CYCLONE DISASTER MANAGEMENT AND REGIONAL/RURAL DEVELOPMENT PLANNING

UNCRD-CIRDAP SEMINAR' PHASEIII
27-29 JANUARY 1992
CHITTANG, BANGLADESH

UNITED NATIONS CENTRE FOR REGIONAL DEVELOPMENT

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PREFACE

Since the commencement of the International Decade for Natural Disaster Reduction (IDNDR) in l990, UNCRD has been making multiple efforts to cope with natural disasters by arranging workshops, seminars and meetings at global, regional and national levels; undertaking research activities with universities and research institutions; and developing human resources through training and technology transfer. However, it has been noticed that developing countries have not paid adequate attention to disaster mitigation measures in spite of the fact that they have been making great efforts for national development, faster economic growth and improvement in people's welfare. As such disasters have much more severe impacts in a developing country than in a developed country. In a developing country generally there is no prior disaster budget and after a disaster funds must be diverted from development budget for rehabilitation and reconstruction. This obviously slows down development activity and hence economic growth.

In the case of cyclone disaster in Bangladesh on 29-30 April 1991, the storm had a maximum wind speed of more than 225 km/hr. and a maximum surge height of about 8-meter that killed about 140,000 people and caused economic losses of estimated 1.4 billion US dollars. Compared to the size of national economy of Bangladesh, a loss of 1.4 billion US dollars is really devastating and the death of so many people by a single disaster is very much painstaking. The damaged infrastructures such as facilities at Chittagong Port, industrial enterprises in Chittagong Export Processing Zone, coastal embankment, roads, bridges, etc. have serious impact on future development of Bangladesh. A farmer or a fisherman whose livelihood had depended on a pair of cows or on a small fishing boat lost his vital property and means of supporting his family, and after the disaster now faces the diffieult task of reconstructing his future from the start. After the 1991 cyclone, UNCRD immediately dispatched one of its experts to Bangladesh in order to gather first hand information and subsequently organised a team of multinational experts for field study and investigation, the results of which have already been published in a report titled as 'Cyclone Damage in Bangladesh'. The above team of experts has identified the following three topics for research towards an improved system for the mitigation of cyclone disaster in Bangladesh.

1. Identification of cyclone disaster risk and feasibility of structural preventive measures.

2. Towards a better accuracy and reliability in cyclone and surges prediction.

3. A Master Plan of emergency response to cyclone disaster including the effective distribution of collective cyclone shelters.

As a follow up of the above activities UNCRD in collaboration with CIRDAP (Centre on Integrated Rural Development for Asia and the Pacific) organised a seminar on `Integrated Approach to Cyclone Disaster Management and Regional/Rural Development Planning'. The seminar was held in Chittagong, Bangladesh from 27-29 January 1992. Six resource papers were presented at this seminar by eminent scholars and experts. Through this seminar on the cyclone disaster management it became clear that the socio-economic measures to the cyclone disaster management is quite important for a country like Bangladesh. Widespread poverty and lack of education are the main causes of severe disaster in Bangladesh. As such, income and employment generation projects; and arrangement of basic education specially for the rural and urban poor should be undertaken together with disaster mitigation programmes.

As basic data for the preparation of disaster preparedness plan, it is fundamental to know the distribution of population and topographic information. It is important to search for disaster mitigation measures which take into consideration the socio-economic conditions of the people and save their lives and properties. Some structural measures are quite effective in preventing or mitigating cyclone disasters, but these are very expensive and need further study and investigation. Emphasis should be put on non-structural measures such as, land use zoning in relation to vulnerability, dissemination of early warning, adequate evacuation facilities including shelters, etc.

The resource papers presented at the seminar along with findings and recommendations are incorporated into this report. It is expected that this report will serve as a very useful reference material for research, training and disaster management planning.

We gratefully acknowledge the contributions made by the authors, discussants and other participants.

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CONTENTS

NUMERICAL PREDICTION OF STORM SURGES

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1. INTRODUCTION

It is well known that the storm surge is a meteorologically forced long water wave motion resulting in a sustained superelevation of the sea surface above that produced by the normal periodic astronomical tide, It is the result of the combined action on the suction of sea water due to pressure drop, wind-driven shear stress and set-up of wind wave generated by a tropical cyclone, especially typhoon in the case of Japan. Historically, storm surges have resulted in considerable damage to exposed coastlines, the flooding of low lying land and loss of life.

In this paper, a numerical simulation method of storm surge generally operated in Japan is presented. The numerical model gives more accurate water height distribution due to storm surges than the result of empirical forecast formulas when wind fields can be estimated correctly.

2. STORM SURGE PHENOMENA

When a tropical cyclone passed over a sea, the long period sea surface fluctuation often appears. This phenomenon is called the storm surge. And the storm surge is caused mainly by the suction of seawater due to the pressure drop as well as by the wind drift of seawater. The suction of seawater due to tropical cyclone is independent of water depth, but the rise of seawater due to wind drift is inversely proportional to the water depth. Because of this latter fact, storm surge in general has a tendency to be large in a shallow water region.

When the storm surge approaches the edge of the continental shelf, the storm surge increase5 in height due to the sudden decrease of water depth, and at the same time suffers the effect of wave reflection due to the sea bottom configuration. In addition to the above, the storm surge induces edge waves which propagate along the continental shelf, and other oscillations on the shelf.

When the storm surge progresses into the shallower region and enters a bay, wave reflection will occur at the head of the bay, Thus a part of the wave energy will escape, but most of the energy will be confined to the bay for a long time. Thus natural oscillation of the bay is developed by the above processes.

Fig.1 General pattern of storm surge in a bay

Figure I is an illustration of the time history of a fluctuation in sea water induced in a bay. The forerunner of the seawater fluctuation appears when a tropical cyclone is located 300 to 1,000km from the site. At this stage the meteorological disturbance cannot be recognised yet. When the bay area is within the tropical cyclone region, the seawater inside the bay rises abruptly. This part is called storm surge in a restrict sense. After the sea level falls, a seawater fluctuation with the natural oscillation period of that bay can be observed for a while. This part is named resurgence.

3. NUMERICAL SIMULATION OF STORM SURGES

3.1 Calculation of Wind Field

As the estimation of pressure field, the conventional axi-symmetric cyclone models can be applied. Pressure distribution functions of cyclone models have been proposed by several investigators as follows,

Fujita (1952):

Schloemer (1954)

In the formulas, P_{∞} is the peripheral pressure of the tropical cyclone, which we fix as 1010 mb, Δp is the depression of the central pressure, r the distance from the center of the tropical cyclone, and r_0 the empirical constant.

For the wind distribution **w**, the Miyazaki's formula,

$$\mathbf{w} = C_1 G + C_2 \mathbf{C} \cdot \exp[-\pi\, r/r_c]$$

can be used, where **G** is the gradient wind, **C** the movement velocity of the tropical cyclone, r_c the attenuation factor of the general wind towards radial direction, which we fix as 500 km. Magnitudes of C_1 and C_2 parameter have been chosen so as to be consist between the computed values and measured values.

3.2 Basic equations of wave motion

After many numerical models have been tried, the leap-frog and ADI methods (Murakami et. al., 1985) became the most common in numerical simulations of storm surges for practical use. Accuracy of numerical results depends on the kind of equations, the scheme of the finite difference method, and grid sizes in space and time.

Motion of storm surges can be described by the depth integrated long wave equations. In deep sea until it arrives at water depth of about 50 m, the linear equations of long waves including the Coriolis and the other external forced terms give satisfactory results. In a sea shallower than 50m, nonlinear shallow-water long wave equations,

are necessary, otherwise errors become non-negligible, where **M** and **N** are the horizontal mass transports in the x and y directions respectively, $\boldsymbol{\eta}$ the water level above mean sea level, **f** the Coriolis parameter, **g** the gravity, $\boldsymbol{\rho}_w$ the water density, **t** the time, $\boldsymbol{\eta}_0$ the water head corresponding to the difference of atmospheric pressure from periphery, **D** the water depth, and $\boldsymbol{\tau}_{sx}$ and the x and y components of wind stress, $\boldsymbol{\tau}_{Bx}$ and $\boldsymbol{\tau}_{By}$ by the x and y components of bottom friction.

Wind and bottom stresses are supposed to be proportional to the square of wind velocity and square of the mean flow velocity respectively as follows,

Where $\boldsymbol{\rho_a}$ is the air density, **W** the wind vector, and **U** the mean flow vector, $\mathbf{C_D}$ and $\mathbf{C_B}$ the drag coefficient for air-sea boundary and sea-bottom boundary respectively.

3.3 Boundary Conditions

At the open boundary, storm surges are assumed to satisfy barometric balance and to pass through outwards waves. The condition is written as the following form,

whose sign is assigned to the open boundary according to the direction of the advance of outwards wave.

At the land boundary, zero discharge is assumed at a fixed shore if the main concern is the behaviour of storm surges in the sea. When storm surges in the near shore region and on land are discussed, an exact expression of the moving boundary is required. Aida (1977) and Houston and Butler (1979) assumed weir-type formulas. Iwasaki and Mano (1979) replaced the velocity-water depth relationship at the front by that at one spatial grid behind. There three boundary conditions are convenient but not physically correct. However, the spatial grid size should be taken fine enough, in connection with the inclination of slope and period of storm surges, not to introduce a serious reduction in run-up height (Goto and Shuto, 1983).

3.4 Selection of Grid Size

In addition to the CFL condition necessary for stability of the hyperbolic difference equations, such as the set of storm surge model, other considerations should be taken in order to reduce numerical errors.

The finite difference method always introduces numerical dissipation and numerical dispersion. A numerical test (Shuto et al., 1986) showed that a finer spatial grid size was preferable iu order to limit errors introduced by numerical dissipation and dispersion. The spatial grid size should be such that one local wave profile includes more than 20 grid points, preferably 30 grid points, if the wave profile is assumed to be one cycle of sinusoidal form. Another study (Imamura and Goto, 1988) also confirmed this conclusion, indicating that one wavelength of a component of nonnegligible power should be divided into more than 20 spatial grids.

3.5 An Example of Simulated Storm Surges

Japan was attacked many rimes by typhoon storm surges. This is due to the location of the islands, which coincide, with the track of typhoons. Among typhoons, Ise-wan Typhoon was the biggest typhoon which attacked the central part of Japan in Sept. 1959. Figure 2 shows the track of Ise-wan typhoon and computed area. The area is divided into two sub-regions.

As the pressure distribution, Schloemer's formula was applied. The empirical parameter is obtained by best curve fitting from data of atmospheric pressure at measured points. Observed and computed wind speeds at Nagoya, Irako and Tsu are shown in fig. 3. Variation of water level due to the storm surge at Nagoya is shown in Fig. 4, where solid lines shows the results of computation and dashed line the observed height. The computed results agree approximately with observed values.

4. FORECAST OF STORM SURGES

4.1 Empirical Formulas

To express the height of a storm surge at a particular point, the value obtained by subtracting the predicted astronomical tide from actually record sea level is used and called the meteorological tide anomaly. The correlation between the maximum anomaly and meteorological conditions such as maximum wind velocity, wind direction, and lowest atmospheric pressure at a particular location is attempted, and is applied to predict the storm surge there.

It is possible to consider that a storm surge is basically generated by the combined effect of suction due to low atmospheric pressure and water mass compilation at the shore due to wind drift; therefore the following equation can be used for practical purpose,

(10)

Fig.2 Track of Ise-wan Typhoon and computed area time

Fig.3 Time histories of wind s peed at Nagoya, Irako and Tsu

Fig.4 Time history of water level at Nagoya Port

Where $\boldsymbol{\eta}_{max}$ is the maximum meteorological tide anomaly. Δp the difference between the spatial mean pressure over the sea surface and the lowest atmospheric pressure on the sea surface, U_{max} the maximum wind speed, Θ the angle between the optimum wind direction to produce the maximum anomaly and the directions of maximum wind speed, and a and b constants determined empirically.

4.2 Dynamical Simulation Method

The simulation method- stated above is applicable only to locations where the observation data have been compiled over many years. The forecast of a tropical cyclone track is not perfectly accurate today for storm surges and we may need several computations of the supposed tracks on real time. Also we have to finish the computation for predict within short time range. However. Konishi (1989) reported that it only takes 90 second in the CPU time by the Japan Meteorological Agency's computer to forecast for 12 hours ahead. We will be able to compute the necessary cases by the model on real time. Moreover, the method has the possibility of advancement to use more realistic atmospheric pressure distribution, which may change its pattern with time. Complicated meteorological field can be included in the future.

5. CONCLUDING REMARKS

Some fifty years ago, no reliable method was available for quantitative study of a storm surge. The numerical simulation for storm surges owes its recent advance to the development of knowledge of coastal engineering and numerical techniques.

In spite of the advances, we have to keep in mind that fact the most of disastrous storm surge in the past belonged to unusual cases and could not be fully explained by the existing methods. There may be two kinds of problems left to study in the numerical model of storm surge. One is perhaps the problem that we can overcome, if we use the more correct meteorological model. Present model can not simulate the modification and the variation of the speed and of the tropical cyclone, so that the accuracy of the model is not good. Common underestimation of the calculated storm surges after the passage of the tropical cyclone would be improved by using the wind field by numerical weather forecasts. There are another unsolved problems and they are perhaps essential and difficult problems. The storm surges at the port of open coasts are not simulated properly by the present model. Also, early increase of storm surges before the approach of the tropical cyclone is not simulated well.

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Japanese Experience in Typhoon Disaster Reduction and its Possible Application and Technology Transfer to Developing Countries - As an Example of the Typhoon Ise Bay -

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The Typhoon Ise Bay, which attacked areas surrounding Ise Bay and Nobi Plain, particularly Nagoya City on September 26, 1959 was the most severe in the history of typhoon disasters in Japan, causing the loss of 5,051 lives, suffering to 1.2 million people and damage totalling 2.3 billion Japanese Yen, which has a present value of some 300 billion U.S. dollars.

The characteristics of the typhoon, the damage and its causes, countermeasures after the disaster are introduced in this paper.

1. Magnitude and course of the Typhoon Ise Bay

The central pressure on landing was 929.5 mb., is the third lowest one in the records of Japan, following the Typhoon Muroto (September 21, 1934), 912 mb., and the Typhoon Makurazaki (September 17, 1945), 917 mb.
Comparison of the three big typhoons is shown in Table 1.

The Typhoon Ise Bay was a medium-sized tropical cyclone with a central pressure of 960 mb. passing to the northeast of Saipan Island on September 22, 1959. The next day the cyclone, which was named Typhoon No. 15, had grown into an enormous typhoon with a central pressure of 894 mb. and a central wind speed of 75 m/s. Radius of 25 m/s storm wind zone exceeded 40a km.

As shown in Figure 1 of typhoon route, Typhoon No. 15 landed on

Table 1. Comparison of the three big typhoons in Japan after 1930

Name of typhoon/ Characteristics	Muroto	Makurazaki	Ise Bay
Landing Date	Sep. 21, 1934	Sep. 17, 1945	Sep. 26, 1959
Minimum Central Pressure on Landing (mb)	91 1 .8	916.6	929. 5
Radius (km)	1100	800	900
Speed(km/h)	70	70	70
Height of tide (m)	3.1 (Osaka Bay)	2.0 (Kagosima Bay)	3.6 (Ise Bay)
Wind velocity (m/s)	S 48	ESE 40	N 45
Maximum instantaneous wind velocity (m/s)	S 65 (Osaka)	ESE 63 (Makurazaki)	S 60 (Komaki)
Dead and missing	3,036	4,229	5,177
Completely destroyed houses	38,771	55,934	35,125
Partially destroyed houses	49,275	51,385	1 05,371
Houses washed away	4,277	2,394	4,486

on the Japanese mainland at a point 15 km west of Cape Siano-Misaki around 6 pm on September 26. The typhoon advanced at an exceptional average speed at 65 km/h to reach the city of Kuwana by 7 pm. Soon after 9 pm, the typhoon had reached a point 30 km west of the city of Nagoya and caused a violent storm on a scale never experienced before. The heavy rain caused rivers to far exceed their alarm levels. What was worse, all these occurred during the night when people were handicapped by darkness. At 11:30 p.m., the typhoon left Tokai Region leaving behind the biggest scars Japan ever had. After causing dreadful

Figure 1 The route of the Typhoon Ise Bay

damage on the southern part of Nagoya City, the typhoon passed out to the Japan Sea at 1 a.m. on September 27. Since most of the damage was around Ise Bay, it was named Typhoon Ise Bay. Most of the typhoons, which had hit the shore in the vicinity of Siono-Misaki used to rapidly abate due to the obstruction by the mountains of the Kii Peninsula. The Typhoon Ise Bay, however, travelled NNE showing little abatement, and ran through with a high velocity of 70 km/h, which caused strong winds over a wide area.

Typhoon No. 13, which arrived on 25th September in 1953, was one of the most severe typhoons to hit Japan. It had far less influence on Nagoya as it passed on its left side, and it was also smaller than Typhoon Ise Bay in size.

2. Damage caused by the Typhoon Ise Bay

Damages in various categories are presented in Table 2.

Table 2. Total damage caused by the Typhoon Ise Bay

Persons	Dead & missing	5,041
	Injured	38,838
Buildings	Demolished completely	35,125
	Demolished partially	105,371
	Washed away	4, 486
	Submerged above the floor level	194,397
	Submerged under the floor level	228, 297
Field (ha)	Paddy fields washed or sedimented	11,293
	Paddy fields submerged	145,597
	Other fields washed or sedimented	6, 248
	Other fields submerged	35, 363
Public Facilities	roads destroyed	11,856
	bridges washed away	4,281
	dikes destroyed	5,978
	land slides	7,701
	railway damages	674
	Communication facility damaged	187,745
Ships	Ships sank	1,145
	Ships missing	1,606
	Ships destroyed	6,282
	Barge damaged	4,692
People suffering		1,615,804

2.1 Flood Conditions

As an example of the most severely damaged areas, flood conditions of South Nagoya is explained as follows.

Here, the damage was caused by a combination of storm surge, floods from the rivers, and inundation owing to inadequate drainage. Record high level of tide at 5.31 m (3.89 m above Tokyo Bay mean level), which surpassed the previous highest tide of 4.39 m at Nagoya port on Sept. 25th of 1921, high winds with a maximum instantaneous speed of 45.7 m/s at Nagoya, and rare flood discharges caused by heavy rain, all occurred almost simultaneously to cause severe damage.

In addition to the above-mentioned natural causes, socio-economic factors contributed to increase the damage.

The high tide among them was so strong that the zero-meter areas were immediately flooded and houses were destroyed or washed away by the flow rushing over the coastal embankments containing huge floating logs. The velocity of the overflow was extremely high, about 6.7 m/s from the river mouth to the upperwards 6 km. The coastal and riparian embankments breached at 57 points and harbor embankments were ruptured at 19 points. The longest break was at about 950 m on the coastal embankment near a

Figure 2 The contourline of flooded depth in the South Nagoya

timber pond. The overflow rushed and destroyed the buildings, which contained several million cubic meters of logs.

The contour lines of flood depths and the number of flooded days in the South Nagoya are shown in Figures 2 and 3 respectively. As it is seen in Figure 2, an area of 120 km^2 was flooded which corresponds to about half of the total area in Nagoya City. As backside area of reclaimed land is 0 to 1 meter

Figure 3 The number of flooded days in the South Nagoya

below the sea level, the flood depth reached about 3 m and the deepest was 6 m. As seen in Figure 3, the flooded days were about 20 to 40 in town area and 50 to 60 in paddy fields, which were the reclaimed low land.

2.2. Characteristics of areas affected by the typhoon

(1) Formation of the areas

Until the 17th century, South Nagoya and the surrounding coastal areas were under sea. These areas are alluvial plains formed by sediments carried from big Kiso, Nagara, Ibi rivers and also composed of estuaries of Syonai and Nikko rivers.

An area of land extending from the lower reaches of the Kiso river down to Nagoya and its vicinity has been developed by reclamation since the 17th century and the ground level of the area is, at the highest is just equal to mean sea level. At this low-lying district the city of Nagoya was developed, absorbing gradually more and more people.

On September 1lth in 1896, Nagoya and its vicinity were attacked by a large typhoon and inundated as extensively as by the Typhoon Ise Bay, although the damage at that time was quite a different from that in 1959. In 1896, it had hard1y. been urbanized and inhabitants in the inundated areas were far fewer in number.

Though the land and the coastal line advanced southwards as a result of active land reclamation, people lived in the limited area of the center where the Nagoya Castle was constructed.

During the period of agricultural society till 19th century, the condition of living and the methods adopted against disasters by floods and tide were much different from now.

The region of the lower Kiso river basin are always under the menace of flood disasters, and it was inundated more frequently than today, but the people living by the river and the sea managed to cope with flood and tides by such ways as they considered best suited in their awn days.

On those days when the areas were only sparsely populated, leaving much unused space, they built their dwellings at a distance from the seashore, letting the low land idle, so as to escape the danger of flood tides. Then the flood tide damages to the inhabitants were much less frequent. Furthermore, as there were tidewater control forests, a greater safety was secured. Those who had no other places than a low-lying land to live were always prepared for emergency eases, as every one built his dwelling elevated, and had a boat and stored provision. It may be said that when the standard of living was low, each house or each community was responsible for prevention of disasters, but with the progress of civilization, such state of things have come to be considered as old fashioned. Even though the methods have changed in the modern times, it is important to realize that there is an important role for each family, and community in the prevention and mitigation of disasters.

Land Subsidence

In addition to low land, which is at a disadvantage against water-related disasters, land subsidence was also another factor which increase the risk of storm surge disasters. South Nagoya, which was under water for a long time after the passage of the Typhoon Ise Bay, had a 180 km of so-called zero-meter area, defined as land below average sea level, at the time of the Marked land subsidence has been observed in South typhoon' Nagoya area even before the typhoon, and at present its zero-meter area has expanded to 274 km.

Although the rate of subsidence has slowed down, the area of subsidence has been gradually expanding,

Figure 4 Cumulative land subsidence from 1961 to 1987

One of the major causes of the subsidence is the excess pumping up of groundwater. Cumulative land subsidence from 1961 to 1987 is shown in Figure 4.

With the progress of land subsidence, several parts of the dyke built after the Typhoon Ise Bay have subsided by more than one meter from their design height. This means that the land is no longer safe against a storm surge of the design height.

In the lower reaches of Kiso, Ibi and Nagara Rivers the river improvement works including reinforcement work of the dyke, dredging the river bed, the saline barrier, have been under way since 1 969 to deal with this new situation. An emergency project to raise the height of the coastal embankment against storm surge using parapets began in 1975 and was completed in 1 988.

It must be noticed that almost all inhabitants living in the low land in 1959 did not know the fact that they were living under sea level. If they knew the danger of living in the zero-meter areas, the damage would decrease, as they would have taken every precaution against the disasters.

(2) Economical growth

Since the latter half of 1950 s Japan s economy had been advancing rapidly. The high economical growth advanced with the concentration of population to large cities and industrial zones. The population in Nagoya City and the Nagoya Coastal Industrial Zone also increased rapidly. Particularly, in the South Nagoya, new factories and houses for labourers were constructed at a high pace at that time. Also, in the lowest region of the Nabeta River running southwest-wards t o Nagoya, new reclamation of land for agriculture was just completed half a year before the Typhoon, bringing in new settlers to the area.

With the rapid economical growth, trade was expanding at Nagoya Harbour where increase of imported logs was very prominent. Due to the sudden increase in the log imports, they were stored in narrow and imperfect ponds. A large number of logs, weighing more than 5 tons a piece, were thus gathered In timber ponds located near Nagoya Harbour and the coastal canals without being anchored properly. These logs have made the disaster worse. Downtown South Nagoya was struck severely by the high tide over banking with floating logs, destroying houses, blocking dykes and killing a large number of people.

As the Typhoon Ise Bay had attacked just at the beginning of high economic growth period, it can be argued that the damage was made worse by the above-mentioned socio-economical factors. As such, the damage would have been much smaller, if the typhoon has attacked the Ise Bay area ten years earlier.

Not only in Ise Bay, but also in other bays and coastal areas on the Pacific side of Japan, work has begun on coastal embankment to cope up with storm surges of a magnitude equivalent to that of the Typhoon Ise Bay.

3. Countermeasures

3.1 Coastal embankment

With the experience of the Typhoon Ise Bay, the design height of coastal embankment was standardised to the high-water level in the spring tide, which means the meteorological tide, plus the tidal deviation at the Typhoon Ise Bay, which means astronomical tide, and the tidal height.

Till the Typhoon Ise Bay, the design height of coastal embankment was different in each ministry. After the disaster, common standards were agreed for not only the design height but for other criterions too.

After an investigation on the characteristics of the failure of the embankment, the following items are recommended.

The structure of embankment should maintain uniformity. In the place where the uniformity is inapplicable, for example, at the connection between a new embankment and the old one, the topographical characteristics, uneven land subsidence and other conditions, a special care must be taken to protect the weak joints.

Concrete coating should protect the levee crown and slope. Resisting against overtopping of waves, it must be increased the resistance of the face and foot of back slope against scouring.

3.2 Storm-Surge Breakwaters

The breakwaters were constructed in order to reduce damages due to storm-surge. With these breakwaters the crown height of embankments and sea walls inside the breakwaters could be lowered, so that the embankments and sea walls would not prevent the port function. The breakwaters consists of three parts, the length is respectively 4,450 m, 2,285m, and 1,515 m.

4. Concluding remarks

As the damage caused by the Typhoon Ise Bay had made clear, the characteristics of the damage depend on not only natural factors such as the magnitude of the typhoon but also the socio-economical conditions such as progress of the anti-disaster works, land use pattern, warning and forecasting system, the consciousness and the knowledge against disasters of the people living there etc.

Furthermore, rising standard of living makes people wealthy, which mean they shall have more property to lose. It is said that more the advancement of civilisation, larger the extent of disasters caused by natural hazards.

During about half century after the Second World War, the characteristics of flood damages changed depending on the economic growth, the progress of engineering technology on flood control, the social needs etc.

Especially for about 15 years after the War, from 1945 to 1959, Japan had suffered from severe floods almost every year.

Immediately after the War from 1945 to the former half 1950's, the cause of the disasters was mainly insufficient countermeasures against the flood. This is because the flood control works, anti-storm surge works etc., could not be carried out sufficiently owing to socio-economical difficulties during and after the War.

But the cause of the disaster by the Typhoon Ise Bay was different from the precedent disaster. The Typhoon occurred at the beginning of the so-called high economical growth period. As explained on the characteristics on the damage, the socio-economical condition at that time influenced the damage through the land use change, concentration of population, industrial development. Other concerned factors such as land subsidence, Rapid increase in logs were also instrumental in worsening the disaster.

In conclusion, the measures against high tide disaster must be considered as follow:

1. engineering control, in particular, dependable coastal embankment projects
2. land use planning to minimise high tide damages
3. guidance to the people living the hazard zones
4. early forecasting and warning system emphasising the methods to be adopted at night
5. relief and restoration measures
6. inclusion of education on disaster in the normal educational programs

The author would like to thank Dr. Srikantha Herath for correcting the English manuscript.

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STRATEGIES AND MEASURES TO REDUCE CYCLONE DA,fAGE

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ABSTRACT

Due to its geographical location and flat topography the coastal areas of Bangladesh experiencing untold sufferings and colossal loss of life and properties from the cyclone and tidal surges in the Bay of Bengal. This paper describes the coastal areas of Bangladesh, history of occurrence of cyclone in the coastal areas, the existing measures to reduce cyclone damages and their effectiveness. Suggestions for improvement of the current integrated measures to further reduce the cyclone damages are made.

INTRODUCTION

Cyclone and tidal surge resulting from monsoon tropical depressions form in the Bay of Bengal in the vicinity of Andaman Islands is a common natural disaster in Bangladesh. Due to its geographical locations and flat topography, the impact is severe every time. Because of the funnel shaped coast. Bangladesh very often become the striking point of cyclone formed in the Bay of Bengal (Haider. Rahman and Huq, 1991; Chowdhury (1991). Most of the cyclone damages occur in the coastal regions of Khulna, Patuakhali, Barisal, Noakhali and Chittagong and the off shore islands: Bhola. Hatiya. Sandwip, Kutubdia, Moheskhali, Nizhum Deep, Urrir Char. etc (see Figure l).

To reduce the damages from cyclone, counter measures are in practice. But the interrelationships of all the problems related to cyclone disaster mitigation are so complex that needs an integrated approach. The objectives of this paper is to describe the currently followed counter measures, their effectiveness and weakness with particular reference to April 1991 cyclone and to make suggestions to increase the effectiveness of the counter measures in the future.

DESCRIPTION OF THE COASTAL AREAS

The topography of the coastal area of Bangladesh is flat low lying adjacent to the Bay of Bengal having land elevation mostly below 3 m PWD. The coastal area is located at the vortex of the funnel shape Bay of Bengal and at the out-fall of the Ganges, the Brahmaputra, and the Meghna Rivers. These rivers deposit enormous quantities of silt in the northern portion of the Bay of Bengal each year, forming temporary islands or chars that are constantly being altered by accretion and erosion. Geo-morphologically, the top deposits are generally silt, clay, silty clay, silty sand, etc. The areas west of Haringhata rivers (Sundarbans of Khulna). Patuakhali. Borguna, etc have been formed mostly by the deposition of the sediments of the tributaries of the Ganges and the tidal back flows. The asterion flood plains east of the Tentulia river, *e.g.* Southern Noakhali, Sandwip,

Figure 1: **Map Showing Cyclone Affected Area**

Hatiya. Bhola, Monpura, Moheskhali, Kutubdia, and other islands haye been formed mostly by the deposition of the sediments of the lower Meghna river. Mostly the deposits of the tidal back flows and sediments from hills have formed the coastal areas between Chittagong and Cox’s Bazar. The fertile soils attract poor landless migrants who are willing to tolerate severe weather conditions in exchange of economic self-sufficiency. This char area along with coastal Bangladesh has been site for cyclones.

Geologically the area suffers from subsidence to some extent due to consolidation settlement of the new deposits of sediments and settlement of the base strata. The annual subsidence rate in this area is estimated to be between 6 to 10 mm/year and the deposition compensates this settlement and builds up lands by further deposition.

HISTORICAL OCCURRENCE OF CYCLONE

Tropical cyclones are the frequent visits to the coastal areas of Bangladesh. Available records dates beyond 1584 but are of unknown reliability. Approximately 35 damaging cyclones have been reported in the coastal areas of Bangladesh in the period from 1868 through 1985 (Hoque, 1991). The reoccurrence of cyclone distribution of 35 cyclones between 1793 and l985 in a month wise calendar year is shown in Figure 2. The time analysis shows that the month of May and October are the most cyclone prone months in a year although cyclones have occurred from March through June and from September through December. From special analysis it has been found that Chittagong. Teknaf and Cox's Bazar are the most cyclone prone areas in the coast. More than 50% of the recorded

Figure 2: Occurrence of 35 Major Cyclones in Bangladesh

cyclone have hit this area. The Patuakhali and Bakergonj have been also found as the cyclone vulnerable areas.

The historical data on surge height very considerably. It is variously reported that 1876 Bakergonj cyclone caused inundation up to 3 to 5 m above normal tide level. Storm surges in the sixties have been noted to be some 3 to 6 m in height. The cyclonic storm could inundate lands, or overtop embankments up to elevations of 9 to 17.5 m should surge occurs at the time of high tides. Any coastal embankment below this height likely to be affected by overtopping and subsequent breaching.

INTEGRATED CYCLONE HITIGATION MEASURES

To mitigate the sufferings of the people from the devastation of cyclone and tidal surge several approaches such as: (1) Cyclone Forecasting and Warning, (2) Cyclone Shelters, (3) Coastal Embankments, (4) Post Cyclone Relief and Rehabilitation are currently in practice in Bangladesh. In this paper main emphasis has been given to identify the prevailing conditions of these efforts in the fields, their effectiveness and their weakness and shortcomings due to which the damages of cyclone is severe every time in this region.

Forecasting and Warning System

One of the most effective countermeasures for the reduction of cyclone is the establishment of early warning system. By predicting the possible occurrence of cyclone its destructiveness may be minimised. In Bangladesh the cyclone forecast is generally the responsibility of Meteorological Department. The forecast is transmitted to the radio and television station and the warning is spread through a comprehensive cyclone preparedness programme (CPE'). This programme is jointly operated by the Bangladesh Read 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 are supposed to do the needful in the event of a cyclone. Each ward is provided to 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 and coastal district head quarters. The volunteers are responsible for spreading warnings against approaching cyclones reported by radios, and the arrangements of shelters for people and for cattle, if possible, and rescue the survivors who are still in danger.

The cyclone warning system, which is prevailing in Bangladesh, based on signal numbers up to 10. This system is cumbersome. By signalling system the precise location of the cyclone, cyclone intensity, its movement, the possible area affected with depth of inundation are not indicated.

It has been learnt that nearly all the people in the affected areas had heard the cyclone warning at least 4-6 hrs before the cyclone of April 29-30, 1991 struck. Nonetheless, very few responded in any way before escape was difficult because of cyclonic winds or the water was upon them. People had no clear idea of the meaning of the signals. For most, the warning came long enough before the tidal wave so that they did not feel moved to act For those who have experienced previous cyclone in the area, previous signal 10 storm warnings were associated with some flooding at a level not much above normal so special behaviour was not required. The ability to motivate people to respond to a once in a decade event a major challenge to communities. The group who decided to stay at home were at the highest risk of deaths from the cyclone, the factors responsible are: no information or late information regarding the impending cyclone, relative distance of the shelter from home and lack of cyclone experience.

To mitigate the suffering from the cyclone and tidal surge the present forecasting and warning system needs to be improved. This needs better knowledge of the causes and timely detection. Application of mathematical model can significantly improve the cyclone forecasting in respect of generation of cyclone, tracking of cyclone movement, the corresponding storm surge and the area and depth of inundation. This will need meteorological and hydrological data on regional basis. Therefore, regional hydrological and meteorological data collection networks to be developed. The warning system on the basis of forecast should be disseminated in a language that can be easily understood by the general people.

Cyclone Shelters

To prevent or mitigate the loss of human lives and probably livestock and poultry, the cyclone shelters can play the most vital role probably more than any other means. After the cyclone of 1971 a number of cyclone shelters were constructed in the coastal areas. These are not sufficient in number and are not properly designed and located,

It has been reported that during the cyclone of April 29-30, 1991 several thousand people who would not have otherwise survived used some shelters. Others were nearly empty throughout the storm even they are located in areas with substantial mortality. People could not use these shelters because the access roads were flooded on early and water flow currents made them difficult to reach. The shelter in Moheskhali had been built by the Red Crescent Society following the 1985 cyclone and was in regular use as a school. It is in good repair and children are in attendance in the school. Most of the shelters were not in routine use in the community prior to the cyclone. Many other pueblo buildings (*e.g.* schools, clinics, Union headquarters, mosque) and private pukka homes served to shelter people during the cyclone. It has been reported that a high school in Kutubdia provided shelter to several thousand people some of whom came from more than 2 kms away. Pukka homes and buildings in all community have been reported provided shelter to neighbour whose kutcha homes did not withstand cyclonic winds and were inundated by the tidal wave.

Given a diversity of shelters that were used, a number of public building could have been built as shelters but were not. The union had quarters are normally one storied with no excess to roof that might have provided protection. One storied school and mosque would have provided ample shelter if they had been built as 2-storied structures and reinforced. It has been reported that a man whose 2-storied pukka house saved the lives of 150 neighbours claimed proudly and spontaneously that people who could afford to build a pukka house should be encouraged to build a structure that would provide shelters to others. Almost all pukka buildings, even those in areas of the highest wind intensity, such as Kutubdia, withstood both the cyclonic winds and the tidal wave.

It has been reported that the existing shelters are not properly located and there is no arrangement for storage of food and drinking water. In planning a cyclone shelter the density of population must be considered. The cyclone shelters should be located in a place, which has very easy access for all the people of the locality for whom the shelters are planned. It is a common belief in these days that the cyclone shelters should be planned designed and implemented for multipurpose use all through the year. Other than cyclone period the cyclone shelters should be used either as a school, or social or religious events as has been reported for one in Moheskhali-Kutubdia. The shelters should have provisions for livestock and poultry. Facilities for storage of adequate food and drinking water must be provided with the shelters. Before, planning, design and implementation of the shelters, hydrologic, storm surge, socio-economical studies must be performed to provide appropriate location of the shelters.

After the recent cyclone, the government of Bangladesh has undertaken a programme gigantic in nature with the help of UNDP to implement cyclone shelters in the coastal Zone. Currently work is in progress in this regard where Bangladesh University of

Engineering and Technology has been involved with advisory capacity.

Coastal Embankments

To protect the coastal areas of Bangladesh from Satkhira to Cox's Bazar (see Figure l) from inundation by tidal saline water the initiation of coastal embankment dates back to 1958, though significant works began in the early 60s with financial assistance from the USAID (Hoque, 1991). The embankments replaced numerous small dikes previously erected and maintained in a haphazard manner by the zaminders and public. About 45000 km of perimeter dikes and 5,200 sluice gates were estimated to be required to provide flood protection within a gross area of 1.4 million ha of land. Currently the coastal embankment comprises a complex system of dikes and drainage sluices. Small and discontinuous embankments had been constructed at Patenga at the time of the 1937-38 survey. Starting in 1963 a continuous embankments was constructed over a distance of 16 km northward from Chittagong Development Authority road with a crest elevation of 7 m. The embankment was set back from normal high tides level with seaward side slopes 8 horizontal to 1 vertical. Durable and surge resistant embankments have to be built around the offshore islands and the coastal areas. During 1891 cyclone and storm surges the coastal embankment has been damaged. The damages occurred due to high tides and by their thrust one shown in Figure 3.

During field study after April 29-30, 1991 cyclone it has been found that most of the damaged embankments has been

Figure 3: Typical Failed Embankment Section Close to EPZ Area

repaired, but some parts of the repaired embankment has been washed away again during the high tides. The local people has been found to repair them again, but they have mentioned that during spring tides the repaired embankment will be washed and breaching will occur allowing saline water inflow into the polder which will cause damage to the recently growing crops. In many places the erosion problem of the just repaired embankment has been observed. In some places it has been found that the distance between the embankment and the shoreline is very small, in fact there is no set back distance. As a result, the embankment is washed away. It has been also reported that there is also a conflict of interest among the beneficiaries of the coastal embankment. For shrimp culture inside the polder particularly in the Chokoria upazila the embankment is out to enter the saline water into the polder, which is helpful for shrimp production. This public cut for shrimp culture cause serious problems during the cyclone inundating the whole area.

During the field study the wave erosion has been observed in polders at Moheskhali and Kutubdia (see Figure 4). This is very common in the coastal embankment, especially for those that are very close to the shorelines. Bank sliding is also a common problem, which is mainly caused, due to poor design, construction, and maintenance. A recent study shows about 60% failure of embankment occurs due to breach while 40% due to public cut 30% due to wave erosion, 20% due to overtopping and 7% due to seepage and sipping and 3% due to sliding (Hoque and Siddique, 1991). Risk management the reasons of failure of coastal embankments

(a)

(b)

Figure 4: Wave Erosion of Embankment: (a) EPZ Area (b) Moheskhali Island

during the normal tides are: poor construction and maintenance.

The coastal embankment is not effective in preventing cyclonic surge, as the height of the embankments is inadequate for wave developed by most cyclones and the embankments structurally inadequate to allow overtopping and submergence. For effective control against storm surges most of sea facing embankments to be raised to a considerable height estimated for designed return period by frequency analysis.

Mangrove and Forest

The mangrove and forest can drastically reduce the velocity of cyclone winds and storm surge when they reach the coast and can effectively reduce the wave action. Therefore, plantation of trees along the coastal area can also diminish the devastation of the cyclones. During the April l991 cyclone climbing on to the trees suggesting that tree plantation projects might in the future improve communities' ability to survive a cyclone saved many people. During the field study a significant difference between the embankments with mangrove and without mangrove has been observed. People of the locality interviewed have strongly expressed the need of growing mangrove along the coast outside the plodders for embankment protection during normal tides and during cyclone and storm surges.

Therefore, an extensive programme should be undertaken to grow mangrove along the coastal belt parallel to the coastal embankment to protect the embankment from wave erosion. Similar programme should be undertaken to grow the forest in the coastal areas of Bangladesh.

POST CYCLONE MEASURES

Relief and Rehabilitation

Extensive relief and rehabilitation programme from the part of Government, NGO's and International Organisation has been launched after the April 29-30, 1991 cyclone. But initially the programme suffered from poor transport and communication due to severe damages of roads and telecommunication system. It was hardly possible to access to the cyclone affected areas over telecommunication and also by road transport. The transport system in the coastal areas should be planned in such a way so that during the storm surges the system faces minimum damages and can help in breaking the impact of water flow during the tidal surge.

Drinking Water and Sanitation

Similar to other infrastructures the cyclone normally causes serious damages to the water supply and sanitation system. The tube-wells are broken, partially damaged and becomes unusable due to submergence. Ponds and tanks in the affected areas have been contaminated by the onrush of saline water and sludge. Therefore, after the cyclone there is a serious crisis of drinking water and an outbreak of waterborne diseases is very common. People in the affected areas use water from this contaminated pond indiscriminately. As a result, they have become vulnerable to diarrhoea and other water borne diseases. Therefore, post cyclone diarrhoea and other common water borne diseases are the major causes of death casualties associated with the cyclone.

A large number of casualties occur from the post cyclone water borne diseases. To mitigate the post cyclone sufferings and loss of lives the water and sanitation sector should be given proper care. The tube-well installation should be made in such a place and elevation that these will not go underwater during the cyclone and can be recovered immediately after the cyclone. A provision should be made to store the drinking water on the basis of early cyclone forecasting and warning for use during after cyclone. Ponds should be protected by raising the embankment of the ponds at the level of storm surge.

SUGGESTIONS AND CONCLUSIONS

l. To develop a computer based mathematical model which will be capable of identifying the generation of cyclone in the Bay of Bengal, tracking its involvement, predicting the magnitude of tidal surge and depth and area of inundation. T o analyses the sensitivity of these variables to orographic and dynamical parameters.

2. To analyses the regional characteristics of cyclone and storm surges and to observe global phenomena related to the cyclone and storm surge.

3. To make basic study on development and installation of early warning systems and to assess the impact of natural disasters on society.

4. To improve and develop the meteorological and hydrological networks, including meteorological satellite data reception facilities and associated telecommunication facilities, required for efficient cyclone, storm surge and flood forecasting

and warning systems.

5. Enhancement of the risk evaluation of storm surge, winds, etc., as inputs to disaster prevention.

6. To improve disaster prevention and communities preparedness measures for preservation of human lives and property.

7. To improve observational and telecommunication networks to permit a more complete and detailed analysis of weather in situations when tropical cyclones threaten the area.

8. To develop cyclone-zoning maps.

9. A master plan should be undertaken for planning, design, and construction of cyclone shelters as a part of over all mitigation system.

10. Shelters should be planned and designed for multipurpose use with a provision for shelter of castles and storage for food, medicine, and drinking water.

11. Shelters should be located at a place where access will be direct and easy during the cyclone.

12. Embankment construction and design procedure now followed in Bangladesh needs to be critically reviewed. Such review using appropriate geo-technical engineering methods may lead to a more durable, economic embankment that would require less maintenance,

13. For protection of polders from cyclonic surge very high embankments are required. Heights will vary for different places. For Chittagong area a minimum height of 10 m is required. Construction of such high embankments all along the coastal areas

would require special study in terms of soil condition and availability of materials for construction

14. In any coastal project involving shore protection, due attention should be given to the local conditions, local morphology, geology and hydraulic characteristics. Local conditions may dictate surge height, possible modes of attack and failure and thus design of the involved structures.

15. The soils within the embankments were very porous and probably contained continuous large pores. These pore are likely to contain significant amount of air due to unsaturation. In addition to turbulence on overtopping, submergence of the embankments induced boiling due to upward rise of trapped air within soil pores. A significant reduction in shear strength is likely to have taken place resulting in collapse of the embankment soil structure and subsequent washing out of the embankments. Al I these necessitates well compaction of the embankment body. This would reduce the maintenance cost and damage due to overtopping and submersion.

16. The temporary reconstruction process followed in the rebuilding of embankments after recent cyclone is deplorable. Embankments should be well compacted and due importance given to proper selection of fill materials.

17. Planting trees on the embankments should immediately be stopped and those already existing should be cleared away. But the embankments should be well covered with grass to prevent surface erosion-

18. The embankments should be well maintained. Necessary

fund for organization and maintenance should be available. Some programme for involvement of local people in the maintenance programme may be ensured,

19. Since coastal embankments are not designed to withstand cyclonic surge, capital intensive projects, if possible, should be avoided within hazardous areas. Those already built should be secured through additional structural protection system. Immediate step should be undertaken to protect this capital intensive project, EPZ area from future cyclonic disaster.

20. The coastal embankment has been reported to create environmental hazards such as the ecological imbalance in Beel Dakatia under Polder 25 in Khulna. Again the sediment-laden water cannot enter into the polder as a result, the land refilling process has been hampered and most of silt materials are carried away to the sea. In addition, the polder system does not allow micronutrients to enter inside the polder, which eventually decreases soil fertility. These aspects should be studied in details before recommending further rise of coastal embankments for cyclonic surge protection.

21. Forest belt should be developed along the coast, between the embankment and shoreline.

22. Mangrove should be developed outside the polders.

23. Deep tube-wells should be installed in sufficient numbers in the coastal area.

24. Water purification tablet in acceptable quality should be made available after the cyclone.

25. Sufficient amount of drinking water should be stored for post cyclone use.

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DISASTER MANAGEMENT: SOCIO-ECONOMIC PERSPECTIVES*

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I. Introduction

It has been universally accepted that various kinds of disasters can not be fully and effectively eliminated, the extent of its damages can be reduced to its reasonable limit minimising lost of lives and properties by implementing well planned and co-ordinated disaster management methods. Disaster Management has many aspects starting from forecasting early warning, relief measures, rehabilitation programme and prevention of disasters and so on. For disaster management,, four basic issues are to be recognised: causes, characteristics, consequences, and human action. Often, conceptualisation of disaster fruitlessly emphasises only the three Cs without attention to the aspect of human action, resulting in futile efforts in technical solution only. I feel tempted to quote the observations of the Club of Rome,

> "Technology can relieve symptoms of a problem without affecting the underlying causes. Faith in technology as the ultimate solution to all problem can thus divert our attention from the most fundamental problem – the problem of growth in a finite system – and prevent us from taking effective action to solve it" (Meadows, 1972 p.159).

* The views expressed here are the author's won and do not necessarily reflect those of UNCRD and CIRDAP

The vulnerability of a society, due to contingencies, stress, and disasters can be minimised by socio-technical solution or in other words, by mobilising human beings to fill the gaps between human beings and the physical environment.

In most of the developing countries the problems of unemployment, undernourishment, landlessness, and abysmal poverty are inexorably linked with various socio-economic-cultural and physical environment. The problems are natural and man compounded by various kinds of disasters – natural and man made. This paper attempts to highlight the socio-economic perceptions and actions to be taken by people.

Usually, a distinction is made between natural disasters like cyclone, tornado, flood, tidal surge, volcanic eruption and technological disasters (caused by human beings) like depletion of ozone layer, toxic pollution of environment, and deforestation. This distinction is not very useful for formulating plans for disaster mitigation. There is a relationship between human actions and disasters, whatever form they assume, except possibly the cataclysmic upheavals of the whole solar system! Nature can not be made the only underdog of disasters, which are faced, by human society. Shakespeare aptly puts it when he said,

> "... when we are sick in fortune, often the surfeits of our own behaviour, we make guilty of our disaster the sun, the moon, and stars"
>
> - Shakespeare. Kin Lear Act I Scene II

Therefore the theme of this paper is that human actions at different levels – individual, community, and national, are important in coping all kinds of disasters; people must be taken as the centre-piece of any disaster management activity.

II. Disaster is a Social Phenomenon

The futility of dichotomising disasters into Acts of God or Acts of human beings has already been mentioned earlier. There is utility to typologize disasters in terms of multiple dimensions as duration, scope of early warning, speed of onset and magnitude of impact. Again it is necessary to develop a multi-typology of disasters in terms of organisations involved in disaster mitigation like the Red Cross, the World Health Organization. UNDRO, and UNHCR. In the absence of a clear-cut conceptual tools and typology of disasters, it is better to look at disaster as a social phenomenon. The advantage of this approach is two-fold: first it provide us with a social science perspective on causes and consequences of disasters and second, it gives us applicable paths for social action at individual, community, and national levels.

It is imperative that we explain the concept of social hen. omenon. This encompasses (besides others as state, process), the meaning of 'occasion' rather than ‘event’. The idea of social occasion draws analogy from analysis of many sociologists which implies that disasters provide multi-possibilities human action for development rather than involving one linear path to an end result which an event implies. Thus disasters are sometimes best seen as social class occasions (Quarantelli, 1986 b).

Human experiences or coping with disasters are best exemplified in the way the poor people cope with vulnerability. Vulnerability, though not the same as poverty, but the poor people are more prone to vulnerability due to external shock disasters. Since, poverty is the overriding issue in a country like Bangladesh, we present the Diagram 1, which depicts the interrelationship between socio-economic factors and disasters highlighting social phenomenon and individual – collective behaviour in mitigating effects of disasters on the poor.

Diagram 1: Poverty and Disaster in Bangladesh

As shown in the Diagram 1, the socio-economic factors and environmental factors are closely related in explaining poverty in Bangladesh. The individual behaviour is influencing the human factors to a large extent. These are somewhat explanatory variables for poverty situation. But these alone can neither explain poverty of the people nor imply that the people are lazy and worthless to come out of the poverty trap. The very fact that the poor people have survived over the centuries is a testimony to their adaptive behaviour and survival contingent strategies. The risk of hazard to disasters is deeply ingrained in the population of a country like Bangladesh and they are aware that sooner or later disasters like flood. cyclone will affect their lives. Studies have consistently shown that people as a whole do not panic in disasters. Instead of collapsing into hysterical breakdowns, people often do what they think to be done in crises. We shall come back to this point again. The array of institutional factors, not common to Bangladesh only, affect the poverty situation and behaviour of people in disasters. The great disparity in access to the nation's resources and concentration of wealth and power in a section of population appear to be increasing in Bangladesh. Meagre resources limit the administrators' responses to hazard of disasters, lack of proper information and lack of coordination. Often there is inefficiency in disaster mitigating measures. There is the presence of corruption in distribution of resources both in normal time and disaster situation – itself both a manifestation of, and a contributor to poverty, unequal access to resources and suffering of the poor. While the impact of environmental factors on poverty is understood well, the complex and diverse nature and the process of its impact are not clearly known (Ahmed, 1988). The re are differences between disasters, but they do not result from supposed source in nature or technology, but result from direct and indirect actions of human beings. What is needed is emphasis on human behaviour and action during differential impact of disaster rather than on types of disasters, because what is important is not the physical difference between a flood and tidal wave, but the fact that, for example, flood allows time for warning whereas tornado leaves little time for warning. As some one puts it :

> "…….a flash flood resulting from a broken dam might have more similarity to a sudden tornado than to a slowly rising Mississippi River flood" (Stoddard, 1968, p.12).

The role of early warning for disaster is particularly important. Herein lies the particular importance of people's responses and actions at the grassroots level. One of the major reasons for high toll of 1988 flood in Bangladesh was the lack of proper early warning system. The damages of the devastating cyclone and tidal bore of 29-30 April, 1991 in Bangladesh could be minimised had the Cyclone Preparedness Programme, with its 2031 units in the coastal areas was given required resources and smooth working facilities at its disposal. Even then, more than 20 thousand volunteers did a remarkable job in warning the people and help evacuating them. These prove that people are well prepared to a fresh disaster. But time has not taught us anything, at least for the organization of the society; the Individual may have learnt something and responded to disaster hazard for survival. That means, we have not developed what is called a "disaster subculture", which involves an interrelated set of attitudes and practices among the populations and organizations to respond to a new disaster.

III. Responses to Disasters

We shall by asking, what way people individually and collectively behave in major disasters? It may be noted that, substantial damage, in terms of loss of lives properties and other assets result from various disasters. The implications of major types of disasters in Bangladesh are given in Table 1 as illustration only. Bangladesh, during the last few years had more than the usual share of disasters compared to other countries of this region.

Table 1: Major Types of Disasters in Bangladesh and its Implications

Type of Disaster	Vulnerability	Major Implications
Cyclones	Whole Bangladesh	Life and crop damages. Damage of human settlements.
Floods	On the average one-fifth of the total area of Bangladesh goes underwater every year	Life and crop damages. Damage of human settlements. Damage of physical infrastructures
River Erosion	About 1 million people affected every year. Erosion caused by 40 major and minor rivers.	High risk in human settlement. Process of human pauperization.
Tidal surges	Coastal zones and up to 16 to 24 km. Inland	Life and crop damages. High risk in human settlements.

What might be anticipated is that, after disaster, people in Bangladesh become nervous, dazed and stunned; various organizations fail to carry out responsibilities of disaster mitigation. In reality, this is far from truth. People, as a whole react in disaster period much better than they are usually given credit for. This is evident from the experiences of two recent successive floods in 1987 and l988 in Bangladesh and the cyclone of April 1991. However, experiences seem suggest that organizations, especially the national level organizations do not perform well as might be expected. The efforts at the community level or at a small group's level seem to have fared well in disaster management people in Bangladesh. At the community level, organizations (if they exist in a specific area) and non-government organizations (NGOs) do fairly well in emergency period.

A. Response at Individual Level

As mentioned earlier, the popular belief about individual behaviour in disaster hazard is that of despair, panic, dependency on outsider, and resort to looting. This is an incorrect view. There may be a temporary panic situation, but individual resilience win and people take control of their situation, though imperfectly, looting and anti-social behaviour are resorted to by outsider mainly, and by only a handful of insiders. There may be expectations of dependency, but what develops ultimately is self and groups-initiative. For example, contrary to the impression left by many press reports, a significant search and rescue in the devastating Mexican city earthquake was carried out by individuals on the scene right after the impact. In Bangladesh, a study on flood states ". . . . . .where people were confronted with particular dangers. Which impelled them to organise and act by themselves. Significantly, women played a prominent role along with men in several such instances. Overall, the ordinary people of Bangladesh proved themselves to be much more active and concerned. . …" (Adnan, 1991). We do not, however, like to give impression that, individuals by themselves or in small groups can handle all disaster-related problems.

Survival Strategies of the Poor

The survival strategies due to disasters like flood, cyclone, river erosion merits some discussion. Basically the poor adopt three types of strategies (either in isolation or in combination): (a) Selling of assets like land, livestock etc., (b) Taking up of alternative employment, and (c) Migrating to other places.

In a study by BARD (Comilla) through a Rapid Response Survey, the effects of 1984 flood in nine villages of Comilla, showed that out of 749 land owning families about 26 percent transferred about 66.07 acres of land (about 5% of all arable land in the village) for various reasons. These are shown in Tables 2 and 3.

Table 2: Transfer of Land due to 1984 Flood

Nature of Transfer	Number of Families	Amount of Land Transferred (acre)
Sold out	33	9.94
Mortgage out	164	56.13
Total	197 (26%)	66.07 (5%)

Table 3: Reasons for Transfer of Land due to 1984 Flood

Reasons	Number of Families*	Percentage of Families
Purchase food	148	75.3
Meet expenses for the next crop	62	31.4
Loan repayment	23	11.67
Others	9	4.57

* Some families mentioned more than one reason.
Source: Effects of Flood (1984) in Bangladesh, BlRD October 1984.

People's perceptions about the causes and consequences of natural disasters like flood, cyclone remarkably shows logical conclusion, which are useful for decision-makers and planners. For example, in a survey of 70 villages affected by 1988 flood in Bangladesh, the victims did not ascribe the phenomenon to God's will and their identified causes covered scientific factors like snow-melt, environmental change, increased upstream rainfall, and drainage problem (Hossain. Sept. 1989). However, this type of objective perception of the causes of natural disasters is sometimes held, alongside a deep conviction that nothing in the world happens without God's will (Alam, 1990).

In Diagram 1, lack of perception and superstition are therefore, shown as human factors behind poverty.

B. Response at Community Level

During disaster hazard, relatives and friends are seen as a major source of help. Member of the local formal organizations and 'samaj' (social informal groups) are also regarded as potential source for material help and services in disaster mitigation. However, formal local organisations like co-operatives, peasants' groups, registered voluntary agencies do not provide much help in disasters. In fact, the informal 'samaj' and other groups are of great help for the poor, especially in rural Bangladesh. What about local government organizations like the Union Parishad (UP) and Upazila Parishad (UZP)? There was very little help by the local government organisations in Bangladesh during emergency period. During the colonial times the district and sub-district officials mainly Deputy Commissioners and Sub-Divisional Officers were given responsibilities with relief operations in their respective areas. Bangladesh inherited such system but it was limited to some routine administrative procedure only, the UPs and UZs were not integrated into the whole disaster relief operation at the local level.

This has resulted in some doubt about the efficacy of local government organization in disaster management. Rogge (1988) in analysing a survey of three river-erosion prone areas of Bangladesh has shown that while only 51% of the victims expected help from such organizations, only 1.8% actually received help from these organizations. Others (Vylder 1978, Yunus 1976) have also highlighted the mistrust by rural populations of the local bureaucracy. The entrenched hierarchical administrative set-up as well as the reluctance of most officials to take into account of *people's perception* about disaster, leave little scope for inputs to decision-making from illiterate local people, nor does It foster a climate for *participatory approach* to disaster management.

The response at community level can further be improved by involving NGOS and community leaders. Given a continual growth in the number of large scale disasters, and many aspects of disaster mitigation are very expensive, and relate to legal measures of a country and require political commitment for practical measures, the role of NGOs is quite significant. During the flood havoc of 1988, and cyclone of 1991 NGOs played a very positive role in Bangladesh in disaster mitigation and rehabilitation of displaced persons. The community leaders need training in the field of vulnerability analysis, early warning systems, mobilisation of people, distribution of materials and account keeping. Modules for training at three levels (planners, community leaders and field staff) have to be comprehensive and integrated one with practical orientations (Raghavan 1990).

C. Response at National Level

As in the case of interventions by local level government institutions, the national government's response to disaster in a country like Bangladesh is also seen as being limited. While the high-ups in the government including the President/Prime Minister themselves have created a high profile for disaster management and generated significant awareness of the plight of various disasters, in general the government response to the problems of disasters has changed little from that traditionally adopted, in the form of engineering solution such as bigger embankments or cross-dams, construction of cyclone shelters, or provision of temporary relief materials like food, cloth and medicine.

For example, government responses to natural disasters (flood, cyclone and drought) in Bangladesh are guided by the Famine Code of 1913, Famine Manual of 1941, Standing Order of 1961, Cyclone Code of 1970, Revised Standing Orders of 1974 and 1975.

From the viewpoint of organisational behaviour, the national level response should concentrate on four basic areas: *mobilisation of personnel*; *management of information*; *exercise of authority*; and or *organisational coordination* (Quarantelli, 1986 a). Care should be taken in mobilising personnel to reduce the conflict between '1ocal volunteers' and 'outside professionals'. There may be 'outside volunteers' in a particular area, but usually the conflict arises between the local people and outside professionals, who sometimes are seen by the local people as someone 'taking over their disasters '. During disaster hazard, the means of communication often break down and there is also lack of proper information on disasters. Mis-reporting, false information and rumours abound. It is necessary to restore communication gap and ensure two-way flow of information between national agency and field staff in disaster areas. Authority problems can arise when different organizations are engaged in multi-faceted works and non-routine tasks. Organisational authority problems can arise due to three major issues: jurisdictional; division of tasks; apprehension and unwillingness to take responsibility. Jurisdictional issues can be overcome if legal and historical traditions are taken into consideration much ahead of a disaster. The non-routine nature of job often causes conflict about division of jobs. The reluctance shown to take responsibility is often related to perceived negative consequences of failure of discharging the duties. This is a clear manifestation of lack of political support and loose exercise of authority. Because of the three major issues mentioned above, *coordination* assumes an important role. Studies have shown that coordination can not be imposed, it has to be created.

IV. Conclusion

It is apparent that irrespective of the nature and causes of disaster, a combined effort manifested in collective behaviour of human beings and proper institutional set-up is essential to combat disasters. The experiences of Bangladesh in April 1991 cyclone-tornado have shown that with proper coordination, all the tiers of government organizations, NGOs, and people can tackle the problem, as the Report on Operation Sheba (in 9 coastal districts of Bangladesh) states,

"With the resilience and fortitude inherited over generations and centuries, the people, the Government, the Armed Forces, BDRCS, all organizations, NGOs, and individuals rose to the occasion as one entity. . . . . .This was one of the largest relief operations mounted anywhere in the world". (Operation Sheba, 1991).

We should remember that flood earthquake, tornado etc., as such is not a calamity, rather the failure of coping with these, which is Identified as a hazard, a disaster or a threat by the affected segments of the society. To quote Robert Chambers, "The lesson for the future is to inquire and question, doubting what we think we know, and learning from and with those who are vulnerable and poor, . …" (Chambers, 1989). In conclusion, it should be mentioned that though the developing countries are experiencing a lot of disasters (both natural and man-made), the bulk of research is carried out in the developed countries. There is a lack of research and reliable data on various kinds of disasters in the developing countries, especially on socio-economic aspects including perceptions of disasters in these countries,

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DISASTER AND SOCIO-ECONOMIC CONSEQUENCES

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1. INTRODUCTION

Most of the coastal areas of the world are at risk from natural hazards resulting from geological or meteorological disturbances. In Bangladesh cyclone and tidal surge are considered as the most catastrophic phenomena of coastal regions. The coastal land of Bangladesh is of recent origin formed out of the process of sedimentation (of salts) by the mighty river systems of the Ganges, the Brahmaputra, and the Meghna. Most parts of the rivers are, therefore, low lying which can be subjected to inundation even under ordinary circumstances of tides.

A tidal surge accompanied by a cyclonic storm makes the situation alarming which the triangular shape of the Bay of Bengal further exacerbates. This shape of the Bay reduces the width of storm induced waves to multiply them in height as the storm moves north and eastward out of the Indian Ocean. This causes widespread fiddling since the coastal areas and offshore islands are low lying and flat.

Although cyclones have been visiting Bangladesh on a regular basis not enough has been done to save the lives and properties of the people from the fury of the cyclones. Some cyclone shelters however, have been built and embankments constructed. But we do not seem to be doing much better in protecting the lives and properties than days of our fathers and grand fathers when the poor victims could do nothing more than praying for the help of God. This is clearly evident from the deaths and destruction caused by the April 29, 1991 cyclone. This cyclone alone took a toll of about 1,40,000 human lives and caused massive damages or destruction to various productive economic assets. No economic sector was spared by the cyclone.

This paper focuses on identifying the socio-economic consequences of the April 29, 1991 cyclone for the national as well as the regional economies. We report findings based on an analysis of published and unpublished data collected from various governmental sources in connection with a field study and investigation of the April cyclone, sponsored by the United Nations Centre for Regional Development. The paper concludes with a discussion of the broader implications and requirements for cyclone disaster management and regional development planning in Bangladesh.

2. INTENSITY OF THE CYCLONE AND HUMAN MISERY

The cyclone was detected as a depression on the 23rd April first in the satellite picture taken at Space Research and Remote Sensing Organization (SPARRSO) of Bangladesh. It turned into a cyclonic storm on 25 April and moved slightly northwestwards and then northward. From 28 April it started moving in a north-easterly direction and crossed the Bangladesh coast north of Chittagong port during the night of 29 April. The cyclone started affecting the coastal islands from the evening of that day. The maximum wind speed as observed was 225 km/hr. The maximum storm surge height during the cyclone was estimated to be about 20-25 feet.

The cyclone really created havoc throughout the coastal belt of Bangladesh. Figure 1 shows the areas affected by the cyclone. Large portions of the area had not only been flattened but were also submerged under deep water. In some coastal villages 70 to 80 percent of the population were swept away by tidal surge. Besides those who lost their lives in the catastrophe about 11 million people were affected one way or the other. A vast majority of them were bereft of a all their belongings.

About eight hundred thousand houses were completely destroyed while another nine hundred thousand houses suffered partial damage in areas affected by the tidal surge people not

Figure 1 AREAS AFFECTED BY THE CYCLONE

only lost their houses but also food clothing utensils and other belongings which were swept away by tidal waves. Drinking water also became scarce as ponds and lakes were submerged under saline water while hand tube-wells became inoperative. Consequently diarrhoea broke out on a large scale throughout the coastal belt affected by tidal surge. By mid May, 1991 more than l,20,000 people had got diarrhoea and nearly 1300 of them lost their lives. Most of the victims of the disease were infants and children.

Farmers suffered heavily due to loss of standing crops deaths of livestock and poultry and intrusion of saline water into their lands. An estimated one million livestock and poultry were lost. Loss of livestock resulted in the deficiency of ploughing animals, which badly affected rice cultivation. Heavy rainfall after the cyclone, however, greatly reduced the problems of 5alinity in agricultural lands. The government also took immediate steps to repair the damaged embankments so as to stop further intrusion of saline water into the farmlands.

The sufferings of the fishing community also knew no bounds. The fishermen were among the worst sufferers and had one of the highest death rates due to the cyclone. A large percentage of them lost their fishing boats and equipment and became totally dependent on relief. In general, poor people especially the marginal farmers and landless labourers suffered more heavily than the non-poor. They were the ones who were unable to build houses which could withstand the fury of the cyclones and tidal surge. The marginal farmers and landless' Labourers not only lost their houses and, shrimp cultivation, belongings but also their jobs as farming salt manufacturing and various other activities in which they were engaged came to a halt due to the disaster. Thanks to massive relief operations of the government, private organizations, and international community that these people could survive and regain their jobs when economic activities restarted.

3. EXTENT OF DAMAGES TO THE NATIONAL ECONOMY

The damage to the national economy has been quite extensive. Widespread damages occurred in all sectors of the economy. Government estimates put the losses at around 1.4 billion dollars (Ministry of Planning, Planning Commission, Ministry of Finance and Economic Relations Division, Government of Bangladesh, 1991). The industrial sector suffered most heavily with an estimated damage of about 388 million dollars. This constitutes about 28 percent of the total damage to the national economy (Table l). Damages to agriculture and physical infrastructure were more or less close with agriculture incurring a loss of about 363 million dollars and physical infrastructure incurring a loss of about 360 million dollars. Damages to socio-economic infrastructure and other sectors have been estimated at about 267 million and 5.72 million dollars respectively. In the following sections sectoral damages have been discussed in more detail.

TABLE - l

EXTENT OF CYCLONE DAMAGES TO THE ECONOMY

Sector	Estimated Damage	
	Million Dollars	Percent
Agriculture	363.57	26.66
Industries	388.27	28.03
Physical Infrastructure	360.01	26.00
Socio-economic Infrastructure	267.35	19.30
Other	5.72	0.41
Total	1384.92	100.00

Source: Ministry of Planning, Planning Commission, Ministry of Finance and Economic Relations Division, Government of Bangladesh (May, 1991).

3.1 Agriculture

The April '91 cyclone has caused extensive damage to the livestock, agricultural sector especially to standing crops, forestry, and fisheries resources. Damages to standing crops have been estimated at about 78.86 million dollars (Table 2) which constitute about 21.71 percent of the total damage in the agricultural sector. The total area of standing crops damaged has been estimated at about 292 thousand acres. Of all crops, boro rice has been affected the most along with aus, jute, pulses, vegetables, fruits, species, betel - leaves etc.

The fisheries sub-sector suffered the heaviest damage with an estimated loss of about 206 million dollars. This constitutes 56.69 percent of the total damage in the agricultural sector. Damages in this sector include shrimp projects, fish seed farms in the coastal belt, buildings and vessels of Marine Fisheries laboratory, trawlers, plants and other installations of Bangladesh Fisheries Development Corporation, fishing trawlers, mechanised and traditional fishing boats etc.

TABLE 2

DAMAGE TO THE AGRICULTURAL SECTOR

Sub-sector	Estimated Damage (Million Dollars)	Percent
Crop Production	78.86	21.71
Forestry	28.20	7.75
Fisheries	206.14	56.69
Livestock	50.37	3.85
Total	363.57	100.00

Source: Ministry of Planning, Planning Commission, Ministry of Finance and Economic Relations Division, Government of Bangladesh (May 1991).

TABLE 3

DAMAGE TO THE INDUSTRIAL SECTOR

Sub-sector	Estimated Damage (Million Dollars)	Percent
Export Processing Zone (EPZ)	16.77	4.32
Public Sector Industries (other than EPZ)	57.22	14.74
Private Sector Industries	314.24	80.94
Total	388.27	100.00

Source: Ministry of Planning, Planning Commission, Ministry of Finance and Economic Relations Division, Government of Bangladesh (May 1991).

In the Forestry and livestock sub-sectors damages have been estimated at 28.00 million and 50.37 million dollars respectively which constitute about 7.15 percent and 13.85 percent of the total damages in the agricultural sector.

3.2 Industry

About 81 percent of the total damage in the industrial sector were caused to the private sector industries. The export processing zone in Chittagong was also hit severely and accounted for about 14.74 percent of the total damage in the industrial sector. Other public sector industries damaged by the cyclone included those belonging to Bangladesh Steel and Engineering Corporation. Bangladesh Textile Mills Corporation, Bangladesh

Small and Cottage Industries Corporation and Bangladesh Forest Industry Development Corporation. Table 3 presents the industrial damage in terms of U.S. dollars. These damages were caused mainly to buildings, machinery, transport equipment, raw material, finished product etc.

3.3 Physical Infrastructure

All types of physical infrastructures were damaged by the cyclone. In the physical infrastructure sector Post and Telecommunication facilities suffered the heaviest damage (35.67%) followed by Rural Infrastructure (29.73%) Inland Water Transport Authority (14.45%), Chittagong Port Authority (11.64%) and Railways (7.84%). Table 4 presents distribution of damages by these sectors.

In case of rural infrastructure damaged facilities include roads, bridges/culverts, educational institutions, Upazila Parishad Buildings, Union Parishad Offices, health facilities services, landing jetties in river ports, growth and market centres, cyclone shelters, pump houses, motors, transport equipment etc.

In the Post and Telecommunications sub-sector microwave tower antenna feeder cable radio and telephone tower, UHF link, trunk lines etc. were badly affected. The Chittagong Port Authority suffered heavy losses in terms of river crafts, barges, ships, shore and floating cranes etc. Damages to Railway includes workshops, sheds, stores, depots hospitals and other buildings while damages to Inland Water Transport Authority Includes navigational aids, jetties, pontoons etc.

TABLE 4

DAMAGE TO PHYSICAL INFRASTRUCTURE

Sub-sector	Estimated Damage (Million Dollars)	Percent
Rural Infrastructure	107.00	29.73
Railways	28.20	7.85
Chittagong Port Authority	41.91	11.64
Inland Water Transport Authority	52.05	14.45
Post and Telecommunication	128.42	35.67
Others	2.43	0.67
Total	360.01	100.00

Source: Ministry of Planning, Planning Commission, Ministry of Finance and Economic Relations Division, Government of Bangladesh (May 1991).

3.4 Socio-Economic Infrastructure

In the socio-economic infrastructure sectors total damage has been estimated to be about 267 million dollars of which nearly half of the damages were in the education sub-sector followed by health and family planning sub-sector (Table 5). Damaged facilities in this sector included valuable instruments, buildings, furniture, transport equipment etc.

TABLE 5

DAMAGE TO SOCIO-EOONOMIC INFRASTRUCTURE

Sub-sector	Estimated Damage (Million Dollars)	Percent
Education	132.02	49.39
Health and Family Planning	78.74	29.47
Science and Technology	49.28	18.43
Mass Media	7.31	2.71
Total	267.35	100.00

Source: Ministry of Planning, Planning Commission, Ministry of Finance and Economic Relations Division, Government of Bangladesh (May 1991).

Thus the damages brought by the April '91 cyclone were massive and widespread. Colossal damages have occurred to standing crops, livestock, fishery, forestry, industrial units, physical infrastructure and socio-economic facilities. Such damages are bound to affect the growth rate of national economy at least in the short run.

The foregoing analysis has, however, focussed on the national economy as a whole. No attempt has been made to analyse the spatial variations in damages caused by the cyclone. But the cyclone affected different areas differently. Populations in some areas suffered heavily while populations in other areas escaped large - scale damage. In the following sections an attempt is made to analyse the variations in the effects of the cyclone on populations in different Upazilas affected by the cyclone.

4. SPATIAL VARIATIONS IN THE EFFECTS OF THE CYCLONE

About one hundred Upazilas were affected by the April '91 cyclone. Most of the worst affected Upazilas are either off-shore Islands or coastal Upazilas. The less affected upazilas are mostly located inside and further from the coast.

For analysing the variations in the effects of the cyclone on population the following aspects were considered loss of human lives damage to houses and damage to standing crops. Most of the affected households suffered from death of their members or damages to properties or from both due to the cyclone. For grouping the upazilas in terms of damages to these aspects following procedures were followed:

(a) In case of human deaths the number of deaths per thousand population in each upazila was calculated. In case of damage to houses and damage to standing crops per capita damage was computed. Damage to houses was considered in terms of number of houses while damage to crops was considered in terms of taka per person.

Figure 2
Delineation of Areas Based on the Loss of Lives

Figure 3

Delineation of Areas Based on the Extent of House Damage

(b) Damages in each upazila were then converted into standard units or Z-scores using the formula $Z = (x - \pi) / \delta$ *where* x represents the number of deaths per thousand population or per capita damage to houses or crops in an Upazila, π represents these values for the affected area as a whole and δ represents population standard deviation.

(c) On the basis of the Z-scores cyclone damages were categorised into the following: (1) Very low; (2) Low; (3) Moderate; (4) High; (5) Very High; (6) Extremely High.

(d) Upazilas were then distributed among these categories on the basis of their Z-scores.

The analysis is based on information collected from Zonal Relief Coordinators Office, Chittagong zone and Directorate of Relief and Rehabilitation, Government of Bangladesh.

4.1 Human Deaths

For analysing spatial variations in human deaths Z-scores were calculated for those Upazilas in which 10 or more deaths occurred. Damages to upazilas with no or less than 10 deaths were considered as insignificant (in terms of deaths).

Table 6 presents the distribution of Upazilas by various categories in terms of human deaths per thousand populations. In figure-2 the areas according to these categories have been delineated. Most of the upazilas suffered no or insignificant number of deaths. Moderate to extremely high deaths occurred in about 10 percent of the affected upazilas. Extremely high deaths occurred in two upazilas where more than 10 percent of the population were killed during the cyclone.

4.2 Damage to Houses

Table - 7 presents the distribution of Upazilas by various categories of house damage. Majority of the Upazilas suffered moderate to extremely high damage. 18.36 percent of the affected upazilas suffered moderate damage while high to extremely high damage was experienced by 39.78 percent of the affected upazilas. In figure-3 regions defined on the basis of the extent of damages have been delineated. A comparison of figure-2 and figure-3 indicates that areas, which were less, affected by human deaths suffered significantly in terms of housing damage.

4.3 Damage to Crops

Distribution of Upazilas in terms of crop damage has been presented in table 8. In figure-4 the regions in terms of crop damage have been delineated. It is interesting to note that the

Figure 4
Delineation of Areas Based on the Extent of Crop Damage

TABLE 6

DISTRIBUTION OF UPAZILAS BY LOSS OF HUMAN LIVES

Extend of loss	Death per thousand Population	Number of Upazilas	Percent of Upazilas
Nil or Very low	0 or less than 0.1	80	81.64
Low	0.1 to 0.9	8	8.16
Moderate	1 to 25	4	4.08
High	26 - 50	2	2.04
Very High	51 to 100	2	2.04
Extremely High	Above 100	2	2.04
Total		98	100.00

Source: Author’s Calculation

TABLE 7

DISTRIBUTION OF UPAZILAS BY THE EXTENT OF DAMAGES TO HOUSING

Extent of loss	Z-Score	Number of Upazilas	Percent of Upazilas
Low or Very low	Below – 0.50	41	41.83
Moderate	- 0.49 to 0.00	18	18.36
High	0.01to 0.50	14	14.28
Very High	0.51 to 1.00	14	14.28
Extremely High	Above 100	11	11.22
Total		98	100.00

Source: Author’s Calculation

Upazilas, which suffered low to very low damage in case of crops, have remained the same while the number of Upazilas, which suffered high and extremely high damage, has increased. Thus more Upazilas were highly affected in terms of crop damage than in terms of house damage.

4.4 Composite Analysis

A composite analysis was done by combining damages to houses and of crops in the affected Upazilas. Since the units of measurement were different per capita damage to houses and crops corresponding to each upazilas were converted into scores on a scale of 0 to 100. In each case the Upazilas which suffered the highest damage per person was assigned a score of 100. Other Upazilas were then assigned scores in proportion to the damage suffered by them. For each Upazila the scores (for house and crop damage) thus obtained were added to give the composite score. Z-scores were then calculated and analysis was done as before.

Table 9 presents the results of the composite analysis. Upazilas have been distributed in terms of overall damage to households (hoses and crops combined). The percentage of upazilas suffering low to very low damage or moderate to extremely high damage has remained the same as before. The result, however, indicates that the overall damage has been influenced more by crop damage than by house damage. 13.26 percent of the affected upazilas suffered moderate damage while High, Very High, and

Extremely High damages have occurred to 17.35 percent and 14.28 percent of the affected upazilas. Figure-3 shows the affected regions as defined in terms of the extent of the overall damage.

TABLE 8

DISTRIBUTION OF UPAZILAS BY THE EXTENT OF DAMAGE TO CROP PRODUCTION

Extent of Damage	Z-Score	Number of Upazilas	Percent of Upazilas
Very low	Below – 1.00	18	18.36
Low	-0.99 to –0.50	23	23.46
Moderate	- 0.49 to 0.00	11	11.22
High	0.01to 0.50	18	18.36
Very High	0.51 to 1.00	14	14.28
Extremely High	Above 100	14	14.28
Total		98	100.00

Source: Author's Calculation

Figure 5

Delineation Based on the Extent of House and Crop Damage Combined

regional development planning.

In an integrated approach to cyclone disaster management and regional development planning in Bangladesh the entire cyclone prone region should be delineated as a special problem reglon Planning efforts, then should aim at increasing efficiency and capability of the cyclone disaster management system improving socio-economic conditions of the people, developing physical infrastructure, restricting economic activities in risky areas and preventing people from interfering with the natural environment. Achievement of these objectives would require various steps to be taken of which the following need special consideration:

(a) *Construction of Embankments*: Most of the embankments which were protecting coast lands were constructed to aid desalinization and not primarily for storm protection. Consequently the formidable tidal surge that accompanied the April 29 cyclone overtopped the embankments or washed them away. The coastal areas and off shore islands therefore need strong embankments to resist tidal bore with a height of about 20 feet from the mean sea level. These embankments should be properly designed and should take into account present and future land use and drainage of water. Due to resource limitations construction of surge resistant embankments may not be possible on a large scale but should be considered where necessary, *i.e.* to save valuable economic resources the IDSS of which cannot be afforded by the country.

TABLE 9

DISTRIBUTION OF UPA Z I LAS BY THE EXTENT OF DAMAGE TO HOUSING AND CROP PRODUCTION COMBINED

Extent of Damage	Z-Score	Number of Upazilas	Percent of Upazilas
Very low	Below – 1.00	22	22.46
Low	-0.99 to –0.50	18	18.36
Moderate	- 0.49 to 0.00	13	13.26
High	0.01to 0.50	17	17.36
Very High	0.51 to 1.00	14	14.28
Extremely High	Above 100	14	14.28
Total		98	100.00

Source: Author's Calculation

In conclusion, following observations have been made from the analyses of the spatial variations in the effects of the cyclone:

(a) While large number of deaths occurred mainly in the coastal Upazilas, serious damage to houses and crops occurred in most of the affected upazilas.

(b) The number of Upazilas suffering from moderate to extremely high damage was the same for both crops and houses; and

(c) The number of upazilas, which suffered from high to extremely high crop damage, was more than the number of Upazilas, which suffered damages of the same magnitudes in case of houses. Consequently overall damage in rural areas was more influenced by crop damage than by house damage.

5. NEEDED STEPS FOR COASTAL AREA PROTECTIUN AND CYCLONE DISASTER MANAGEHENT

It is now quite clear that the April 29 cyclone not only devastated the coastal regions but also badly affected the national economy. This points to the serious limitations of the disaster management capability of the country. Apart from resource constraints the failure to perceive the multidimensional nature of the problems associated with natural disasters could be cited as one of the reasons why an efficient disaster management system could not be developed. It is important to recognise that the extent of cyclone disaster is not only a function of the intensity of the cyclone by also of various aspects influencing the process of socio-economic development and environmental changes. In other words human activities also play a significant role in determining the dimension of natural disasters.

The traditional concept of disaster management, which considers only one way flow from natural phenomena to human activities has, therefore, serious limitations (Sazanami, 1991). The new concept of two-directional disaster management, on the other hand, considers the effects of human activities on natural and socio-economic environment which, in turn, influence the extent of natural disasters significantly. This concept therefore, emphasises the need for controlled and guided development and integration of cyclone disaster management with appropriate institution with needed powers, functions and resources is required for implementing programmes for mitigation of cyclone disasters with people's participation. Such institution should exist at the national, regional and local levels having both horizontal and vertical linkages. This institution should not only co-ordinate agencies responsible for some type of disaster mitigation function but also work in close co-operation with NGO's, co-operative societies and other organizations in developing and implementing cyclone disaster management programmes.

8. CONCLUDING REMARKS

In the last few decades Bangladesh has teen devastated by a series of natural disasters. The cyclones of 1970, 1985, and 1991 and the floods of 1974, 1987, and 1988 were particularly devastating and caused serious damage to the national economy. Millions of people lost their lives and billions of dollars worth of properties were destroyed. The existing governmental resources and organizations were found inadequate to match the crises. Massive international help was therefore needed to tackle the situation.

Apart from these major disasters flood and cyclone disasters of smaller magnitudes also occur almost every year. What can be learned from the experiences of these disasters is that the

(b) ***Coastal Afforestation***: Absence of thickly planted trees is also cited as one of the reasons why embankments failed in many places during the cyclone. Thickly planted trees diminish the wind velocity and quickly reduce the tidal height.

A long-term programme of afforestation in our coastal areas and off shore islands should be considered. A green built of a considerable width would not only protect the coastal embankment but also reduce the devastation significantly by diminishing the wind speed and lowering the height and intensity of tidal surge. The trees would also serve as a life saving device as many people would be able to save their lives by climbing or holding on to the trees in case they fail to go to a cyclone shelter. The experiences of November 1970 and April 1991 cyclones bear this out.

(c) ***Zoning***: Environmentally sensitive and high-risk areas should be zoned and restricted for settlement purposes or location of economic activities. The areas at risk should be zoned as high risk, medical risk and low risk areas. Farming, 5hrimp cultivation and salt manufacturing in these areas should be evaluated In terms of their Impacts on the environment and control led accordingly. Policies and programmes for disaster management in these areas should also be formulated In terms of the nature of risks. Industries should not be allowed to locate in high-risk areas.

(d) ***Improving Warning System***: In Bangladesh cyclone warnings are given in terms of signals. These signals are meant for inland river ports and seaports. There are a total of 4 for inland river ports and all signals for seaports signals. Cyclone warning system in Bangladesh has been criticised on the ground that people face problems in understanding these signals (Rauf, 1991; Matin, 1991). It has been pointed out that people are not aware of the inner significance of different warnings nor are they aware of these implications of different kinds of signals, *i.e.* maritine port signals and riverine port signals. Since the Meteorological Department issues cyclone warnings for the ports only the people also become confused about the actual signal numbers for their own localities.

The weaknesses of the cyclone warning system, therefore, should be removed if we want to make warnings both better understood and persuasive. The improved warning system should provide for warnings not only for the ports but also for areas likely to be affected by a cyclone. Simplification of the warning system is, therefore, essential.

(e) ***Construction of Cyclone Shelters***: One of the reasons for the heavy loss of life due to the April cyclone was the lack of cyclone shelters in the affected coastal areas and off-shore is lands. Multi-storied shelters should be built in adequate numbers. Proper design of these shelters is very important since these should not only be used as platforms for survival but also as centres for different types of community activities. Such multiple use would, on the one hand, en5ure proper maintenance of the buildings and on the other hand, enable the inhabitants to enjDy community facilities in their own localities.

(f) ***Development of Transportation and Communication Facilities***: The human settlements in the coastal areas and off shore islands mostly developed in an unorganised and isolated manner. As there was no control or guidance from the government development of the settlement followed a scattered pattern making it difficult to provide public or community facilities. Consequently these settlements became inaccessible without the existence of improved system of transportation and of and communication proper management of disasters would be extremely difficult. The shelters should be well connected with the surrounding localities and the localities should be well connected with outside through road network, wireless and telecommunication facilities. Early dissemination of warnings, evacuation of people to safer places or carrying relief materials to the distressed people after the disaster would suffer set backs if such facilities do not exist.

(g) ***Development of Proper Institutional Framework***: There is no high-powered disaster management organization to co-ordinate and supervise the activities of all the organizations involved in cyclone disaster management. Due to lack of coordination among various organisations and participation of general public in their activities mobilisation of all kinds of resources for dealing with a disasters situation becomes extremely difficult.