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HYDRO-METEOROLOGICAL DISASTER MANAGEMENT IN BANGLADESH-AN OVERVIEW

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Abstract

Bangladesh is the most susceptible for floods, cyclones and tidal surges due to its geographical location which makes the country's hydrology very diverse. The poor socio-economic conditions of the people have also made the nation more vulnerable to natural disasters. Although hydro-meteorological disasters are beyond the control of human beings, however, the impacts can be minimized through effective disaster management. Significant reduction in death toll and socio-economic loss caused by cyclone and floods in Bangladesh during 1988 to 2007 was the result of improved means of communication, information and broadcasting technology. These mechanisms have been possible due to timely forecasting and dissemination of warnings, as well as the evacuation of vulnerable people living in disaster prone areas. Still some rural people of the country usually consider natural disasters to be punishments from God and try to find solutions through praying and relying less on people's help.

Keywords: floods, cyclones, climate change, disaster management, vulnerability, early warnings, socio-economic impact.

Background

Bangladesh is an alluvial deltaic plain at the confluence of Ganges, Brahmaputra and Meghna rivers and their tributaries discharge into Bay of Bengal. It is known as one of the highest flood and cyclone prone countries in the world. It lies between 20°34´ to 26°38´ N latitude, and 88°01´ to 92° 41´ E longitude. It is located in the funnel shaped to the north and conically shaped

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to the south of the Bay of Bengal. This peculiar geographical location makes the country hydrology very diverse and the poor socio-economic condition of the people have made the nation more vulnerable particularly to floods and cyclones disaster. Heavy rainfall, melting of the ice and snow in the Himalayas, siltation of rivers are the main causes for flash floods and riverine floods in Bangladesh (Paul and Rahman, 2006; Islam 2008, Madsen and Jackobsen, 2004; Das 1997, Rashid, 1997).

The average temperature fluctuates a lot in Bangladesh from Mid-March to Mid-September and almost all hydro-meteorological disasters occur during this period. The river Ganges starts rising gradually in May-June to a maximum in August and September. High water levels are normally sustained until mid September Rashid A.K.M. Harun, Das K.M., 1997). Due to the continued process of siltation both in the riverbed and at the mouth, the flow became gradually insignificant and ultimately it did not carry any discharge during lean Season months. In the Brahmaputra maximum discharge occurs in early monsoon in June and July. During low flows the river becomes a multiple channel stream with sand bars in between and the channels shift back and forth between the main stream banks (Paul and Rahman2006; Madsen and Jacobsen 2004). The discharge of the river Brahmaputra is mostly contributed by the spring snowmelt in the Himalaya region and heavy rainfall in the north eastern states of India. As a result, flash floods and riverine floods occur in northern-western and southern plain of Bangladesh due to heavy discharge of water by the Ganges and Brahmaputra. Synchronization of the peaks during August-September of these rivers results in devastating floods. Storm surges are generated due to cyclonic storms in the coastal areas of Bangladesh. The coastal areas are also subjected to tidal flooding during the months from June to September when the sea is in spate due to the southwest monsoon wind (Das 1997, Rashid, 1997).

Hydro-meteorological disasters are caused not only by excessive runoff from precipitation or snowmelt, or by coastal storm surges or the failure of dams, but also by man-made changes to the earth's surface such as deforestation, devegetation, unplanned settlements, and urbanization in flood prone areas. Inadequate sustainable management strategies may increase the impacts.

Disaster management in the deltaic plain is aimed at abatement of human death and economic losses caused by the floods, cyclones and sea surges. Total disaster control is neither feasible nor desirable either physically or economically (Nishat, 1997).

Flood management can be classified into structural and non structural measures and both measures are always carried out parallel to reduce loss and damage to life and property. However, it is now realized that absolute control over floods is rarely feasible, either physically or economically. There is now a growing understanding that 'Zero risk' is not a possibility and 'safe' is not equivalent of 'risk free'. Such a structure is called flood management (Nishat, 1997). Future climate change will affect hydro- meteorological variables such as air temperature, precipitation, and evapotranspiration. Frequent precipitation events, increased likelihood of floods and erosion in the hills of Nepal which result in heavy siltation of river beds. Melting of snow and ice paves the way for the rising of the sea level (IPCC, 2007; UNEP, 2007).

Objectives

The present study deals with the following objectives:

i to make an appraisal of diverse relief and drainage patterns;
ii to determine the relationship between the vulnerability to natural disasters and socio-economic impacts on the conditions of the people;
iii to identify the impacts of disaster management reduction of loss of life and property;
iv to assess the mechanisms of means of communications, early warning systems, and evacuation of people from disaster prone areas;
v to suggest disaster preparedness and mitigation measures for management;

Methodology

The present study has been primarily based on secondary vector and raster data drawn from various edited research books, journals' research articles, reports, magazines, news papers, and websites. A deductive method was used

to describe data in order to arrive at conclusions. The aim of this research study was to evaluate and to present an overview to what extent Bangladesh has been able to minimize the hydro-meteorological disasters. Although it may not be possible to prevent the occurrence of natural hazards but the severity they generate can be minimized if timely and properly measures of management is taken.

Historical perspective of disasters

According to study by CRED (2010) about 335 natural disasters (excluding biological disasters) were reported globally in 2009. More so, 11,000 persons were killed and 119 million others were affected by these disasters. The economic damages associated with these natural disasters were estimated to be just over US$ 40 billion. Hydrological disasters- floods, 54% remained the most common disasters in 2009, followed by meteorological disasters-storms, 25%. About 40% of the total global storm surges are recorded in Bangladesh (Jonkman, 2005; Murthy, 1984). In the last decade of the 20th century floods killed about 100,000 persons and affected over 1.4 billion people globally. The statistics show that floods have a large impact on human well-being on a global scale. As a direct consequence, floods may lead to economic damage, damages to ecosystems, historical and cultural values (Hajat *et al.,* 2003). Furthermore, it is likely that up to 20% of the world's population will live in areas where river flood potential could increase by the 2080s (IPCC, 2007). According to GoB, 2008, 80% to 90% of global losses and 53% of total cyclone –related deaths worldwide occur in Bangladesh.

According to the official information of the Government of Bangladesh, 2008, the first disaster in Bangladesh which recorded a high death figure occurred in 1822 during the colonial era when a cyclone killed 40,000 people. In 1876, a cyclone killed 100,000 people and twenty two years later another one in 1898, killed an estimated 175,000 people. The worst kind of such cyclone was in 1970 and in 1991 which caused loss of 300,000 and 138,000 human lives respectively. The most severe cyclone of 2007 caused 4,234 deaths, a 100-fold reduction compared with the devastating 1970 cyclone (GoB, 2008). Bangladesh has suffered most severely as a victim of natural disasters during the period 1991-1995, it faced economic losses of more than USD 9.014

billion; in 1996-2000, USD 7.996 billion; in 2001-2005, USD 15.599 billion and in 2006 alone it faced economic losses of more than USD 3.390 billion (Bhandari, 2013). However, Bangladesh has managed to reduce deaths and injuries from cyclones.

Table 1: The volume of loss of lives and properties

Affected people	10,798,275
Affected crops	924,893 Acres
Damage to houses	1,702,358
Number of death	138,882
Death of livestock	1,061, 029
Number of people injured	139,054
Damage to educational institutions	9,666
Damage to roads	764 miles
Damage to bridges/culverts	496
Damage to cross dams/Embankments	707 miles
Number of untraceable people	1,225

Source: Ministry of Disaster Management and Relief, Government of Bangladesh, 1991.

The above table shows casualty of death and damages but it does not give any clear picture about the disaster prevention, management, and mitigation measures that have been taken. In fact, the death and devastation report can range from inaccurate to inflated, and the intentions to shock and at the sight of suffering to the desire to attract more relief and rehabilitation aid are both possible in such cases (Rashid, 1997). Studies have shown again and again that disasters are part of a process and not a solitary event. This is particularly true in case of Bangladesh which has a history of disasters linked to the socio-economic dynamics and management of the state. The people of Hatiya affected by the cyclone of 1991 were the residents outside the protective embankment, who had moved out to the highly vulnerable area because they couldn't afford the land within the protected area. The process of their destruction began before the cyclone arrived and it was caused by lack of resources and inability or unwillingness of the state machinery to take care of the most vulnerable. Poverty was the first disaster and storm surges comes later (Rashid, 1997). Cyclone shelters are scarce and unavailable in most of

the small islands in Bangladesh. In many cases, shelters are occupied by nearby local elites first, and there is rarely space for marginalized vulnerable people. Thus, they are more likely to stay in highly vulnerable low-lying areas and take refuge only on earthen embankments (Paul and Routray, 2013).

Climate Change

Climate change is thought to be an important cause of increased floods and cyclone events in the deltaic plain in the Bay of Bengal (IPCC, 2001; Emanuel 2005; Ahmad, 2005). The Intergovernmental Panel on Climate Change (IPCC, 2007) findings suggests that developing countries like Bangladesh will be more vulnerable to climate change due to their economic, climatic and geographic setting. Climatic change studies are increasingly drawn attention on coastal and river plain population, which is quite vulnerable to various natural catastrophes (Nicholls et. al., 1999). The Intergovernmental Panel on Climate Change (IPCC, 2001) reports that floods and cyclone tracts will remain unchanged, with the possibility of increasing peak intensities by 5-10% under current climate change conditions. This would have severe implications for Bangladesh, which is already vulnerable to several hydro-metrological disasters (Ahmed, 2005).

The strength and number of major cyclones may be increasing because of higher sea surface temperatures associated with global warming (Romm, 2007). Tropical cyclones and storm surges are particularly severe in the Bay of Bengal region. The increasing trend of climate change in Bangladesh is about 1°C in the month of May and 0.5°C in the month of November, during the period from 1985 to 1998(14 year period). The decadal rain anomalies have been above long term average since 1960s (IPCC, 2007). Climate change will constrain water resources, already stretched by growing demand from agriculture, industries and cities. Rising temperature will further diminish the mountain snow pack and increase evaporation, thus altering the seasonal availability water (IPCC, 2010). The production pattern of rice in Bangladesh is changing, ranging from -6% decreases to 14% increase over a 14 year period due to increased vulnerability of agricultural areas to floods, cyclones, and storm surges, increasing salinity of soils due to reduced upstream fresh

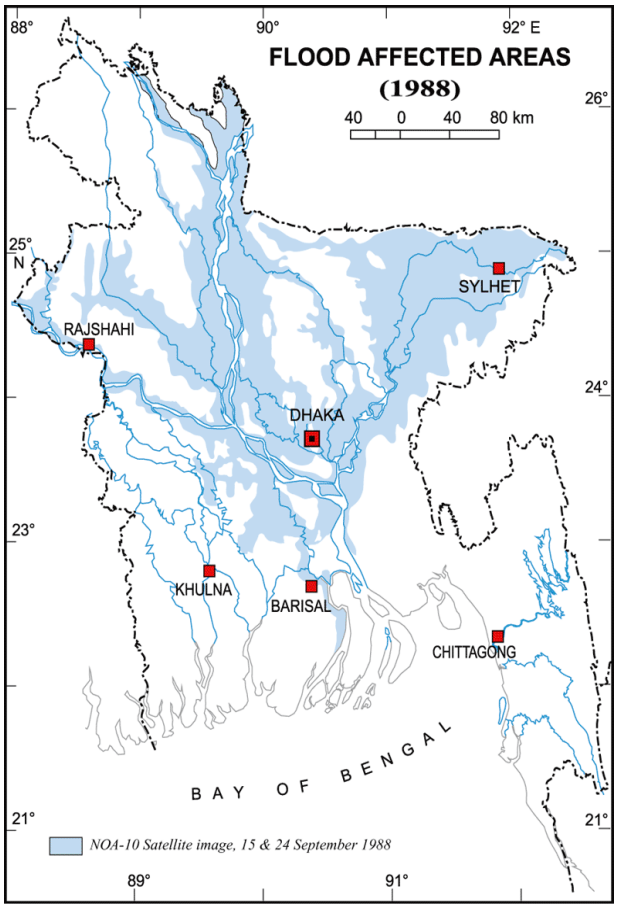
water supply and salt water intrusion in aquifers (IPCC, 2007). Glaciers melting in the Himalayas are projected to increase flooding and will affect water resources within the next 2 to 3 decades (UNEP-DA, 2008).

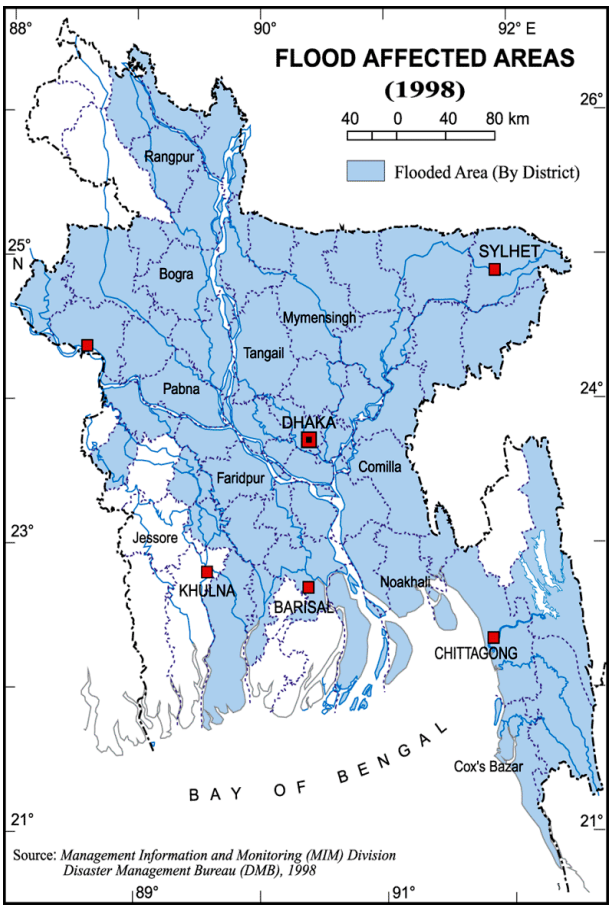
Sea level rise will exacerbate inundation, storm surges, erosion and increased risk of floods, water borne diseases, adverse impacts on fisheries, and ecological systems. In addition, the impact of climate change will exacerbate existing socio-economic and environmental implications in the Ganges-Brahmaputra plains (World Bank, 2007). Although observational evidence from previous years does not show a clear trend in the number of tropical cyclones occurring, climate change is likely to cause an increase in the intensity of tropical storms (IPCC, 2007).

Bangladesh is recognized globally as one of the countries' most vulnerable to the impacts of global warming and climate change due to its unique geographic location, high levels of poverty, high levels density of population, and reliance on floods.

Flood affected areas

The floods map of 1988 and 1998 were catastrophic, leading to widespread destruction, misery and loss of life. In the year 1988 the flood affected area was 89,970 square kilometer while in the year 1998 it was 100,250 square kilometers. The total flood affected area increased between these two events of 1988 and 1998 was 10, 280 square kilometer. The affected area of 1988 and 1998 is represented by the flood maps provided herewith through NOAA and MIM sources.


FLOOD AFFECTED AREAS
(1988)
40 0 40 80 km
88°
90°
92° E
26°
25° N
24°
23°
21°
89°
91°
SYLHET
RAJSHAHI
DHAKA
KHULNA
BARISAL
CHITTAGONG
BAY OF BENGAL
NOA-10 Satellite image, 15 & 24 September 1988



Source: NOA-10 Satellite Image, 15 and 24 September1988.
Source: Management Information and Monitoring (MIM) and Disaster Management Bureau (DMB), 1998.

Disaster Management

The Bangladesh Meteorological Department (BMD) is the main responsible authority of cyclone forecasting as well as providing warning to the media for dissemination in the country (Miyan, 2005); while Cyclone Preparedness Programme (CPP) is responsible for the dissemination of warnings to the coastal villagers. The Storm warning Center(SWC) is a specialized department of the BMD, responsible for weather forecasting and issuing warnings to sea and river ports, public, non-governmental organizations, relief and rehabilitation authorities and local level administrative officials(Chowdhury,

2002). The CPP volunteers are provided with Depression tracking Map, and they receive Radio instruction from CPP Control Room to plot the track on the map. The task of the volunteers include the arduous wide dissemination of warnings by bicycle, walking, using megaphones, sirens, signal lights and signal flags (Paul, 2009 a).

Apart from early warning systems, other measures such as cyclone shelters and coastal embankments have contributed to reducing death rates in Bangladesh. Prior to 2007, the country had 1500 shelters, each capable of offering refuge to up to 5000 people in coastal districts. After Cyclone Sidr, the Bangladesh government initiated the construction of 2000 new cyclone shelters in 15 low-lying coastal districts, but the number and location of shelters remain inadequate for the population (GoB, 2008).

Despite improvements in warning systems, pre-cyclone evacuation remains a challenge. Illiteracy, lack of awareness, poor communication, and poor road network connecting to shelters and long distance of cyclone centers from home was a major cause of not seeking a refuge in cyclone shelters (Paul and Routray, 2013). Disbelief of cyclone warnings had also been a major factor. Cyclone early warnings had turned out to be false on many occasions in the past despite issuing early warnings to the people. It was observed that coastal people sought refuge several times and stayed in the shelters for several hours; when the storm weakened, they returned home. Another cause of disbelief was the relatively small number of occurrences of severe cyclones (Lindell and Perry, 1992). It happened on many occasions that people had received the warning but in most cases the cyclone had changed the trajectory to hit elsewhere on the coast. In fact the people received the warnings and they were trying to move towards cyclone shelters but due to high surge of water they attempted to make their decision to back home. However, they neither reached the shelter nor got back to the village. On the way they were washed away (Paul and Routray, 2013). Therefore, the people were encouraged to take no action by the failure of tsunami warnings in the recent past and by the low frequency of severe events of this kind (Lindell and Perry, 1992). These disasters are positively linked with relaying warnings and response (Paul and Routray, 2013).

Irrespective to hazards, the main aim of warning is to reduce disaster impacts through enabling people to take precautionary measures. Therefore, the success of warnings depends on appropriate hazard detection, information dissemination, and responses by affected people. (McLuckie, 1970; Rogers, 1997; Sorsen and Mileti 1987; Haque, 1997). In addition to a variety of socio-economic factors, psychological and cultural factors may also determine the human response to warning (Drabek, 2004). However, very little research has been conducted on seeking shelter in response to warnings (Sorsen, 2000).

Rural people usually consider natural disasters to be punishments from God. The cyclone is Allah's will. Allah will save us and people can do very little (Haque, 1993; Paul and Routray 2013). Disaster exposed people with no alternative but to live under socio-economic, infrastructural and logistical constraints usually surrender to God and try to find solutions through praying. Hence, during natural disasters and sea surges and flood, climbing trees and praying to God provide the people with the psychological strength to overcome disaster impacts. Religious belief is deep rooted in Bangladesh society; hence some studies find association between gender aspects of hazard response and fatalism (Paul and Routray 2013). For example, women in conservative Muslim society are not allowed to leave home to go to cyclone disaster shelters because of *"purdah"* culture(Bern et. al., 1993; Haider,1992). There are some instances of gender biased selection of children to rescue both sexes the female children are mostly sacrificed. Cyclone shelters entails a lack of privacy, and men and women need to stay together for long hours until the disaster is over. Cyclone shelters are found to be over crowded, unhygienic, with no separate sanitation for males and females and very much uncomfortable to women (Islam et. al., 2004). Some Bangladeshis rely on natural warning signs, such as unusual animal behaviour and weather and ocean patterns, to prepare for the impacts of a cyclone (Howell, 2003); however, these signs may be unreliable and inconsistent.

Therefore, leaving homesteads and staying together with unknown males in a crowded room is not only uncomfortable for women from a conservative society but also creates a negative impression of women's status in the family and kinship group (Haque, 1993). Many women are not allowed to seek

refuge without permission from their husbands. In such a situation, women stay in the home and pray to God until the last minute, when they are forced out by surge water to evacuate with their children. However, studies show that this kind of behavior and reliance on fatalism is common but gradually declining in the coastal region of the country.

For effective disaster management, not only scientific, technical and economic but also social, psychological, administrative and political factors should be taken into account (Chowdhury, Nishat, 1997). As early warning is not simply a linear process of information dissemination, the success of a warning depends on the proactive response of individuals and the community as whole (Paul and Routray 2013). Therefore, effective early warning, awareness campaign and education among the disaster victims are quite necessary.

Socio-Economic Impact of Disasters

A number of efforts have been made to document hydro-meteorological disasters such as hurricanes (Dow and Cutter, 1998), floods (Drabek, 2000) and several other disasters (Sorensen, 2000). In 1971 the cyclone-induced total death toll was estimated between 300,000 and 500,000, with 100,000 missing people; estimated damage was about USD 450 million(GoB, 2008). After the 1991 cyclone, the official death toll was recorded as 140,161 and the total affected population totaled 10, 721, 707; estimated damage was USD 1.8 billion to 4.3 billion (GoB, 2008). Compared to the cyclone in 1970 and 1991, the death toll in 2007 was relatively small: approximately 3,406 people died and 55,000 were injured, with more than 1,000 missing, and estimated damage of USD 1.6 billion(GoB, 2008; Haider et. al. 1991;Paul, 2009a, b). In addition to the geographical setting of Bangladesh coast, the poor socio-economic conditions also contribute to increasing the vulnerability of inhabitants to cyclones, storm surges and floods (Paul, 2009a). Livelihood of most of the people of Bangladesh is highly dependent on agriculture, fishery, forestry and salt farming etc. Therefore, the increasing trend of cyclones and floods will certainly affect the socio-economic of the vulnerable populations of Bangladesh (Mian, 2005; Islam, 2008).

The periodic floods in deltaic plain have had an immense direct implication on its economy and population. Advanced warning systems and flood prevention have decreased the loss of lives on one hand while economic impact has been increasing on the other. The economic impact of the floods does not appear to be indirect correlation to the severity of the floods.

The trend and comparison can be seen from the following table 2 of the flood events of 1988, 1998, and 2004.

Table 2: Comparison of impacts resulting from the 1988, 1998 and 2004 floods in Bangladesh

Loss	**1988**	**1998**	**2004**
Number of Livestock killed	172, 000	26,564	8,318
Crops damaged (million hectares)	2.12	1.74	1.30
Deaths	2,300	1,100	747
Rice production losses (million metric tons)	1.65	2.06	1.00
Number of people affected	45 million	31 million	36 million
Roads damaged (km)	13,000	15, 927	27, 970
Percent of land inundated	60	68	38
Number of homes / destroyed	7.2 million	980,000	4 million

Source: Ministry of Fisheries and Livestock; Papers from the national Reduction in Bangladesh, September, 7-9, 2004, ADB and World Bank Staff Estimates.

The 1988 floods reported over 2,300 deaths while in 1998 the figure declined to 1, 100 human lives lost is conferred to the improvements in early warning systems and flood management. The flood of 2004 clearly shows that the trend of livestock killed in twenty times less when compared to 1988, while the deaths are almost three times less when compared to 1988. This is a tremendous improvement in terms of casualties. The 1988 floods affected more than 45 million people while the 1998 floods affected about 31 million people which slightly increased in 2004. The 1988 floods had a wide ranging impact on the infrastructure of Bangladesh with 13,000 km of roads rose to over 27,000 km. in 2004.

Despite being poor and vulnerable to a range of natural disasters, Bangladesh has made significant progress in disaster management in recent years (Paul, 2009, a, b). Studies by Blake (2008), Heath (2007), Hossain et. al., and Shamsuddoha and Chowdhury (2007) confirms that the lower- than-expected death toll and socio-economic loss caused by cyclone and floods in Bangladesh was the result of timely cyclone forecasting and dissemination of warnings, as well as the evacuation of vulnerable people living in disaster prone areas.

Conclusion

Based on the collected data from various literature sources can be concluded that the main cause of the hydro-metrological disasters in Bangladesh is its unique geographical location as well as its tropical monsoon climate make the country more vulnerable to riverine floods, flash floods, and cyclonic sea surges. International Panel Climate Change (IPCC) 2010, reports that floods and cyclone tracts will remain unchanged with the possibility of increasing intensities by 5% to 10% under present climate change conditions. The production of rice pattern has changed in Bangladesh during the period from 1985 to 2008; over this 23 years period due to increased vulnerability of agricultural areas to floods. The flood map of 1988 and 1998 supports the mentioned argument and shows clearly the widespread areas under floods and loss of life and property. Cyclones and storm surges increasing salinity of soils, soil erosion on river beds, adverse impacts on fisheries will exacerbate existing socio-economic and environmental implications for Bangladesh which is already highly populous, economically poor and vulnerable.

On several occasions, coastal people sought refuge and stayed in the shelters for long hours when storm weakened, they returned homes with a disbelief of false forecasting, and issuing warnings. It also happened many times that people had received the early warnings, but in most cases the cyclone had changed the trajectory again make their disbelief stronger. Such disbelief encourage people to take no actions, while hydro-metrological disasters are positively linked with relaying early warnings and response from people to minimize the impacts. Therefore, the success of warnings and preparedness depends on appropriate hazards detection, dissemination of information, and response by the affected people.

Recently, cyclone warning systems have improved because of information and communication technology, especially internet facilities and mobile phones which ultimately reduced the death tolls in 1991 compared to 1970 cyclones, however the property damage was more that caused in 1991 compared to the cyclone in 1970. Apart from early warning systems, other measures such as education, awareness programmes, cyclone shelters, and coastal embankments have contributed to reducing death rates in Bangladesh. Cyclone Sidr in 2007 can be cited as an example which enabled the successful evacuation of coastal communities resulting less than expected deaths and property.

Despite significant progress in detecting and disseminating early warnings in Bangladesh, still it affected by a lack of understanding of warnings, ignorance, poor infrastructure of roads network, the long distance of cyclone shelters from homes, the low capacity of shelters, and emergency relief. Existing embankments should be repaired and maintained. Careful planning with sufficient sluice gates, especially in the south-eastern area of Bangladesh, will protect against both flash floods and storm surges during a cyclone. Effective disaster management can help in curtailing as well as controlling the impact of hydro-meteorological disaster in the country.

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