SUPERCYCLONE SIDR 2007 AND BANGLADESH

by

Dr. A. M. Choudhury

THE SUPERCYCLONE SIDR - 2007

The supercylone SIDR was observed in the satellite picture as a depression on 10 November, 2007. On that day it was at a distance of some 1150 kms (about 700 miles) from Chittagong port and about 1100 km (680 miles) from Khulna coast. It turned into a Cyclone with a distinct eye. Gradually it turned into a supercyclone. It was initially moving in a northwesterly direction and then northwards. Its movement was slow in the beginning but it rapidly accelerated and reached Bangladesh shore in the evening of 15 November. As it was reaching the Bangladesh coast, it turned northeastwards and crossed Patuakhali coast near Patherghata at about 9 pm on the 15th November. Had it continued its northward motion in its last journey before it turned northeastwards, it would have crossed the Sunderbans along the Bangladesh-India border and the damage would have been much less, this was the forecast given by many world famous weather agencies.

However, Banghladesh authorities made a correct assessment of the situation and raised signal no. 10 at Mongla port and signal no. 9 at Chittagong and Cox's Bazar on the 14th of November.

There was the order of complete evacuation of the affected people into Cyclone shelters by 15 November. However, as the number of shelters was not adequate, everybody in the effected area could not go into the shelter and some people ignored the warning and did not move into a safe place. As a result some 3300 people (may be more as whereabouts of many could not be known) lost their valuable lives.

The strength of the cyclone was so intense (its velocity when it was at the sea was estimated to be some 240 km/hour, the fiercest cyclone that hit Bangladesh so far) that it has been termed as a supercyclone. Its dimension was larger than the area of Bangladesh. However, as its landfall did not coincide with the high tide, the maximum storm surge generated was about 20-25 feet as estimated from the marks on the surviving trees. As the coast was only few feet above the sea-level, this surge along with very strong wind was able to do colossal damage. Some one million

people who have been affected and survived the Cyclone are facing the fight for their lives. Most of them have lost everything – their food, their houses, their livestock, edible water and other essentials which support, life. However, the Gov't with the support of the armed forces came to their assistance very promptly. Food and cloths are being distributed by helicopters in the far flung areas. Many NGO's, political organisations and people in general are also coming to their help. Foreign donors are also very prompt in coming to our assistance. Two relief ships equipment with some 40 helicopters, small planes, food, medical stuff are already in operation. They have made their resolve to continue relief work as long as necessary.

SIDR DAMAGES

The supercyclone SIDR had a wind speed of 240 km/hr which was higher than those of 1970 and 1991. The storm surge generated was somewhat less, tree marks show some maximum of 20-25 feet. This is because the landfall did not occur at the time of high tide. But this wind and storm surge combined has made colossal damage which exceeds that due to other similar cyclones mentioned above.The overall damage estimated by the govt is 2.31 billion US dollars which exceeds the damage caused by 1991 cyclone which was estimated to be 1.38 billion US dollars. SIDR has affected some 22 districts of the country. The most seriously affected districts are the coastal districts of Barguna, Patuakhali, Bagherhat, Barisal, Pirojpur, Satkhira, Khulna, Jhalakati. Some of the worst affected areas are Dublarchar, Patharghata, Sharankhola and the like. Even there has been large scale damages in Bhola, Chandpur, Lakshmipur etc. The cyclone after crossing Patharghata moved in a northeasterly direction and as it passed over the land it damaged the standing crops in the Madaripur, Shariatpur, Gopalganj, Faridpur and various districts of Sylhet Division though as it passed inland its intensity started diminishing. There has not been much damage in the Chittagong area though there has report of storm surges. This time there was no damage to our ships or aircrafts unlike 1991 cyclone because they were taken to safe place well in advance. There were strong winds throughout the Dhaka city during the night of 15 November. The electric grid was down over the entire country for about 36 hours as a result of the storm. The damage has been very extensive in many char areas which characterize the region. The human casualty was 3300 and 773 missing persons which figure has been given by the Govt. The casualty figure was much less this time compared to 500,000 and 138,000 in 1970 and 1991 respectively. This is due to the advance preparedness measures taken by the authorities concerned including the armed forces. The casualty would have been lesser had there been more cyclone shelters. The resilience of the people needs to be mentioned here. Many have survived by climbing trees and fighting the storm surge. However, the cyclone has ravaged everything wherever it

has passed through. The major sectors of the economy affected are habitat, drinking water, agriculture, livestock, fisheries, communications, embankments, educational institutions and so on. It is estimated that more than a million households have been affected. After the cyclone was over, most of the people had no shelter. They lived under open sky for many days. The affected people had no drinking water as the source of drinking water, local ponds were contaminated by both animal and human corpses. It took quite sometime to make drinking water available to th needy. The two US rescue ships Kearsarge and USS Tarawa supplied drinking water and medical relief to the cyclone affected people.The ponds have been purified by adding appropriate chemicals and removing corpses. The agriculture in the affected area had been very severely damaged. They were just ripe to be harvested. The cyclone has damaged the standing crops all along the area it has passed, say in the Madaripur area where destruction was not as widespread as in the coastal districts, but crops have been damaged very badly. A conservative estimate has given a loss of six lac ton of Amon rice, which together with double this amount of loss due to two floods, and regular shortfall has put a serious strain on the food security. The Govt has requested the donors to supply five lac tons of rice instead of cash. India has lifted ban on export of rice to Bangladesh and the latter can import rice from India to the tune of five lac tons. The fisheries sector has suffered a severe blow. The fishermen have lost their boats and the fishing nets and as a result they are at a loss what to do. Lot of trawlers have been drowned. Moreover, many of the shrimp farms have been washed away. This will reduce our foreign exchange earnings due to shrimp exports. It was estimated that about five lacs cattle died. Road communication was largely disrupted by the fallen trees due to cyclones. Culverts and bridges numbering 1654 and 1100 kms. of road were destroyed. It is estimated that damage to educational institutions numbered 9248 affecting 750,000 students. Most of the coastal embankments in the area have given to the fury of the storm surges. The largest Mangrove in the world-the Sunderbans which has been declared as world heritage by UNESCO has been destroyed to the tune of 20%.The Govt has admirably tackled the rescue and relief operations and has pledged to rehabilitate the affected people who will be given VGF relief for four months. Foreign donors have pledged so far US dollar of 600 million. Some of the damages are shown in figures.

WHY CYCLONES ?

Our planet earth receives all its energies from the sun. Hence it may be thought that the calamities like cyclones and blessings like monsoon rains owe their origin from the sun. But this is so only indirectly. Solar radiation is maximum at the earth's equator and minimum at the poles. Again different surfaces on the earth have got different capacities for

absorption and emission of solar radiation. Thus different areas on earth are heated unequally. These variable factors give rise to low and high atmospheric pressure areas on the earth. It is because of the existence of the low and high pressure areas that we get good or bad weather.

Though solar energy ultimately controls the terrestrial weather, the following environmental conditions have been found to be prerequisites for the development of cyclones (i) Absence of strong vertical wind shear of the horizontal wind near the cyclone centre and presence of strong vertical shear of opposite sign on either side of this system. The difference between the wind vectors between two vertical levels is known as the vertical wind shear (ii) Presence of low pressure region with cyclonic vorticity (iii) Warm ocean temperatures. A tropical storm does not form if the sea temperature is less than 26.5^0C.W Such a high surface temperature is necessary to produce a steep lapse rate for maintaining the vertical circulation in a cyclone. This condition is met throughout the year in regions of the Bay of Bengal where cyclones are formed.

The Bay of Bengal cyclones are formed mostly near the Andamans. They usually occur at latitudes greater than 5^ON or 5^OS. It is thought that Inter-Tropical Convergence Zone (ITCZ) has got to do something with their formation. The ITCZ is the region where winds from the two hemispheres meet and is situated near the equator, but its position varies with season. A cyclone derives its spinning motion from the Coriolis Force arising out of the rotation of the earth. This force is virtually zero at the equator. Hence, cyclones do not usually form at the equator. They are formed slightly north or south of the equator to get the necessary spin. It is probable that the easterly waves also play some part in the formation of cyclones.

As soon as a low pressure area is formed, air from all directions converges towards this area. This phenomenon is called low level convergence. It causes the air to spin faster and the air spirals inwards and upwards at an increasing rate causing heavy rain and thunderstorm. The air is also made very moist by rapid evaporation from the warm ocean. In the low pressure region itself, air rapidly moves upwards and diverges. This is called high level divergence. Thus, there must exist some mechanism for the quick removal of the ascending air. The latent heat released by the condensation of water vapour warms the air and keeps it unstable. This latent heat is also thought to supply the necessary energy of the cyclone. The total energy involved in a moderate cyclone may be equal to that in several thousand atom bombs of megaton strength.

A cyclone can extend upto a height of 15 kms. Some suggest that a triggering mechanism may exist in the upper atmosphere for

the formation of cyclones. All the low pressure systems may not develop into cyclones. Some just die out whereas others intensify into cyclones. It has been observed that both the frequency and strength of the cyclone are on the increase as a result of global warming. We cannot say that SIDR has occurred as a result of global warming but certainly its increased intensity has got to do with global warming which has been proved mathematically by the author. Thus we can say that the colossal damage which SIDR has done can be ascribed to global warming. Catastrophic cyclones used to occur in our region at intervals of say hundred years, but now they occur at intervals of ten years or less.

CLASSIFICATION

Cyclones in the South Asian sub-continent are presently classified according to their intensity and the following nomenclature is in use:

Depression	**:**	**Winds upto 62 kms/hr.**
Cyclonic Storm	**:**	**Winds from 63-87 kms/hr.**
Severe Cyclonic Storm	**:**	**Winds from 88-118 kms/hr.**
Severe Cyclonic Storm of Hurricane Intensity	**:**	**Winds above 118 kms/hr.**

It has been observed from satellite pictures that a mature cyclone has got a well organized cloud pattern. It is possible to deduce the wind speeds in cyclones from the size and degree of organization of the cloud pattern as observed in the satellite picture.

Classification of cyclones from categories T1 to T8 has been made. This system of classification has evolved after simultaneous observation of tropical cyclones by both spacecraft and aircraft. During aircraft reconnaissance, various parameters like wind speed, atmospheric pressure and temperature were measured at various locations of the cyclones of the Atlantic and the Pacific. By a mathematical analysis of the cyclone data of the Bay of Bengal, it has been shown that the cyclone models of the Atlantic and the Pacific can be applied with reasonable accuracy in the case of the cyclones of the Bay of Bengal. An analytical formulation has been made by the author regarding the structure of the cyclone with T numbers.

FEATURES

The most individual feature of a cyclone is its `eye' usually found in severe cyclones. The eye can be seen in the satellite pictures clearly in the case of strong cyclones. The eye is small and almost circular, it coincides with the area of lowest pressure having a diameter ranging from 8-50 kms. The eye is warmer than the rest of the storm. The more violent is the storm, the warmer is the eye. The winds are very light in the

eye, usually not more than 25-30 kms/hr. and rain is practically absent. In contrast, the strongest wind and the heaviest rain occur just outside this central eye.

The wind speed gradually diminishes as one goes away from the region of strongest wind. The main core of the cyclone is circular or nearly circular having a diameter ranging from 100-800 kms. The main cyclone is often accompanied by a long tail having more than one band, the whole thing making a spiral structure, and looking like an inverted comma, the tail may extend upto a few hundred kms. The tail usually crosses the land well before the main core of the cyclone and as a result the sky is overcast with cloud and rain often sets in before the onset of a cyclone. Such symptoms can serve as a warning for the possible approach of a cyclone.

THE TRACK OF THE CYCLONE AND STORM SURGES

The cyclones in their initial stages move at a rate of 5-10 kms/hr. In their final stages they may move at a rate of 20-30 kms/hr. or even upto 40 kms/hr. Cyclones formed in the Bay of Bengal usually move northwesterly in the beginning and then curve eastwards. But this pattern is not uniformly followed seen from the tracks of various cyclones. The cyclone usually decays after crossing the land. Cyclones are accompanied by heavy rains and swell of the sea called storm surges. If the cyclone occurs during high tide, the storm surge is reinforced considerably. The maximum value of storm surge can be as high as 40 ft. in the Bay of Bengal. Most of the damage is done by the deadly wall of water associated with cyclones and inhabitants are met with watery graves. The storm surge values along with speeds and official casualties associated with various cyclones that struck Bangladesh since 1960 are shown in Table I.

TABLE I

Cyclones affecting Bangladesh since 1960

Date	Max. wind speed in Kms/hr	Storms surge ht. (in ft.)	Deaths
09 Oct. 1960	162	10	3,000
30 Oct. 1960	210	15-20	5,149
09 May 1961	146	8-10	11,466
30 May 1961	146	20-29	-
28 May 1963	203	14-17	11,520
11 April 1964	-	-	196
11 May 1965	162	12	19,279
31 May 1965	-	20-25	-
14 Dec. 1965	210	15-20	873
01 Oct. 1966	146	15-30	850
11 Oct. 1967	-	6-28	-
24 Oct. 1967	-	5-25	-
10 May 1968	-	9-15	-
17 April 1969	-	-	75
10 Oct. 1969	-	8-24	-
07 May 1970	-	10-16	-
23 Oct. 1970	-	-	300
12 Nov. 1970	223	20-30	5,00,000
08 May 1971	-	8-14	-
30 Sep. 1971	-	8-14	-
06 Nov. 1971	-	8-18	-
18 Nov. 1973	-	8-13	-
09 Dec. 1973	122	5-15	183
15 Aug. 1974	97	5-22	-
28 Nov. 1974	162	7-16	a few
21 Oct. 1976	105	8-16	-
13 May 1977	122	-	-
10 Dec. 1981	97	6	02
15 Oct. 1983	97	-	-
09 Nov. 1983	122	-	-
03 June 1984	89	-	-
25 May 1985	154	10-15	11,069
29 Nov. 1988	162	5-10	2,000
29 April 1991	225	20-25	1,40,000
02 June 1991	100	6	-
02 May 1994	200	-	170
25 Nov. 1995	100	-	6
19 May 1997	225	15	126
26 May 1997	150	10	70
20 May 1998	120	-	03
15 Nov. 2007	240	20-25	3,300

The wind speed in a cyclone is more towards the right hand side of a cyclone track and less on the left hand side. In the

case of Bangladesh coast, the wind in a cyclone is from sea to landward on the right hand side of the track and from land to seaward on the left-hand side of the track. As a result there is great surge on the right hand side of the track and negative surge on the left hand side. This is the reason for lowering of the river levels at various locations like Dhaka, Patuakhali & Khulna which fell on the left side of the track during the great cyclone of 29 April, 1991.

A model estimation of maximum storm surge heights corresponding to various wind speeds as prepared by SPARRSO is shown in the Table II.

TABLE II

Relationship between Wind Speed and Surge Height

Wind Speed (Kms/hr)	Surge Height in ft. (Maximum value)
64	3.87
76	5.71
89	7.48
97	9.18
108	10.81
108	10.81
124	13.88
132	15.31
141	16.68
147	17.98
151	19.21
158	20.48
163	21.48
167	22.51
171	23.48
176	24.38
179	25.21
182	25.98
185	26.68
188	27.31
192	27.88
195	28.38
198	28.81
201	29.18
208	29.70
211	29.88
214	29.98
219	30.01

This table only gives the maximum value of storm surges for Bangladesh coast. It is possible to calculate from mathematical equations governing the motion of the sea by numerical means with

the help of a computer the storm surge at various locations for a particular cyclone with a given track and wind speed distribution.

DETERMINATION OF THE CYCLONE TRACK

The precise forces responsible for the motion of tropical cyclones is not understood clearly and hence determination of the path of the cyclone in advance is one of the most difficult tasks in meteorology.

The classical methods for forecasting cyclone tracks are judicious consideration of climatology of cyclones, persistence of motion and some steering current of the upper atmosphere. Tropical cyclones often show different preferred paths in different times of the year. Hence, climatology of cyclones provides some good guess for considerations to base the initial forecast. However, as there are large numbers of exceptions, forecast based on climatology alone cannot be entirely relied upon.

Persistence of motion assumes that integrated effect of all forces which have caused the tropical cyclone to move during some past period will continue in the future period. However, the technique fails when re-curvature takes place and some cyclones may depict re-curvature more than once.

In cyclone forecasting, it is often assumed that cyclone follows the direction of upper atmosphere current at some height. SPARRSO in collaboration with Dhaka University has undertaken an investigation of the problem and it has been found that there seems to be a steering current for every cyclone, but the level differs from cyclone to cyclone and there does not seem to be any relationship with intensity of the cyclone. Moreover, the upper atmospheric current is as variable as the track of the cyclone and hence it is difficult to find out the exact steering current.

Recently various statistical and numerical dynamical methods have also been introduced for the forecast of cyclone paths. (1) Steering Principle was 1st applied by H. Mohn in 1870. Until 1950 forecasts of tropical cyclones were made by subjective methods based on synoptic maps and climatological behaviour. Following are some of the objective methods applied in modern times for cyclone forecasting. (2) Statistical methods relate predicted movement to one or more parameters in an empirical way. (3) Dynamical techniques, on th other hand make use of some forms of the equation of motion to predict numerically the motion of cyclone from an observed initial state of the atmosphere. (4) Hybrid model in which output parameters from a dynamical model are used in a statistical model. The author has developed a model called Rose Petal Theory for the Bay of Bengal Cyclones which has been found to be very promising for cyclone forecasting.

ROLE OF WEATHER SATELLITES IN CYCLONE WARNING

Weather in a global phenomenon and to know the initial state of the weather at a particular time, accurate observations on worldwide scale are needed.

The distribution of surface observations is heavily biased towards well populated land regions. Commercial shipping does provide some observations over the oceans. But as the ships avoid the cyclones, most vital data on cyclones are left out. High up the atmosphere, balloons can rise upto a maximum height of 30 kms only. Thus the vast expanse of the atmosphere and the oceans remained unexplored before the space age. With the advent of the space age, rockets can gather data at different heights of the atmosphere and satellites can survey the earth's weather from a point well above the earth's surface. The advantages of space meteorology over the conventional methods are as follows:

(1) Spatial continuity: The observations are horizontally continuous, this eliminates interpolation and thus the ambiguity often present in synoptic charts.

(2) Provides information on a synoptic scale with virtually no time lag.

(3) Visual Integration: Permits integrated visualization of weather systems in a way readily acceptable to the human mind.

(4) Independence of Communication System: Provides large scale weather information even if normal system of communications have broken down.

Thus the superior quality of the Space Meteorology is unquestionable. But this does not make the traditional synoptic meteorology obsolete. It rather supplements the old system. Improvement and innovations of the old system are continually taking place. In actual warning system, forecast is made integrating data from various sources like the conventional ground and balloon observations, radar and satellite observations.

Bangladesh does not have either rocket or satellite facilities of its own, but with the help of ground stations, we can receive weather pictures from weather satellites launched by advanced countries.

An APT (Automatic Picture Transmission) Ground Station for the reception of imagery from weather satellites was established in 1968 in Bangladesh. Initially it was installed by former

SUPARCO (Space and Upper Atmosphere Research Committee) in the Atomic Energy Centre Building, Dhaka. Recently SPARRSO has established advanced receiving and analyzing equipment including VAX computers, printers and International Imaging System monitors for the reception and analysis of satellite data under its Agroclimatic/Environmental Monitoring Project with financial assistance from US-AID under NASA supervision. SPARRSO has also acquired facilities for the reception of very high resolution meteorological satellite data from Chinese satellite FY 2C.

With the help of these equipments high resolution data from US NOAA-and Chinese satellites are received. Chinese satellites transmit good quality high resolution data every hour and NOAA transmits data at six hourly intervals. An automatic grid i.e. latitude longitude and national boundaries can be fitted in the picture with the help of the present equipment. Because of these equipments, no cyclone in the Bay of Bengal can escape our notice. We can detect the cyclones, analyze their intensity, determine their position and track their motion. From the degree of organization of the cloud patterns and their sizes, we can deduce the maximum wind speeds in cyclones.

CYCLONE WARNING SIGNALS

There is a system of signal numbers for warning the port authorities of the danger of an impending cyclone. The same signal numbers are also applicable to public in general. There are ten signals is use for the sea ports. Explanations of the signals are as follows:

1. **Distant Cautionary signal Number One: This signal number means that a depression has formed in any part of the Bay of Bengal and the concerned port is not thretened by it, but ship leaving the port is likely to experience bad weather due to it on her way.**
2. **Distant Warning Signal Number Two: This means that a cyclonic storm has been formed with a sustained wind speed of 40 miles/hr. Or more and the port is not threatened but the ship leaving the port is likely to get bad weather on her way.**
3. **Local Cautionary Signal Number Three: This means that the port is threatened by squally weather.**
4. **Warning Signal Number Four: This signal number means that the port is threatened by a storm, but it does not appear that the danger is yet sufficiently great to justify extreme measure of precaution.**
5. **Danger Signal Number Five: This means that the port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the South of the port in the case of Chittagong and Cox's Bazar and East of the port in the case of Mongla.**
6. **Danger Signal Number Six: This means that the port will**

experience severe weather from a storm of slight or moderate intensity. That is expected to cross to the North of the port in the case of Chittagong and Cox's Bazar and West of the port in the case of Mongla.

7 **Danger Signal Number Seven: This means that the port will experience severe weather from a storm of slight or moderate intensity that is expected to cross over or near to the port. The above three signals 5, 6 & 7 are advised to be hoisted when a cyclonic storm is expected to have sustained wind speed of 39 miles/hr. Or more but less that 55 miles/hr.**

8 **Great Danger Signal Number Eight: This means that the port is threatened by severe weather from a storm of great intensity that is expected to cross the coast to the south of the port in the case of Chittagong and Cox's Bazar and to the East of port in the case of Mongla.**

9 **Great Danger Signal Number Nine: This means that 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 the case of Chittagong and Cox's Bazar and to the West of the port in the case of Mongla.**

10 **Great Danger Signal Number Ten: The port will experience severe weather from a storm of great intensityh that is expected to cross the coast over or near the port.**

The signal Nos. 8, 9 & 10 are advised to be hoisted when acyclonic storm is expected to have sustained wind speed greater that 54 miles/hr.

We see that the Signal numbers 5, 6 & 7 are similar, the difference is due to the direction of the storm. Same is true for signal numbers 8, 9 & 10.

11 **Failure of Communication Signal Number Eleven: This means that communications with the Meteorological Warning Centre have broken down and the local officers consider that a devastating Cyclone is following.**

Signals for Riverports : Besides these signal numbers, a set of four signal numbers are used for the river ports as described below :

(1) Cautionary signal 1 means that the area is threatened by squally weather, the rivercrafts should move with caution but may not stop navigation.

(2) Warning signal number 2 means that the area may face wind due to depression with wind speed less that 39 miles/hr. or by a norwester. Vessels of 65 feet and under in length will seek shelter immediately.

(3) Danger signal number 3 means that the area is threatened by a cyclonic storm with sustained wind

speed between 39 miles to 54 miles/hr. All vessels will seek shelter immediately.

(4) Great Danger signal number 4 means that the area is threatened by a cyclonic storm with wind speed greater than 54 miles/hr. All vessels will take shelter immediately.

CAN CYCLONES BE PREVENTED

The energy involved in a severe cyclone is equivalent to that of several thousand atom bombs of megaton strength and hence it is difficult even at this advanced stage of technology to try to modify a tropical cyclone. Experiments have been conducted by United States by spraying silver iodide in the region of the maximum wind speed with a view to minimizing the wind speed of cyclones in the Atlantic. However, these experiments though very promising have remained inconclusive. Moreover, there is a chance that these cyclones could change their track. A cyclone which would have moved towards one country stands the chance of moving towards another country as a result of these experiments and hence they have become subjects of international law and politics. Consequently, these experiments have been stopped for the time being. Cyclones which are formed far away from land areas and do not have the chance of hitting any land area as a result of experimental modification and at the same time meet the logistic requirements could serve as experimental guinea-pigs. However, such cyclones are difficult to find.

Other methods which have been suggested for preventing the formation or reducing the severity of tropical cyclones is to cover the suspected area of sea surface with a thin layer of oil or some chemical substance for reducing evaporation from the ocean. However, pollution effect of this gigantic effort needs to be considered before this experiment could be carried out.

PROTECTION AGAINST CYCLONES

What can be done to protect ourselves from the cyclones? A cyclone is a natural phenomenon like an earthquake or a volcanic eruption. We have to learn to live with it. We have to strengthen the cyclone warning system and adopt protective and relief measures to minimize their onslaught. Strongly built houses have to be constructed high above the sea level to serve as shelter places. People from the low lying areas in the coastal region can be evacuated into these shelters in the event of a cyclonic hit. Coastal embankments have to be made to protect life and property from the onslaught of storm surges. Plantation of trees along the coastal area can also diminish the fury of the storm surge.

Bangladesh to-day has got a comprehensive Cyclone Preparedness Programme (CPP) jointly operated by the Bangladesh Red Crescent Society and the Ministry of Relief and Rehabilitation. It has a membership of about 20,000 devoted volunteers spread over 2,043 wards of 195 unions of the coastal belt of Bangladesh. In each ward the trained volunteers do the needful in the event of a cyclone. Each ward is provided with a transistor radio, a megaphone-cum-siren, a signal torch light and first aid kits. Almost each Upazila is provided with a wireless set which keeps direct communication with Dhaka. The Red-crescent volunteers are responsible for the following:

(1) Spreading warnings against approaching cyclones reported by radio, surveying damages caused by cyclones and reporting them to the Union Headquarters.

(2) The arrangement of shelters for people, possibly also for cattle and for security of other property.

(3) The rescue of survivours still in danger.

(4) First-aid to the wounded and post-cyclone sanitary measures.

(5) Distribution of food and clothing to the needy.

The whole Government machinery including the Army, the Navy, the Air Force and the relevant ministries and organisations discharge their respective duties in the event of a cyclone disaster. The directive for actions at various stages comes from the highest seat of the Government. There is a standing order for cyclones which lay down actions by all concerned during the various stages of the disaster.

CONCLUSION

Cyclone warning and preparedness measures have improved considerably in Bangladesh during the past two decades. However, the recent catastrophic cyclone of 1991 has demonstrated that lot more action needs to be taken in this respect. Human lives and property are all very precious and utmost attention needs to be given to protect them from the onslaught of ravaging cyclones. The low-lying coastal areas where the cyclones do the maximum damage have very poorly built houses. Wind-resistant construction of frame and concrete block buildings are recommended. As most of the destruction is due to storm surge, a gap of some ten feet could be left out at the bottom and there should be at least two or three storied buildings so that even if the ground floor is submerged by surge water, people can take shelter in the upper floors.

It has been found from experience that cyclone shelters have served the purpose very well in giving shelter to cyclone ravaged-people. However, presently their numbers are far from adequate. They should meet the demand of the existing population and considering this, some several thousand shelters need to be constructed. They could serve multipurpose functions like schools, community centres, mosques etc. and should be maintained regularly. Cyclone warning forecasts need to be improved and their inherent meaning explained to people in simple language so that the credibility gap of the forecasts reduced and their reliability improved.

There is a need for coastal embankments to protect the people from the onslaught of storm surges. The existing embankments were not designed for protection against storm surges, rather their purpose was protection against salinity intrusion due to normal tides. Hence they are not at all effective against storm surges. If embankments are to serve the purpose of protection against storm surges, they should be consistent with the maximum height reached by storm surges and they must be maintained regularly. They could have appropriate slope to minimize wave action. However, environmental aspects of such projects need to be considered before they are taken up. They could be stabilized by planting multi layer trees. Afforestation in the coastal area must be strengthened. Forests reduce effects of both winds and storm surges. That is why cyclone damage when it passes through Sunderbans is less which we have witnessed this year. There was a forest in the Chakaria regions similar to Sunderbans. But recently this forest has completely been denuded and prawn firms were established. Thus a belt of forest throughout the coastal area is essential. Forest can stabilize land and also reduce the fury of the cyclone. Necessary legislation in respect of disaster preparedness should be formulated so that the actions become binding on all concerned.

==========