition to the loss of lives, these tropical cyclone cause heavy loss of property and jeopardize the development activities. And climate change is expected to rise sea surface temperature (SST) which eventually results in more frequent tropical cyclones with higher intensity. So, obviously future loss and damage will change. It is really necessary to capture these changes for ensuring better policies for country like Bangladesh.

3. THE CONCEPTUAL FRAMEWORK

This study only deals with the tropical cyclone that had a landfall in Bangladesh. It would be comprehensive to account all the cyclone that generated in the Bay of Bengal. But it is out of the scope of this research. The study conceive the following operational definition to carry out the analysis.

3.1 TROPICAL CYCLONE INTENSITY

Cyclone intensity is defined as the maximum wind speed in the storm. This speed is taken as either a 1-minute sustained or 3-min average or 10-minute average at the standard reference height of 10 meters. There are different scale for measuring the intensity of cyclone. Saffir–Simpson wind scale considers one minute sustained wind speed to measure cyclone's intensity (Table 2).

Table 2: Saffir–Simpson wind scale

Category	1 min sustained wind speed (km/hr)
Five	≥252 km/hr
Four	209–251 km/hr
Three	178–208 km/hr
Two	154–177 km/hr
One	119–153 km/hr
Tropical storm	63–118 km/hr
Tropical depression	<62 km/hr

Another concept of measuring the intensity of cyclone by India Meteorological Department (IMD is also widely recognized. It considers 3-min average winds speed to measure the cyclone's intensity (Table 3).

Table 3: Tropical cyclone intensity scale by IMD

Category	3 min average wind speed (km/hr)
Super Cyclonic Storm	>222 km/hr
Very Severe Cyclonic Storm	118–221 km/hr
Severe Cyclonic Storm	88–117 km/hr
Cyclonic Storm	62–87 km/hr
Deep Depression	52–61 km/hr
Depression	≤51 km/hr

In this study both the above mention scales will be used depending on the pattern of analysis.

3.2 CYCLONE WARNING SIGNAL SYSTEM OF BANGLADESH

In Bangladesh, 4 stages of Storm warning Signals for river ports (Table 4) and 11 stages of signals for maritime ports (Table 5) are being used by Bangladesh Meteorological Department (BMD). These signals are used for alerting the coastal people.

Table 4: Warning signals for river ports

Serial No.	Warning Signal Number	Warning Signal Number Explanation
1	Warning Signal No. I	The area is threatened by squally winds of transient nature.
2	Cautionary Signal No. II	A storm is likely to strike the area (vessels of 65 feet and under in length are to seek shelter immediately).
3	Warning Signal No. III	A storm will strike the area (all vessels will seek shelter immediately).
4	Great Danger Signal No. IV	A violent storm will soon strike the area (all vessels will take shelter immediately).

Source: BMD, 2013

Table 5: Warning signals for maritime ports

Serial No.	Warning Signal Number	Warning Signal Number Explanation
1	(i) Distant Cautionary Signal No. I	(i) There is region of squally weather in the distance sea where storm may form.
2	(ii) Distant Warning Signal No. II	(ii) A storm has formed in the distant sea.
3	(iii) Local Cautionary Signal No. III	(iii) The port is threatened by squally weather
4	(iv) Local Warning Signal No. IV	(iv) The port is threatened by a storm but it does not appear that the danger is as yet sufficiently great to justify extreme precautionary measures.
5	(v) Danger Signal No. V	(v) The port will experience severe weather from a storm of slight or moderate intensity, that is expected to cross the cost to the South of the port in case of Chittagong and Cox's Bazar and, East of the port in case of Mongla.
6	(vi) Danger Signal No. VI	(vi) The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the North of the port in case of Chittagong and Cox's Bazar and to the West of the port in case of Mongla.

7	(vii) Danger Signal No. VII	(vii) The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross over or near the port.
8	(viii) Great Danger Signal No. VIII	viii) The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the South of the port in case of Chittagong and Cox's Bazar and to the East of the port in case of Mongla.
9	(ix) Great Danger Signal No. IX	(ix) The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the North of the port in case of Chittagong and Cox's Bazar and to the West of the port in case of Mongla.
10	(x) Great Danger Signal No. X	(x) The port will experience severe weather from a storm of great intensity that is expected to cross over or near to the port.
11	(xi) Communication Failure Signal No. XI	(xi) Communications with the Meteorological warning centre have broken down and the local officers consider that a devastating Cyclone is following.

Source: BMD, 2013

4. METHODOLOGY

The study has been done on the basis of secondary sources. Only cyclones which had a landfall in Bangladesh are considered for analyzing their profile. Time series data of cyclones that occurred in the past year in Bangladesh includes, number of cyclone, their respective maximum wind speed, level of storm surge, number of death and amount of loss & damage. To find out the changing pattern of cyclone, secondary data sources of Bangladesh Meteorological Department (BMD),Ministry of Disaster Management and Relief (MoDMR) and Comprehensive Disaster Management Programme (CDMP) has been compiled to take account of all cyclones an make it an inclusive one. Main cyclonic storm data has been used from MoDRM and CDMP where preliminary cyclonic formation data in the forms of early warning hoist has been used from BMD. For socio economic profile of the people Bangladesh Bureau of Statistics was a very good source. Apart from this, data has been collected from various government policy document like NAPA (National Adaptation and Program of Action) and BCCSAP (Bangladesh Climate Change Strategy and Action Plan). However, this study will focus on certain aspect of cyclone backup by multiple variable as outlined in table 6.

Table 6: Variable of cyclone's profile analysis

Objectives	Issue	Variables	Source
Changing trend of cyclone	Change in frequency of occurrence	Number of landfall in a year	Secondary source
		Frequency of Early Warning System	Secondary source
	Change in intensity	3 min average wind speed	Secondary source
	Landfall area	Number of landfall in a particular area	Secondary source
		Frequency of Early Warning System hoisted in a particular area	Secondary source
	Storm surge height	Average storm surge height	Secondary source
	Life loss	Total number of death due to cyclone	Secondary source

5. ANALYSIS AND RESULT

5.1 TREND IN CYCLONE FREQUENCY OF OCCURRENCE

Every year around 80 tropical cyclone (wind speeds equal of greater than 61km/hr) forms in worlds water (McBride JL, 1995), out of which 5.5% are formed in Bay of Bengal. But this number is decreasing. The time series data of cyclone that made landfall in Bangladesh is available from 1960 to date. But due to the simplicity of the analysis data series of 1960-2010 has been used for all sorts of interpretation. In the whole analysis cyclone has been considered only when its wind speed is greater than or equal to 59 km/hr. The following figure (figure 3) illustrates the frequency of occurrence of cyclone in the coastal area of Bangladesh. It shows that number of cyclone hitting Bangladesh coastline is decreasing based on the decades. In 1960s number of cyclone hitting Bangladesh coast was 17 which reduce to only five in 2000s.

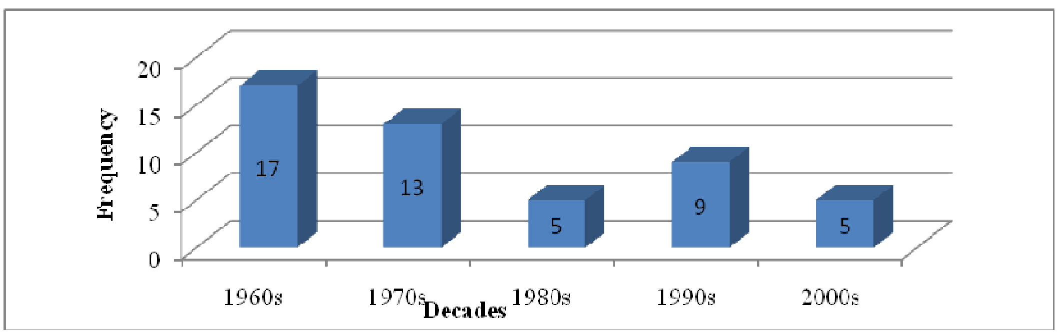

Figure 3: Frequency of cyclone hitting Bangladesh in last 50 years *(Source: Compiled from CDMP, MoDMR)*

5.2 FREQUENCY OF WARNING SIGNAL HOIST

Early warning signal is one of the indicators of propensity of cyclone formation. BMD is the sole authority of hoisting the different number of signal both for maritime and river ports. It will capture all cyclones in the form of depression or depression. Here the data series of 1998-2010 has been analyzed. But the trend is showing some ambiguities. For example, figure 4 represents total number signal (Distant cautionary 1 to communication failure 11) hoisted by BMD.

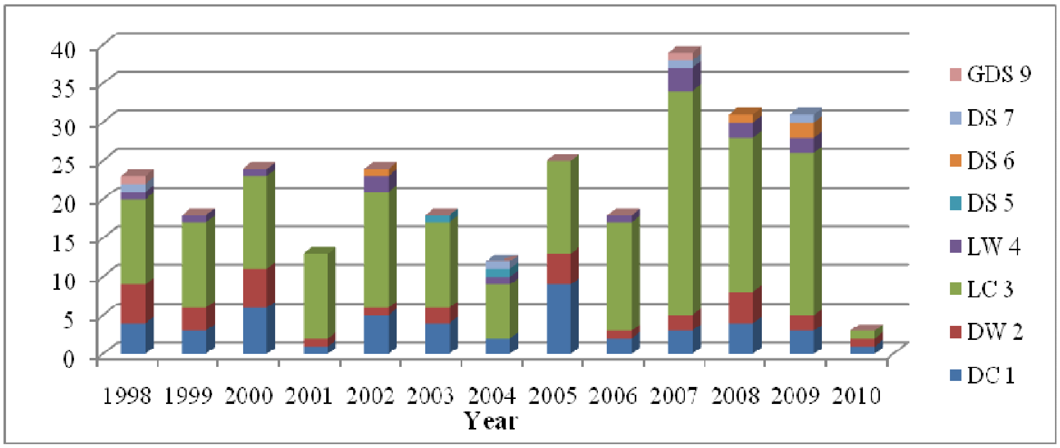

Figure 4: Total number of warning signal hoisted by BMD between 1998-2010 *(Source: BMD, 2013*

Though the number of signal hoisted increased in the later part of 2000s it cannot be concluded that the number of cyclones increased. On the other hand figure 5 showing the increasing trend of LC3 hoisted but not to that significant level which commensurate with the result of figure 4.

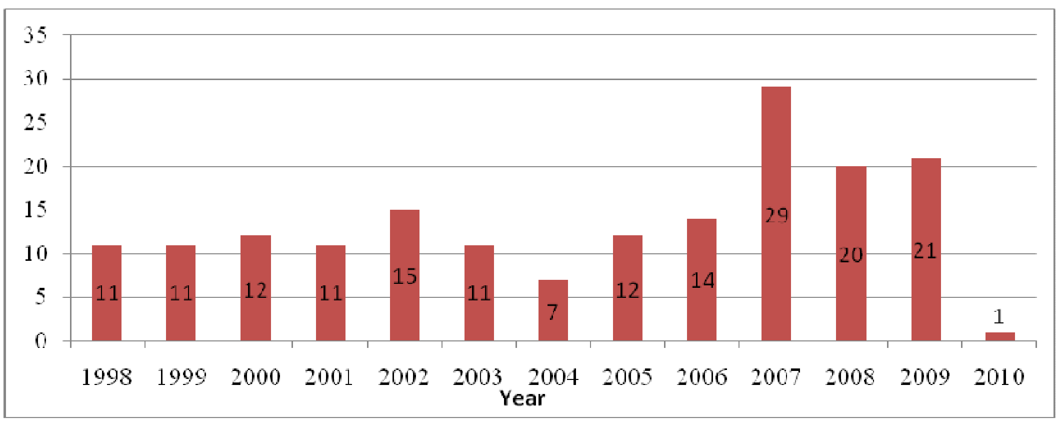

Figure 5: Total number of LC3 signal hoisted by BMD between 1998-2010
(Source: BMD, 2013)

5.3 TREND IN DURATION OF HOISTED SIGNAL

Another perspective of analysis (figure 6) reveals that the duration of hoisted signal is increasing. In 1998 total duration of hoisted signal was 40 days which jump to 85 days in 2007. It means that the cyclones now forming in Bay of Bengal have more duration.

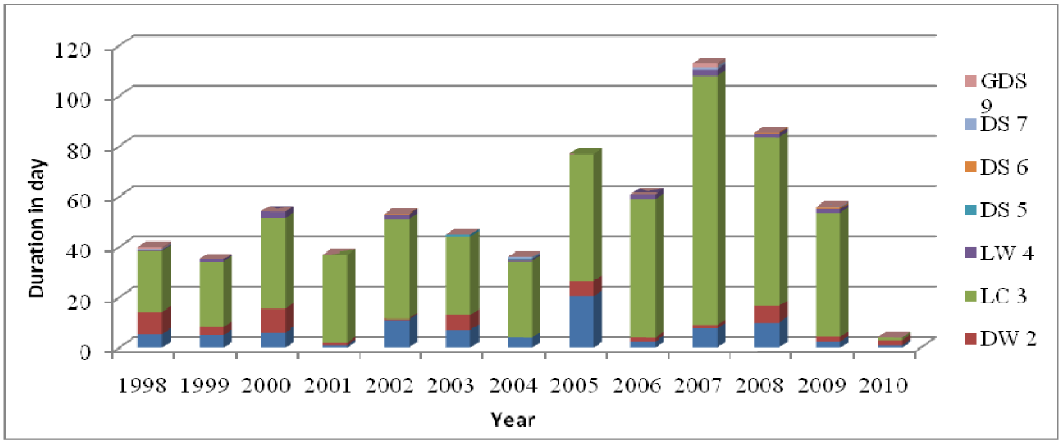

Figure 6: Duration of hoisted signal by BMD *(Source: BMD, 2013)*

5.4 TREND IN CYCLONE INTENSITY

The formation of cyclone largely depend on the sea surface temperature to reach 26 to 27°C. Consequently about 33% of world total cyclone form in the western north pacific which has a very warm water of about 30°C (Frank, 1985). During 1951 to 1987 sea surface temperature has been increasing constantly in Bay of Bengal. Consequently the intensity of cyclone is increasing. The following figure 7 and figure 8 shows the intensity of cyclone according to Saffir-Simpson scale and IMD. In both cases cyclone of higher intensity tend to increase regardless of the intensity classification. In Saffir-Simpson scale, category 4 cyclones (wind speed 209-251 km/hr) increased to 31.25% between 1986-2011 time frame which was only 6.1% between 1960-1985. And in IMD scale, super cyclonic storm (wind speed >222 km/hr) increased to 18.25% between 1986-2011 time frame which was only 3% during 1960 to 1985.

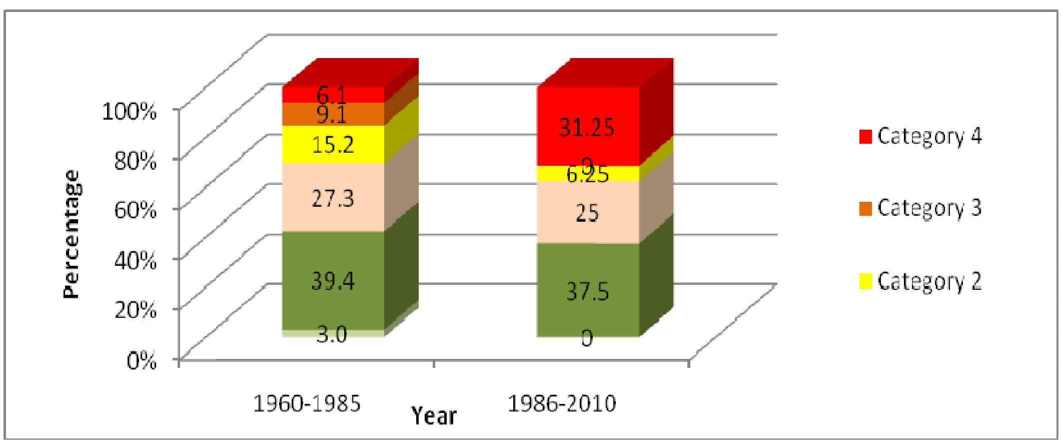

Figure 7: Comparison of cyclone intensity according to Saffir-Simpson scale
(Source: Compiled from CDMP, MoDMR)

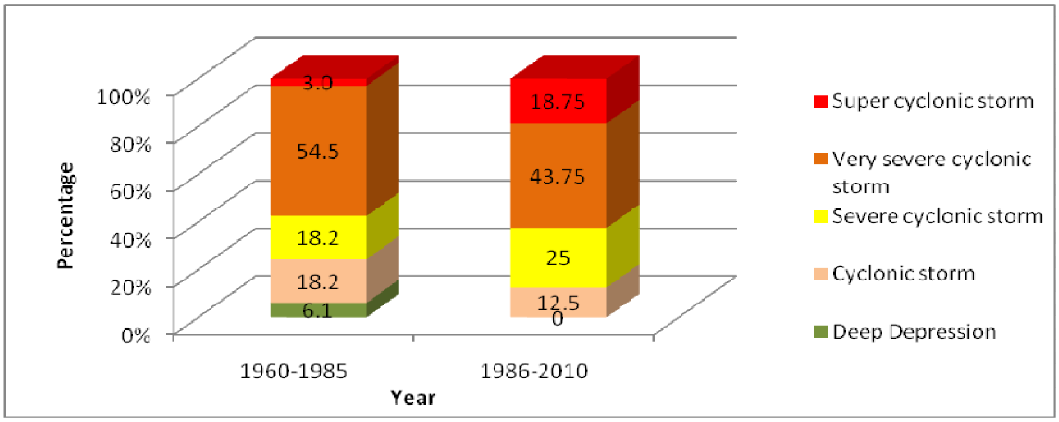

Figure 8: Comparison of cyclone intensity according to IMD scale
(Source: Compiled from CDMP, MoDMR)

From the above discussion it is clear that the cyclones intensity is increasing and climate change is contributing to the fact by accelerating SST. Apart from empirical data the relationship between cyclone intensity and SST is well discussed in the literature. For example compare to the threshold sea surface temperature of 27°C, if we assume the IPCC lower bound and upper bound temperature to increase 2 °C and 4°C, the likelihood of increasing the maximum wind speed of future cyclone is 10% and 22% higher respectively(Ali, 1999: 111). Moreover, as the number and duration of signal hoist is increasing (figure 4, 5 and 6) there is probability that a significant number of depression may turn in to cyclone, cyclonic storms will become severe cyclone storm and severe cyclonic storm will become even more severe.

5.5 TREND IN CYCLONE LANDFALL

The coastal area of Bangladesh consist of 17 district which are apparently most vulnerable to cyclones and it can be divided into three parts namely eastern coast, central coast and western coast. Table 7 delineates the boundary of this demarcation.

Table 7: Area demarcation of coastal area

Area	**Covered coast line**	
Eastern coast	Chittagong coast	Cox's Bazar coast
	Teknaf coast	Feni coast
	Noakhali coast	Sandwip coast
Central coast	Meghna estuary	Bhola coast
	Patuakhali coast	Barguna coast
	Barishal coast	
Western coast	Sundarban coast	Bagerhat coast
	Khulna coast	Satkhira coast

Figure 9 illustrates comparison about the location of cyclone landfall between 1960-1985 and 1986-2010. It reveals that hitting the central coast of Bangladesh by cyclone increase to 35.9% in 1986-2010 which was 13.46% in 1960-1985. The figure explicitly demonstrations the increasing vulnerability of Meghna estuary, Bhola coast, Patuakhali coast, Barguna coast and Barishal coast than any other coast of Bangladesh due to the changing trend of location of cyclone landfall.

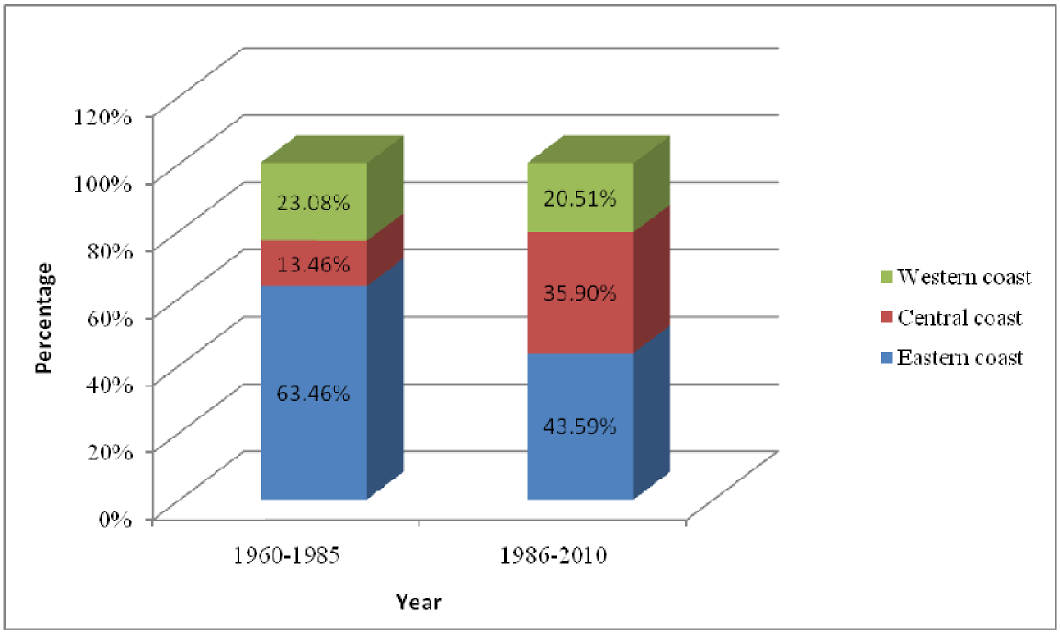

Figure 9: Comparison about location of cyclone landfall

(Source: Compiled from CDMP, MoDMR)

5.6 TREND IN LIFE LOSS

The gist of the above illustrated that showed that the frequency of cyclone is decreasing but its intensity is increasing. Though its intensity is increasing, the number of death due to cyclone occurrence is declining over the time (table 8).

Table 8: Total number of death due to cyclone during 1960-2010

Year	**1960-1985**	**1986-2010**
Total number of death	447717	155571

(Source: Compiled from CDMP, MoDMR,)

During the period of 1960 to 1985 number of people died due to cyclone was around 0.45 million which reduce to around 0.15 million during the period of 1986 to 2010. There are certain factors that contribute to the reduction of life causality due to cyclone. Construction of cyclone shelter, development of early warning dissemination system, early evacuation plan and improved disaster management practices through volunteerism both by public and private sector are the major contributor to such rapid reduction of life loss.

6. RURAL ADAPTATION MEASURES

Bangladesh has a tremendous success in reducing cyclone mortality in its rural area through introduction of innovative cyclone shelter, improving poverty scenario as well as engaging community in disseminating the early warning system. The death toll of 1970's and 1991's cyclone was 300000 and 138866 while the human loss due to cyclone *Sidr* of 2007 was only 4234 (UNISDR, 2015: 46). Moreover in 2009, during cyclone *Aila* many volunteers helped to evacuate people from disaster area limiting the death toll to only 2000(United Nations, 2013). However, from the analysis section it is clear that the cyclone frequency is reducing while increasing its intensity. But, the loss and damage is reducing in rural area due to disaster preparedness, early warning system, successful formation of resilient community, large number of volunteers and increasing number of cyclone shelter. Furthermore, both public and private sector is playing their active role in reducing loss and damage both in short and long term. This section will mainly elaborate rural adaptation measure on the basis of above profile analysis.

Due to the insignificant contribution to climate change and higher vulnerability to its impact, Bangladesh mainly focus on adaptation strategies rather than mitigation. Broadly such adaptation strategies for cyclone is typically applicable for cyclone prone area which is mostly rural in nature in case of Bangladesh and includes three types of strategies namely structural, non-structural and policy measures.

6.1 STRUCTURAL MEASURES

Structural measures embrace the capital investment for building resilient infrastructure both at individual, community and regional level. Therefore following consideration need to take into account.

1. Lots of cyclone shelter has been constructed in recent years which is saving thousands of lives. But, still many areas are out of the reach of cyclone shelter.
2. The cyclone shelter should be equipped with storing facilities for livestock. Because sometimes livestock are more important for them than their life and they are not willing to go to cyclone shelter leaving their livestock at home.
3. Coastal embankments are the most effective way of avoiding loss and damage due to storm surge. So, embankment should be repaired immediately.
4. Technical and financial Support should come from public and private sector in assisting the local people to build cyclone resilient house. Promoting should focus not only on the superstructure but also on the basement. In this regard a raised platform for their house as well as for storing livestock's food needs to incorporate in design consideration.
5. Raising the pond banks is necessary so that saline water from storm surge cannot enter into the pond which will destroy not only the source of fresh sweet water for drinking but also hamper the fishing activities.
6. All damaged bamboo bridges should be repaired immediately after the cyclone to facilitate emergency relief action by establishing road connection.

7. The early warning system of cyclone is already developed by BMD. But the challenge is now to disseminate the information to the local people with appropriate device. So, dissemination device should be available at local level with cheaper price.

8. BMD should develop the system of warning dissemination through mobile device of that particular local area under warning.

6.2 NON-STRUCTURAL MEASURES

Non-structural measures refer to the building adaptive capacity of the community by awareness building, education and capacity development. It includes

1. An updated vulnerability maps is an essential tool to understand the extent of risk that the community is in so that they can prepared themselves accordingly.

2. One of the major weakness of existing cyclone warning system in Bangladesh is that the delivered message sometime not easy to understand for the general people. Moreover, in the forecasting only the storm surge height is being indicate without giving comprehensive information about it stage (e.g. high/spring tide and low/neap tide) during the landfall of cyclones on the coast. Besides, the forecasting/warning system does not forecast the intensity of rainfall from the approaching cyclone. So, transformative changes need to be made in warning presentation, dissemination and public understanding to reap the full benefit.

3. At household level all house should be tied up with strong tree like date trees and Palmyra trees to reduce damage.

4. Community is the main driver of making them resilient. But facilitation should come the public and private sector through meetings, regular drill, interactions, discussions, exposure visits and trainings that will enable them to understand their factors of vulnerability and necessity of taking action at community, household and individual level.

6.3 POLICY LEVEL MEASURES

The following policy level measures are necessary to minimize the loss and damage due to cyclone in Bangladesh.

1. As per above trend analysis, cyclone is now hitting more in the central coast (Meghnaestuary, Bhola coast, Patuakhali coast, Barishal coat, Barguna coast) compared to eastern and western coast (figure 10). The socio economic profile and livelihood opportunities of this central coast are much lower than others, considering the extreme poverty levels (figure 11). So, it is very lucid that more frequent cyclone coupled with high level of poverty making the people of the central coast area are much more vulnerable. Consequently, both the public and private sector should select this coastal regions as priority area for rural adaptation strategies.

2. In preparing customize evacuation plan for each area there should be legal framework to provide protection to abandoned properties during cyclone.

3. Issues regarding disaster management in the context of climate change should be incorporate in textbooks as a long term measures.

4. Land use regulation should be strictly maintained. In small scale, vulnerable areas should not be used for critical activities and it should be kept for parking, grazing and playground.

However, the efficiency of cyclone preparedness, early response and reconstruction plan depend on the coordination of different agencies of Government of Bangladesh (GoB). The challenge would be how efficiently these damages are managed, how best the affected people are rescued and provided relief and rehabilitation assistance in a humane and transparent manner, how fast the damaged houses and infrastructure are reconstructed and how quickly the pre-disaster situations are restored and normal life bounces back to its rhythm.

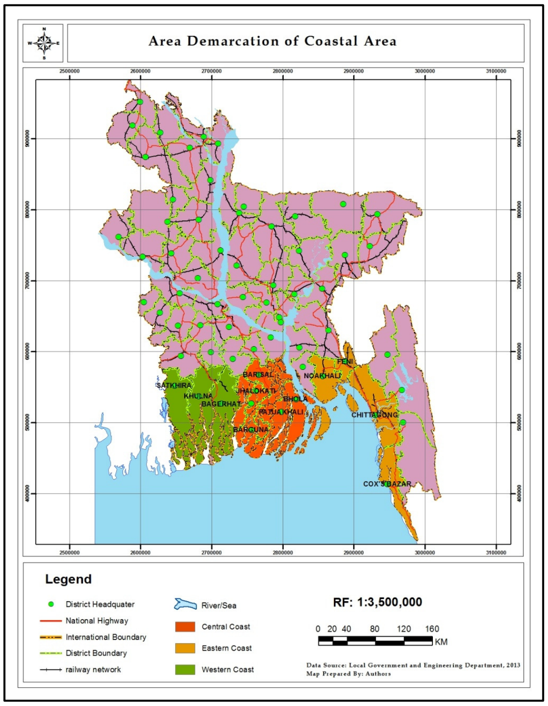

Figure 10: Area demarcation of eastern, central and western coast

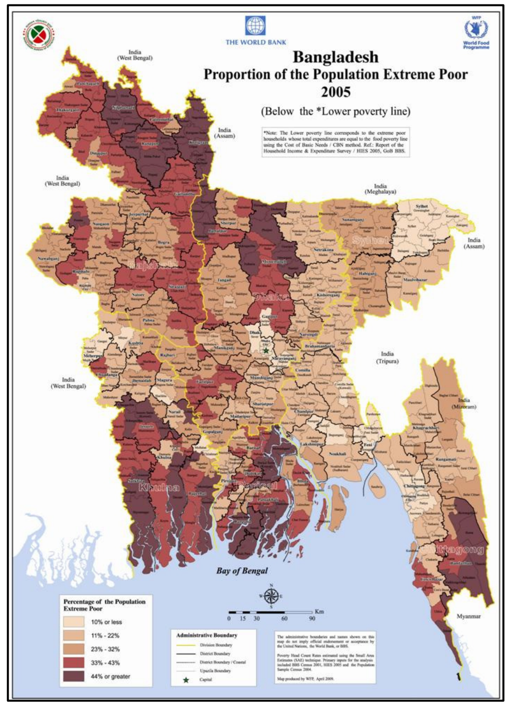

Figure 11: Extreme poverty level of Bangladesh *(source: World Bank)*

7. URBAN ADAPTATION MEASURES

The impact of changing trend of cyclone is not identical for all urban areas of Bangladesh. Urban centers like Khulna, Barisal, Chittagong is going to face the direct impact where capital city Dhaka is supposed to face the rapid influx of climate migrants. The fifth assessment report of Intergovernmental Panel on Climate Change (IPPC) identified Dhaka as city of low adaptive capacity or resilience due to huge shortfall of resilient infrastructure, proportion of people living in informal settlement without basic service provision and deficiency in institutional capacity for local government to minimize climate change impact (Revi, et al., 2014: 546).

However, climate change adaptation measures in urban centers can be consider at two level, i) household or community level and ii) institutional level by local or national government. At household level in some informal settlement of Dhaka city people build adaptive capacity against flood by constructing front door barriers, raising the height of their furniture and placing the ground floors and shelves above the flood line. They are also using false selling to keep the room temperature lower which in turn is being used as storage facility for important element during disaster (Jabeen, et al., 2010: 424). But external support is necessary to scale up the process.

Institutional measure of adaptation in urban area come into picture in terms of providing large infrastructure like basic service provision, constructing shelter and flood protection wall which are beyond the capacity of community. Not such initiative are visible in Dhaka city except some community based shared water supply and sanitation facility by Water Aid (an international NGO) with the support of Dhaka City Corporation (Hanchett, et al., 2003). But a strong organized community is necessary to implement this kind of initiative. NGOs could play a vital role in enabling community, private and public sector's role to provide basic services through forming effective partnership.

8. CONCLUSION

Bangladesh has a vast experience in disaster management because every year it faces several types of disaster like flood and tropical cyclone. However, the pattern of tropical cyclone is now changing due to climate change as the frequency of tropical cyclone is decreasing but its intensity is increasing in terms of wind speed. Moreover, though cyclone's intensity is increasing, the life loss and monetary damage is decreasing due to the proper dissemination of early warning signals and rapid preparedness measure taken by Government of Bangladesh and although there are certain scopes for improving. There is no doubt that Bangladesh is going to be one of the most affected countries due to climate change through cyclone of greater intensity. But tropical cyclones are now most likely to hit the central cost of Bangladesh making them most vulnerable due to the socio economic condition. To reduce the impact, though Bangladesh is mainly concentrated on adaption measures, still mitigation measures as well as compensation are needed from the developed countries to reduce the impact. It can be achieved by developing global partnership in climate change negotiations. However, The high profile Comprehensive Disaster Management Programme, 50000 volunteers in Cyclone Preparedness Programme(Cyclone Preparedness Programme, 2011), incorporating of NGOs during post disaster period are some of the example of Bangladesh's expertise in disaster management mostly in the rural area. But there is heightened urgency to put emphasize on urban context which is much more complex in all aspects.

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