# Cyclonic Storm Surge Related Emergency Management: A Bangladesh Case Study

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**Abstract**

Bangladesh, a low-lying delta, is known globally as one of the most vulnerable country to natural disasters. High intensity floods and cyclonic storm surges often devastate its land, economy, ecology and people. In two high intensity cyclones in 1970 and 1991, the death toll exceeded 300,000 and 138,000 persons, respectively. Following the devastating events of 1970 and 1991, both the government and citizens made concerted efforts and took firm measures towards managing such disastrous events. As a direct consequence, a large number of deaths were avoided during the two succeeding high intensity cyclones in the 1990s. A combination of structural and non-structural measured were considered to mitigate damages caused by cyclones. Community based voluntary groups were trained to advance cyclone warnings at the grassroots, while citizens were trained to prepare themselves for issuance of warnings. Multipurpose cyclone shelters built along the coastal areas were successfully utilized to save lives of millions. Non-structural measures were also applied to rebuild the local economy of the cyclone-battered areas. This article provides an overview of the success story regarding cyclone-related emergency management in Bangladesh.

## 1. Introduction

Bangladesh is highly prone to natural disasters. The deltaic plains of the country are located at the southern foothills of the Himalayas and also at the tip of northern Indian Ocean. The land is criss-crossed by over 230 rivers of the Ganges-Brahmaputra-Meghna (GBM) system, mainly the distributaries and tributaries of the three eastern Himalayan rivers. These rivers constitute the second largest outfall after the Amazon system, with over 80% of the GBM flow occurring within about five months from June to October. Only about 7% of the GBM catchment area lies within the border of the country,

which is used for draining out about 93% of the runoff generated in the entire catchment. Such realities cause acute drainage congestion resulting into frequent flooding in the country. The confluence of the major rivers located within 100 kilometers from the sea, are under the influence-zone of backwater effects causing further delay in water discharge during the flood season (monsoon). Flood is, therefore, a common disaster in Bangladesh.

The coastline, some 70 kilometers out of a total of 3500-kilometer border, has also a unique feature--the coastlines of the neighboring countries form an inverted funnel, with the Bengal delta being at the tip of it. Moreover, the Bay of Bengal itself is quite shallow. As a result, when cyclones with high wind speeds visit the coast, the shallow continental shelf produces high surges. A combination of high wind velocity and surges causes havoc to the infrastructure and standing crops, drown thousands of human beings and cattle heads, and impede coastal agricultural development by increasing soil salinity due to inundation with brackish water. Cyclonic storm surge related hazards, therefore, appear to be one of the worst types of disasters that the country faces very often. Table-1 provides a list of cyclonic storm surges, which had disastrous implications in the coastal areas of Bangladesh.

Table-1: Devastation caused by some recent cyclones in Bangladesh

| Year of occurrence | Number of | | | | |
|---|---|---|---|---|---|
| | Districts | Upazilas | Affected people | Dead people | Dead livestock |
| 1970 | 5 | 99 | 1100000 | 470000 | NA |
| 1985 | 9 | 30 | 167500 | 10 | 2020 |
| 1986 | 7 | 30 | 238600 | 12 | 1050 |
| 1988 | 21 | 131 | 1006536 | 9590 | 386766 |
| 1989 | 33 | 71 | 346087 | 573 | 2065 |
| 1990 | 39 | 127 | 1015866 | 132 | 5326 |
| 1991 | 19 | 102 | 13798275 | 138882 | 1061029 |
| 1991 | 33 | 100 | 121229 | 76 | 25 |
| 1994 | 2 | 8 | 422020 | 134 | 1296 |
| 1995 | 28 | 67 | 305953 | 91 | 1838 |
| 1996 | 2 | 9 | 81162 | 545 | 4933 |
| 1997 | 10 | 66 | 3784916 | 127 | 7960 |
| 1997 | 12 | 61 | 2015669 | 78 | 3196 |

Source: MDMR, 1999

Unfortunately, the country could not offer substantial resistance in order to reduce its high vulnerability to such natural events. Since time immemorial, intense cyclones have been visiting the coast of the Bengal delta. But rich endowment of natural resources enticed people to continue to live in cyclone-prone zones, often defying the fury of nature. Moreover, for the ever-increasing population who are confined within very small landmass, virtually no room is left to retreat from the dreadful zones. The geographical realities

and the imminent danger posed by global warming suggest that cyclonic devastation in the coastal areas will be more intense than ever before (Huq *et al.*, 1996). With these increasing risks, it is essential to devise mechanisms to mitigate cyclonic hazards and manage such events better.

In recent years Bangladesh' efforts managing such events have been highly successful. Evidence may be readily found if one compares with the damage figures of the two events in 1970 and 1991. This article analyzes how government and citizens worked together to reduce damages and cope with the aftermath of such events.

## 2. Cyclones: A Natural Phenomenon in the Coastal Areas of Bangladesh

Cyclones are usually generated in the deep sea when sea surface temperature reaches the threshold value of about 27° C. With increasing temperature, barometric pressure drops and the additional energy is dissipated in the form of high-speed winds. In Bangladesh, cyclones are observed twice a year: during late April and early May (early summer) and between late October and early November (late autumn). According to the definition of the government, the following is the classification of the cyclone based on the intensity and velocity of wind (GoB, 1999).

| | | |
|---|---|---|
| (a) Depression | : | Wind speed (WS) 31 miles/hr or 50 km/hr. |
| (b) Deep depression | : | WS 32-38 miles/hr or 51-61 km/hr. |
| (c) Cyclone | : | WS 39-54 miles/hr or 62-88 km/hr. |
| (d) Severe cyclone | : | WS 55-73 miles/hr or 89-117 km/hr. |
| (e) Cyclone with hurricane | : | WS 74 miles/hr or 118 km/hr and above. |

A storm surge during a cyclone inundates coastal areas and offshore islands, which causes most of the damages, foremost loss of lives and properties. Information on storm surge height is very scanty and often unreliable. Literature provided a range of 1.5 to 9.0 meter high storm surges during various severe cyclones (Haider *et al.*, 1991). The locations of these surge heights are not specific; therefore, it is difficult to compare maximum wind speed and corresponding surge heights. The displacement of water surface during a cyclone storm surge also depends on the height of tide. There is a great deal of difference in tide-height depending upon the season and position of the moon relative to the sun.

Cyclones of varied intensities have frequently visited the delta and caused huge damages to the lives and assets of millions of people in the coastal districts. The cyclone prone coastal areas are shown in figure-1. In 1584, about 200,000 people were reportedly killed in Barisal by a cyclonic storm surge. Another cyclone that occurred in 1822 killed more than 70,000 people in Barisal and 95% population of the Hatiya Island. Considering much smaller population in those years compared with the present, the death tolls

indicate the severity of the cyclones. A cyclone in November 1970 hit the southern districts of Bangladesh (the then East Pakistan) forcing a 9 m high storm surge and killing approximately 300,000 people (Haider *et al.*, 1991). In recent years, however, deaths caused by the cyclones with severe intensity are much less because of growing successful institutional arrangements for disaster management and the fact that there are now over 2000 cyclone shelters spread along the coast protecting the lives of those affected

## 3. Managing Hazardous Cyclones: Bangladesh's Experience

Bangladesh's management of cyclones comprises three steps: (a) pre-cyclone measures, (b) measures during cyclones, and (c) post-cyclone measures. A brief account for each measure is given below.

### *Pre-cyclone Measures*

The pre-cyclone measures are predominantly non-structural measures, which include detection of a cyclone and getting prepared for the event. Detection of a cyclone usually involves advanced technologies and expertise to translate satellite-based information, while preparing to save lives and properties involve management capacities and coordination.

#### *Cyclone forecast and warning*

The first step of a preparedness program is to have a clear forecast that would answer the following questions:

(i) whether a cyclone is formed;
(ii) whether the cyclone is approaching;
(iii) what would be the approximate time of landfall;
(iv) what would be the approximate location of landfall;
(v) what would be the intensity (maximum wind speed and approximate height of associated tidal surge) at the time of landfall etc.

Since the late 1970s, the scientists of the Storm Warning Centre (SWC) in collaboration with the Bangladesh Meteorological Department and the Bangladesh Space Research and Remote Sensing Organization have been working to monitor formation of depressions in the Bay of Bengal. The SWC analyzes the occurrence of cyclones by use of space technology. They receive online information from weather satellites and analyze digital information to answer the questions mentioned above. As soon as such information is known they inform the Ministry of Defense (MOD) and the Ministry of Disaster Management and Relief (MODMR) to take necessary actions concerning frequent forecast and issuance of warnings. SWC scientists were vital managing cyclones throughout the 1990s.

#### *Preparedness program*

Cyclone preparedness program (CPP) calls for a participatory non-structural measure that would help communities to prepare themselves in avoiding loss of lives and valuables upon receipt of cyclone warning. Dissemination of

warning at the grassroots involving local volunteers is a prerequisite for successful implementation of CPP. The very idea of CPP was initiated in 1965 by the courtesy of International Federation of Red Cross and Red Crescent Societies (IFRC, formerly the League of Red Cross and Red Crescent Societies). In 1966, IFRC and Swedish Red Cross undertook a pilot project that consisted of providing warning equipment and imparting training to the *Ansars* (local militia) to facilitate the people to get prepared for the events. In its initial phase there was no consideration for building structures to save lives, whereas emphasis was given to use the locally available infrastructure. CPP was made operational in 299 coastal locations.

After the devastation by the cyclone of 1970, it became obvious that CPP would have to be revitalized in order to make it more useful. Accordingly, the United Nations General Assembly requested the IFRC to take the leading role in establishing and improving the pre-disaster planning program. The new phase of CPP was started in 1972 with over 20,000 volunteers spread over 204 unions of 24 Upazilas. In 1973, following the independence of the country the new Government of Bangladesh (GOB) assumed its responsibility and strengthened the program with an institutional framework. As a joint activity between the GOB and IFRC two Committees have been created to administer and implement the CPP. To provide policy guidelines a Program Policy Committee was created. A larger committee, namely the Program Implementation Board, has been created to effectively administer and implement the program under the guidance of the former committee. The CPP now has a total of 158 full-time personnel and 32,796 trained volunteers, including 5,466 female volunteers, working at four different tiers: Units, Union, Upazila and Zone.

There are 2,733 Units, located in villages, each having a team of twelve volunteers including two female members. The villagers choose the volunteers themselves. Their responsibility is to disseminate the cyclone warning signals among villagers and assist in their evacuation. They receive meteorological forecast by using transistor radio. They use hand-held warning sirens, megaphones and hoist warning flags as per the forecast. There is a central office at the capital city Dhaka and there are six zonal (district level) and 30 Upazila offices under the CPP. The Zonal and Upazila offices are equipped with high frequency (HF) radio that maintains contact with headquarters. The Upazila office retransmits the forecast and warning by use of VHF radio and at times by sending messengers. Upon receipt of the warning, the Union-based Team Leader activates the village-level Units (volunteers) and starts door-to-door dissemination of warning signals.

In case of high risks, i.e., following the issuance of danger signals, an emergency meeting is convened for the Inter-ministerial Disaster Management Coordination Committee. For very high risks with great danger warnings, the National Disaster Management Council, headed by the Prime

Minister, sit for emergency meeting to take policy decisions regarding evacuation, rescue and relief (GOB, 1999). Depending upon the seriousness of the weather situation the GOB passes order for evacuation. In such cases the volunteers advise the community and help them take refuge in available safe places in the vicinity. After the event the volunteers take part in rescue operations, provide first aid to the injured, take the seriously injured to the local hospitals, and assist in the post-cyclone emergency relief operations.

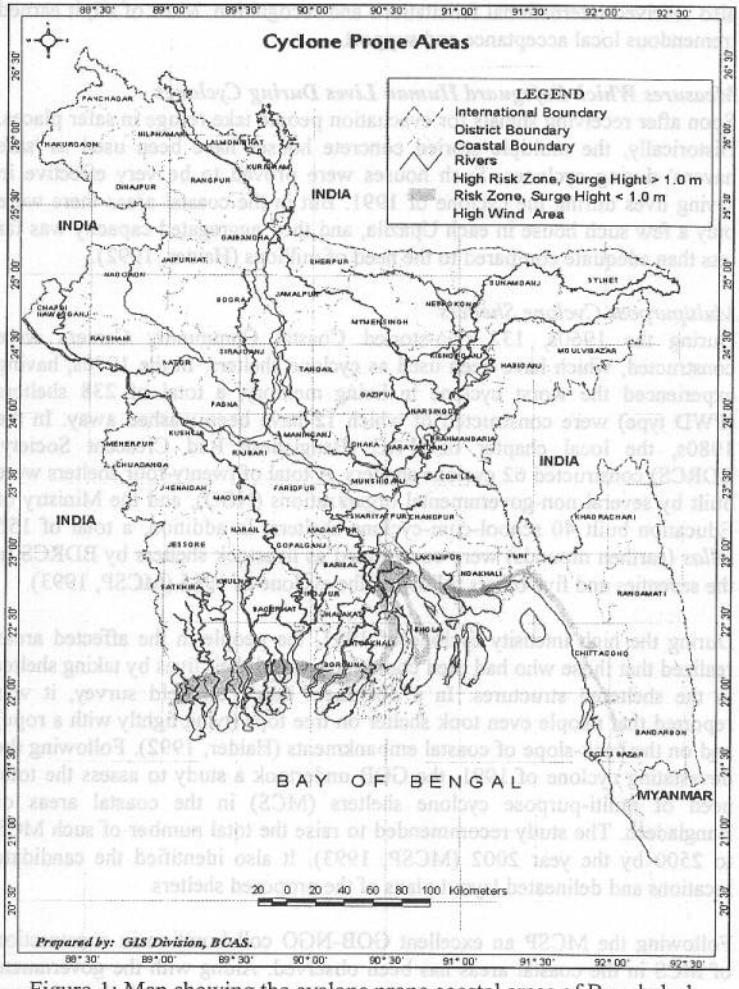


Figure-1: Map showing the cyclone prone coastal areas of Bangladesh.

Since the beginning of CPP a total of 168 depressions have been formed in the Bay, of which 19 intensified into severe cyclonic storm. Through the coordinated activities of SPARRSO, ministries in charge of Disaster Management & Relief, Defense, Communication and Information, and above all, the prompt response and activities of the CPP volunteers at the grassroots the Bangladesh have avoided large-scale loss of lives during the cyclones of 1994, 1997, and 1998. CPP has not only emerged as a successful program; it also received international felicitations and recognition. Most of all, it earned tremendous local acceptance and support.

***Measures Which Safeguard Human Lives During Cyclones***

Soon after receiving signals for evacuation people take refuge in safer places. Historically, the multiple storied concrete houses have been used as 'safe havens' during cyclones. Such houses were proved to be very effective in saving lives during the cyclone of 1991. But in the coastal areas there were only a few such house in each Upazila, and their aggregated capacity was far less than adequate compared to the need of millions (Haider, 1992).

*Multipurpose Cyclone Shelters*

During the 1960s, 132 two-storied Coastal Community Centers were constructed, which have been used as cyclone shelters. In the 1970s, having experienced the worst cyclone in living memory, a total of 238 shelters (PWD type) were constructed of which 12 have been washed away. In the 1980s, the local chapter of IFRC (Bangladesh Red Crescent Society, BDRCS) constructed 62 cyclone shelters. A total of twenty-four shelters were built by several non-governmental organizations (NGO), and the Ministry of Education built 40 school-cum-cyclone shelters. In addition, a total of 156 *killas* (earthen mounds) were constructed as livestock shelters by BDRCS in the seventies and five others following the cyclone of 1985 (MCSP, 1993).

During the high intensity cyclone of 1991, the people in the affected areas realized that those who had died could have saved their lives by taking shelter in the sheltered structures. In a document based on field survey, it was reported that people even took shelter on tree tops (tying tightly with a rope) and on the back-slope of coastal embankments (Haider, 1992). Following the devastating cyclone of 1991, the GOB undertook a study to assess the total need of multi-purpose cyclone shelters (MCS) in the coastal areas of Bangladesh. The study recommended to raise the total number of such MCS to 2500 by the year 2002 (MCSP, 1993). It also identified the candidate locations and delineated layout plans of the proposed shelters.

Following the MCSP an excellent GOB-NGO collaboration in construction of MCS in the coastal areas has been observed. Along with the government the NGO communities raised funds from national and international philanthropic organizations and built about a thousand MCS within a span of eight years. By September 1997, the total number of MCS in about 15 coastal

districts stood at 1841, including the newly constructed ones, with a total 'estimated' capacity of 1.3 million people. Table-2 provides the District-wise distribution of MCS with total capacity in each District. During the cyclones of 1994 and 1997, analysis determined that over 2.5 to 3.0 million people saved themselves by taking refuge in MCS..

Table-2: District-wise distribution of MCS and their capacities

| Name of district | Number of MCS (number) | Capacity (million people) |
|---|---|---|
| Bagerhat | 7 | 0.007 |
| Barguna | 42 | 0.037 |
| Barisal | 62 | 0.018 |
| Bhola | 152 | 0.061 |
| Chandpur | 5 | 0.002 |
| Chittagong | 479 | 0.522 |
| Cox's Bazar | 401 | 0.251 |
| Feni | 106 | 0.082 |
| Jhalokathi | 26 | 0.003 |
| Khulna | 34 | 0.022 |
| Laxmipur | 109 | 0.060 |
| Noakhali | 198 | 0.096 |
| Patuakhali | 161 | 0.100 |
| Pirojpur | 31 | 0.040 |
| Satkhira | 28 | 0.023 |
| Total Bangladesh | 1841 | 1.300 |

Notes: Capacity represents estimated capacity. Actual capacities are higher.
Source: GOB, 1998.

Although about 74% of the proposed MCS are now in place, their aggregate capacity appears to be far less (only about 20%) than the projected demand for 2002. Moreover, the MCS are not built according to the MCSP recommended specifications and locations. There are reports that maintenance of a large number of recently built MCS is less than satisfactory for the local users. Nevertheless, people threatened by cyclone usually do not have much choice when they are forced to use such shelters.

***Embankments***

Historically, coastal embankments were meant to safeguard prime agricultural lands from saline intrusion. The Bangladesh Water Development Board, a government agency, has been involved in building coastal embankments since 1960. During the first two phases of the coastal embankment project (CEP), a total of 108 polders were built between 1960 and 1978. The sea-facing parts of some identified polders have been revamped under the Cyclone Protection Project-II in order to protect lives and properties, in addition to agricultural lands. Such improvements covered

some 678-km of embankment length along the coastal belt facing the sea. A number of other polders have also been constructed later. Although the coastal embankments were not meant to protect lives and assets from cyclonic storm surges, people found the embankments as refuges when necessity arose. The inner slope of the embankment appeared to be the second best choice for those who could not find a shelter in the vicinity.

***Post-cyclone activities***

The major activities following a devastating cyclone involve undertaking a relief operation and facilitating the people in the affected areas to rehabilitate themselves. The activity of the MDMR begins during the pre-disaster stage with checking the stock of food stuff and relief supplies, assessing state of transportation and communication at all levels. Grants of food items, drinking water and cash are made available to the needy. The Directorate of Relief and Rehabilitation (DRR) is the implementing agency under the MDMR that manages the procurement, clearance, and distribution of relief goods.

The medical units undertake search operations to find the injured, rescue and treat them. The DRR mobilizes available relief stocks in the cyclone battered areas in collaboration with the local administration and continues all relief and rehabilitation efforts until situation returns to normal. The Officials of DRR and the local administration also help people bury the dead, dispose animal carcasses, restore disrupted water supply, mend communication and transportation systems etc. In addition to the government agencies, the community based organizations (CBO) and the non-government organizations (NGO) reach out to those in remote areas providing for the needy. It was observed during the cyclone of 1991 that the NGOs promptly responded to the emergency and helped people rehabilitate themselves in a concerted manner, while the government activities were facilitated by external forces (Haider *et al.*, 1991).

In the short run, CBOs and NGOs can play a very significant role towards rehabilitation. In most cases, they offer short-rotation, micro-credit to the affected households. Such short-rotation lending has been very useful in rehabilitating agricultural activities, fishing and other small-scale activities. On the other hand, it is observed that government can play much bigger a role towards rehabilitating the communities for a longer term. While CBOs/NGOs offer smaller grants/credits to restore livelihood of the affected people, the government offers large lending to the affected industries and business communities. By rehabilitating large businesses, the owners are instructed not to lay off the employees and thereby, mass unemployment is avoided.

## 4. Conclusions

Over the years, Bangladesh, with its very limited resources and assistance from abroad, have successfully introduced a disaster management program. The overall performance of the program managing various types of disasters

is not so satisfactory, but the performance of the component responding to cyclones has been quite satisfactory. The MCS premises have been utilized round the year for a number of uses and the local people have thankfully accepted them. School children have found a place to study, the elderly have found a community meeting place--the premises have given the right infrastructure to build social capital.

The non-structural measures, on the other hand, are also proved to be useful. The government is trying to install a sustainable mechanism through which communities can help each other during and after a cyclonic disaster. Empowering communities, especially the poor ones, is a difficult task. A good pro-active guideline and coordinated approach can help accomplish the task. This is the lesson the country has learned over the past decade.

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