3.5.1 INTRODUCTION

Bangladesh is most vulnerable to several natural disasters and every year natural calamities upset people's lives in some part of the country. The major disasters concerned here are the occurrences of flood, cyclone and storm surge, flash flood, drought, tornado, riverbank erosion, and landslide. These extreme natural events are termed disasters when they adversely affect the whole environment, including human beings, their shelters, or the resources essential for their livelihoods.

The geographical setting of Bangladesh makes the country vulnerable to natural disasters. The mountains and hills bordering almost three-fourths of the country, along with the funnel shaped Bay of Bengal in the south, have made the country a meeting place of life-giving monsoon rains, but also makes it subjected to the catastrophic ravages of natural disasters. Its physiography and river morphology also contribute to recurring disasters. Abnormal rainfall and earthquakes in the adjacent Himalayan range add to the disaster situation. Effects of *El-Nino*-Southern Oscillation (ENSO) and the apprehended climatic change have a great impact on the overall future disaster scenarios.

The task of sustaining the very limited resource base is aggravated by population growth and over exploitation, with consequent environmental degradation. It has been further complicated by natural disasters, which further damage the resource base, including flora and fauna.

Since Bangladesh is a disaster prone country, it is subject to colossal damages to life and property almost every year. The different types of disasters,

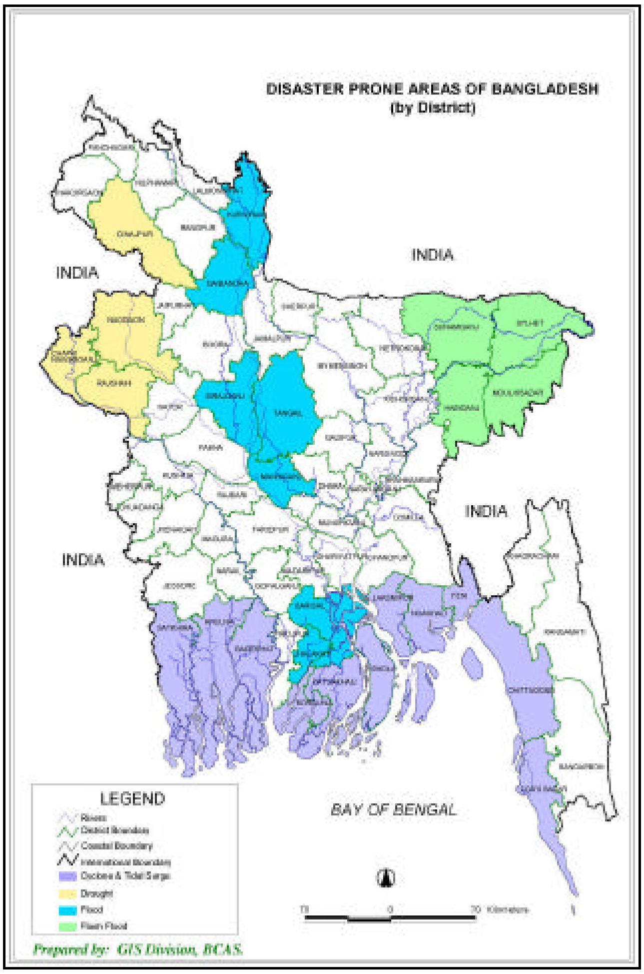
Table 3.5.1 Types of Disasters and their Impacts in Specific Disaster Prone Areas

Types of Disaster	Areas Affected	Impact
Flood	Floodplains of the *Brahmaputra-Jamuna*, the *Ganges-Padma* and the *Meghna river* system	Loss of agricultural production, disruption of communication and livelihood system, injury, damage and destruction of immobile infrastructure, disruption to essential services, national economic loss, evacuation, and loss of human lives and biodiversity, displacement and sufferings of human population and biodiversity
Cyclone and Storm Surge	Coastal areas and offshore islands	Loss of agricultural production, disruption of communication and livelihood system, damage and destruction of immobile infrastructure, injury, national economic loss, loss of biodiversity and human lives, need for evacuation and temporary shelter
Tornado	Scattered areas of the country	Loss of human life and biodiversity, injury, damage and destruction of property, damage of cash crops, disruption in lifestyle, damage to essential services, national economic loss and loss of livelihood
Drought	Almost all areas, especially the Northwest region of the country	Loss of agricultural production, stress on national economy and disruption in life style
Flash Flood	Haor Basins of the North-east region and South-eastern hilly areas	Damage of standing crops, disruption in life style, evacuation and destruction of properties
Hail Storm and Lightning	Any part of the country	Damage and destruction of property, damage and destruction of subsistence and cash crops and loss of livelihood
Erosion	Banks of the Brahmaputra-Jamuna, the *Ganges-Padma* and the *Meghna* river systems	Loss of land, displacement of human population and livestock, disruption of production, evacuation and loss of property
Landslide	Chittagong and Chittagong Hill Tracts	Loss of land, displacement of human population and livestock, evacuation, damage of property and loss of life
Earthquake	Northern and central parts of the country	Damage and destruction of property, loss of life and change in geomorphology

Source: SoE Study Team

and their impact on the affected areas can broadly be summarised as in the accompanying Table 3.5.1.

Figure 3.5.1 Disaster Prone Areas of Bangladesh (by Districts)



Source: GIS Division, BCAS

Flood is a recurring phenomenon in the country, locally termed as *Bonna* or *Borsha* based on the intensity of monsoon rain, magnitude and time of occurrence. When the floodwater damage resources, and disrupt communication and livelihood systems, then it is treated as *Bonna*. Bangladesh gets damaging floods like that of 1988, which bring untold sufferings to millions of people, and result in human deaths, loss of livestock, spread of diseases and hunger, damaged standing crops, destroyed physical and economic infrastructures, damaged fish and shrimp ponds and hatcheries, etc. Cyclone and storm surges occur frequently and cause significant destruction in the coastal areas of the country. Nor'westers and tornadoes also frequently hit different places. Tropical cyclones and tornadoes uproot trees, telephone, telegraph and electricity lines, destroy bridges, culverts, and houses, kill people and domestic animals, leaving serious and adverse effects on the economy as well as on the whole environment. Although this country with monsoon climate has enough rain, droughts frequently take a significant portion out of the agricultural economy of Bangladesh, and cause hunger, instability, and insecurity. The north-western part of the country is vulnerable to drought. Disastrous erosions are mainly associated with the major river systems of the country and are seen along these river banks i.e., the *Brahmaputra-Jamuna*, the *Ganges-Padma*, the Lower *Meghna*, and other rivers.

The effects of a natural disaster, or a combination of more than one natural disaster may be direct loss of life, and certainly damage to physical properties. This requires large resources for disaster management including mitigation, recovery and preparedness. Therefore, the consequences of these natural hazards and the resulting environmental degradation pose a serious threat to the economic development of the country. The situation calls for an effective disaster warning and dissemination system. A timely and accurate alert system about impending disasters will help reduce the loss of life and property (Pramanik, 1991).

Natural disasters cannot be prevented, but the damage can be mitigated with adequate planning and adaptation. The impacts of these disasters vary with their type and magnitude. They also critically depend on institutional strength and response by the different agencies that usually take measures to mitigate and eventually overcome the losses, such as the government and other civil service organizations.

3.5.2 PRESSURES

It has often been pointed out that the worst disasters in the world tend to occur between the Tropic of Cancer and the Tropic of Capricorn, which is coincidentally the area that contains the poorer countries (Carter, 1991). This applies to Bangladesh where the cause of natural disasters is its geographical setting. The lofty Himalayas in the north, and the funnel-like shape of the Bay of Bengal in the south, have made Bangladesh one of the worst victims of the catastrophic ravages of natural disasters like floods, cyclones, storm surges, droughts, etc. Various anthropogenic activities contribute to worsen the situation. Due to recurring disasters, the country is subject to food shortages in spite of its fertile land, network of rivers, subtropical monsoon climate, and hard working people. A large part of the population is dependent on agricultural production. But harvesting of produce is often affected by extreme natural events and the weather patterns frequently associated with them.

The pressures on the environment that exacerbate the natural disasters in Bangladesh are summarized in Table 3.5.2 and some are described briefly below.

3.5.2.1 Geographical Setting and Physiography

Bangladesh is situated in the Bengal Basin, which is one of the largest geosynclinals in the world. It is bordered on the north by the steep Tertiary Himalayas, on the norhteast and east by the late Tertiary Shillong Plateau, the Tripura hills of lesser elevation and the Naga-Lusai folded belt, and in the west by the moderately high ancient Choto Nagpur plateau.The southern fringe of the basin is not distinct, but the geophysical evidence indicates that it is open towards the Bay of Bengal for a considerable distance. The geographical setting makes Bangladesh particularly vulnerable to cyclones, storm surges and tornadoes.

The Bay of Bengal is the breeding place of catastrophic cyclones. It is situated in the northeastern corner of the Indian Ocean, and is bounded between 5°-22′ North Latitude and 80°-95′ East Longitude. It occupies an area of about 2.2 million sq. km, and is 1,609 km wide, with average depth of more than 7912 meter, and the minimum depth is 4,500 meter (Encyclopedia Britannica, 1980). The Bay of Bengal cyclones mostly originate at latitudes greater than 5°N (near the Andamans). It is presumed that the Inter-Tropical Convergence Zone (ITCZ), which is situated near

Table 3.5.2 Pressures, State, Impacts and Responses of Natural Disaster

Issue	Pressure/Cause	Impacts	Responses
Flood	• Excess flow in monsoon • Improper infrastructural development • 92 per cent of the total catchment area across the boarder • Drainage congestion due to river bed siltation • Deforestation in upper catchment area	• Disruption of communication and livelihood system • Loss of agricultural production • Disruption of essential services • National economic loss • Loss of human lives and biodiversity	• CDMP (Comprehensive Disaster Management Program) • FAP (Flood Action Plan) • National Water Policy • Flood forecast and inundation modeling • Dredging of river bed • Construction of embankments with sluice gates
Drought	• Less and uneven rainfall in dry season and wet season • Non-availability of surface water in dry season • Fluctuation of Ground Water table	• Loss of agricultural production • Stress on national economy due to bad harvesting • Disruption of life style • Reduction of fresh water fish production	• Agricultural research and extention works • Intensive Afforestation Program • Re-excavation of channels and ponds in rural areas • Augmentation of surface water flow • Construction of water reservoir
Cyclone & Storm surge	• Geographical setting of Bangladesh • Coastal configurations and bathymetry of the Bay of Bengal • Location of ITCZ near the equator and its shifting with the apparent movement of the sun across the Bay	• Disruption of communication and livelihood system • Damage and destruction of property • Environmental degradation • Loss of lives and agricultural production • National economic loss	• CDMP (Comprehensive Disaster Management Program) • Strengthening of CPP (Cyclone Preparedness Program) • Local Disaster Action Plans for the grassroot levels along the coastal belt • Awareness building programs for the target group • Reliable and timely warning and effective warning dissemination system
Tornado	• Intense ground heating and low level moisture incursion from the Bay of Bengal during pre and post monsoon • Conjugation of western disturbance with locally developed low pressure	• Loss of lives and biodiversity. • Destruction of property and damage of cash crops • Damage to essential services • National economic loss and loss of livelihood	• Proper radar network • Reliable and timely forecast capability for severe nor'wester • Awareness building programs • Quick search and rescue system
Earthquake	• Geographical location of Bangladesh having major and moderate faults	• Damage and destruction of property • Loss of lives and disruption of life style	• Proper implementation of Building code (1993) • Inventory of equipment for rescue operation

Source: SoE Study Team

the equator, and where winds from the two hemispheres meet, plays a part in the formation of the tropical cyclones.

The storm surge heights are directly related to cyclone intensity, but also to coastal configurations and bathymetry at the time of cyclone landfall. Astronomical influences on the tides can lead to further amplification of surge heights, resulting in severe flooding.

The geographical location of Bangladesh also makes it subject to various climatic features that make it more susceptible to abnormal storms and tornadoes. Intense ground heating during pre-monsoon months can influence the normal seasonal winds that bring rain, the Nor'westers, into forming the swirling, high-speed winds of a tornado. The conjugation of western disturbances with locally developed low pressure also causes tornadoes. The occasional occurrence of Nor'westers, and hence tornadoes, in early June is due to a delay in the onset of the southwest monsoon over the region (Karmakar, 1989).

The location of various major and minor faults near Bangladesh also makes it vulnerable to the effects of earthquakes and tremors.

3.5.2.2 Hydrology

Bangladesh is a land of many rivers, and heavy monsoon rains. Bangladesh is the largest delta in the world, formed by the *Ganges*, the *Brahmaputra*, and the *Meghna* (GBM) river system. This delta is characterized by flat terrain interlaced with an intricate system of about 700 rivers, canals, and streams, with a total length of approximately 22,155 km (BBS 1979, 1998), which carry an enormous quantity of sediment-laden water downstream. Over 92 per cent of the annual runoff generated in the GBM area flows through Bangladesh, which is only about 7 per cent of the total catchment's area (Ahmad, 2000).

Thus, a vast amount of water flows through Bangladesh. It is estimated that every year an average of 870 million acrefeet (MAF) of water flows into the country from India. The amount of rainfall received within the country is estimated at 203 MAF, with evaporation, evapotranspiration, and deep percolation losses probably accounting for about 120MAF. This means that about 953 MAF flows out to sea - from that 914 MAF flows through the *Ganges-Brahmaputra* delta (within Bangladesh), and 39 MAF through the rivers of the Chittagong sub-region and Feni district (Rashid, 1991).

During the peak flow season (July - September) most of the rivers normally overflow their banks onto the low-lying surrounding flat land, which is essential for providing vital moisture and fertility to the soil. However, occasionally abnormal conditions lead to drainage congestion, excessive rainfall run-off, and storm-tidal surges that induce high-magnitude flooding that inundates large areas, and causes widespread damage to crops and property. The devastating floods of the recent past are due to excessive rainfall in the GBM catchment area, and synchronization of peak flow of the Ganges and the Brahmaputra-Jamuna rivers. Effects of *El-Nino*, *La-Nina*, and synchronization of high tide are also considered to be the causes of the flood of 1998. The likelihood of abnormal floods is also increased due to infrastructure development activities that neglect proper concern about environmental impacts and drainage facilities.

An analysis of hydrographs and other hydrological data of a few selected stations indicated the following salient features (Matin and Husain 1988):

- The synchronization of backflows of the major rivers accounts for the floods in the years 1954 (30 days), 1974 (27 days), 1987 (30 days), and 1988 (30 days). The synchronization accentuated the disastrous and catastrophic flood of 1988.
- Frequency analysis shows that the flood level of the Brahmaputra at Bahadurabad and Sirajganj, and the Ganges at Goalondo had a return period of about 100 years. The flood level of the Buriganga at Dhaka, and the Sitalakhya at Narayanganj had a return period in the order of 50 years.
- During 1987, there was an abnormally heavy rainfall throughout the country, whereas in 1988, very heavy rainfall in the upper catchment area occurred.

The mean annual rainfall in Bangladesh varies from about 1400 mm. in the western part of the country, to almost 5000 mm. in the northeast region. There are wide seasonal fluctuations, with about 90 per cent of the rainfall occurring during the four months of the monsoon period (June-September). A number of constraints are inherent in this monsoon-dependent rainfall and climatic pattern, which can lead to excessive amounts of rainfall and floods, or inadequate rain resulting in drought.

Along with the floodwater, the rivers of Bangladesh carry huge amounts of sediments, an estimated 2.4 billion m.tons/year. The sediments are washed down from highlands on three sides of the Basin, particularly from the Himalayas, where the slopes are steeper and the rocks are less consolidated. Erosion plays an important role in the siltation process, and the water-holding capacity of rivers. The deterioration of the river system due to siltation is one of the causes of floods in Bangladesh.

The river sediments are subjected to coastal dynamic processes generated mainly by river flow, tide, and wind actions. The ultimate result may be additional new land in some places due to accretion, and loss of land in some other places due to erosion. As a result of sedimentation, the formation of *chars* (islands) through accretion takes place. These undesirable *chars* in the river system threaten inland water navigation, cause erosion in the riverbanks, and create other socio-economic problems for people due to land loss and displacement.

Erosion in the coastal regions of Bangladesh is caused by a number of factors, such as high monsoon wind, waves, and currents, strong tidal actions, and storm surges (Ali, 2000).

3.5.2.3 Global Environmental Pressures

The causes of natural disasters in Bangladesh have an international dimension. The 57 main rivers flowing through Bangladesh are trans-boundary; 54 of them have origins in India, and 3 in Myanmar. The upstream deforestation, heavy rainfall, melting of glaciers, and soil erosion play a vital role in causing siltation in riverbeds. This in turn leads to natural disasters like floods, flash floods, etc. The upstream activities also enhance the magnitude of damages caused by these disasters. The upstream withdrawal of water due to the Farakka barrage across the Ganges in India leads to local drought conditions in regions of Bangladesh.

There is firm scientific evidence that largely due to human activities the concentration of greenhouse gases in the earth's atmosphere is increasing. The consequences will be progressive global warming and climate change. Bangladesh is thought to be one of the most vulnerable countries in the world to climate change, and the resultant Sea Level Rise (SLR) that is apprehended.

It is expected that Bangladesh may get warmer and wetter owing to global warming. Higher precipitation may increase the area and depth of flooding, which will require additional measures for protection and adaptation. Other probable pressures include disruption of the monsoon rhythm, prolonged drought, and increased frequency of cyclones. The most serious consequence of climate change for Bangladesh will be a rise in sea level along the Bay of Bengal coast, causing submergence of 10 to 20 per cent of the land (including the Sundarbans), as well as saline intrusion in the rivers.

Bangladesh is one of those poor countries which may face the irony of adapting to and mitigating the consequences of man-made global warming and climate change, which are largely not of their own making; while they have little human, societal, technological, or financial capability for such adaptation and mitigation (Huq *et al.*, 1999). Bangladesh is thought to be one of the most vulnerable countries in the world to Climate Change and Sea Level Rise (SLR). The apprehended Climate Change and SLR will lead to coastal inundation throughout the world, particularly along low-lying coastal areas. In Bangladesh, it is likely to inundate wetlands and lowlands, accelerate coastal erosion, increase the risk of flood and cyclone disasters, change rainfall pattern, create drainage and irrigation problems; and increase salt water intrusion into ground water, rivers, agricultural, and coastal forestlands. This may in turn cause damage to port facilities and coastal embankments/structures, destroy quality farm lands, disrupt mangroves, fisheries and bird habitats, result in loss of recreational beaches, and affect cyclone and storm surge protection measures in the coastal areas (Ali, 2000).

The SLR might make an impact on the country as a whole by inundating one-tenth of the total land area along the coastal belt. If this happens, about ten million people living in the coastal areas of Bangladesh will be forced to migrate further inland. This will put a tremendous population pressure on the mainland.

3.5.3 STATE OF NATURAL DISASTERS

This section, describes the state of various natural disasters which visit Bangladesh frequently and an attempt has been made to elaborate some general causes related to these disasters.

3.5.3.1 Floods

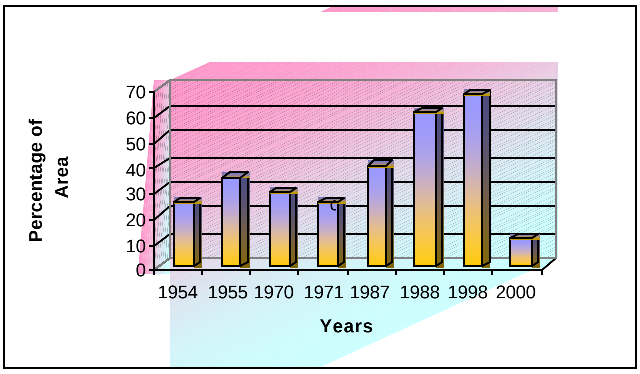
Bangladesh is a land of many rivers, and heavy monsoon rains. Therefore, the country is subject to inundation by overflow from the riverbanks due to drainage congestion, rainfall run-off, and storm-tidal surges. Some 30 to 35 per cent of the total land surface is flooded every year during the wet monsoon (Hossain *et. al.,* 1987 and Milliman *et. al.*, 1989). These normal floods are considered a blessing for Bangladesh-providing vital moisture and fertility to the soil through the alluvial silt deposition. Only abnormal floods are considered disastrous, i.e., the high-magnitude events that inundate large areas, and cause widespread damage to crops and properties.

Flood is more or less a recurring phenomenon in Bangladesh, and often within tolerable limits. Occasionally, it becomes devastating. In 1997, 1988, 1998, and 2000, Bangladesh faced unprecedented floods, causing massive loss of life and property.

During the peak flow season (July, August and September), most of the rivers overflow their banks, and deposit silt on the flood plains - providing vital moisture and fertility to the soil. Thus, the normal floods are considered a blessing for Bangladesh. Only abnormal floods are considered disastrous, i.e., the high-magnitude events that inundate large areas, and cause widespread damage to crops and properties. In the years 1988 and 1998, two devastating floods inundated more than 65 per cent of the geographical area of the country. In the year 2000, Bangladesh faced an unusual flood over its usually flood-free southwestern plain, which also caused loss of life and massive damage to property. Figure 3.5.2 shows percentage of total flood affected areas of the country for some selected years.

Flood is a recurring phenomena

Figure 3.5.2 Flood Affected Areas of Some Selected Years



Source : Miah, 1988, DMB, 2000

The 1988 flood affected about two-third area of the country. Extensive studies by various authors have shown that the area of flooding at different times, varied from 31 per cent to 85 per cent of the total area of the country (Bashar, 1988, Choudhury, 1988, Matin and Hussain, 1988, Pramanik, 1988, and Rashid and Pramanik, 1990).

Causes of Devastating Floods

- Excessive rainfall in the catchment area
- Synchronization of the peak water levels of all the major rivers of Bangladesh.
- Sometimes solar eclipse retards the outflow of water drainage by raising the tidal level.
- Earthquakes cause tectonic anomaly in the Himalayan region and the Bay of Bengal.
- Infrastructure development without adequate drainage facilities.

During the 1988 flood, 8 out of 10 stations in the Brahmaputra basin exceeded the flood level of 1987, and for the Ganges basin that occurred in 5 out of 9 stations. The flood level of the Ganges upstream of Hardinge Bridge was higher in 1987, than in the 1988 flood. Flood-flow of the Ganges was also higher in the 1987 flood. In addition, in the southeastern hill basin, the flood level of all the streams were higher in 1987, than in 1988. During 1987 an area of 57,270 sq. km was inundated, whereas in 1988 an area of 81,831 sq. km was inundated.

The flood of 1998 is considered one of the century's longest and worst natural disasters ever experienced in Bangladesh. Flooding occurred from July 12 to September 14, with duration of 65 days, and affected about 67 per cent area of the country. This devastating flood caused an enormous impact on the national economy, in addition to hardships for people, and disrupted livelihood systems in urban and rural areas.

The devastating floods of the recent past are due to excessive rainfall in the GBM catchment area, and synchronization of peak flow of the Ganges and the *Brahmaputra-Jamuna* rivers. Effects of *El-Nino*, *La-Nina*, and synchronization of high tide are also considered to be the causes of the flood of 1998. Major investment on flood protection in the country began after the devastating flood of 1988.

3.5.3.2 Cyclones and Storm Surges

Cyclones can cause immense loss of life and destruction of property during pre-monsoon (April-May), and post-monsoon (October-November.) periods.

The Bay of Bengal is the breeding place of catastrophic cyclones. It is presumed that the Inter-Tropical Convergence Zone (ITCZ), which is situated near the equator, and where winds from the two hemispheres meet, plays a vital part in the formation of the tropical cyclones in this area.

Tropical cyclones derive their energy from warm moisture of the sea and to sustain this energy, sea surface temperature needs to be at least 26°C. While developing, tropical depression needs a continuing spiral inflow to supply momentum and water vapour to the spinning vortex (Crane 1988).

Cyclones in the Indo-Bangladesh-Pakistan sub-continent are classified according to their intensity of wind speeds. Tracks of cyclones in the Bay of Bengal show that normally cyclones at their initial stages move at a rate of 8-16 km/hour, and in their final stages at 24-32 km/hour, or even up to 48 km/hour. Table 3.5.3 depicts the nomenclature of cyclone.

Table 3.5.3 Nomenclature of Cyclone

Depression	winds up to 62 km/hour
Cyclonic storm	winds 63-87 km/hour
Severe cyclonic storm	winds 88-117 km/hour
Severe cyclonic storm of hurricane intensity	winds above 117 km/hour

Source: Reviewer's comments

Table 3.5.4 Major Cyclones that hit Bangladesh Coast

Date		Maximum Wind speed (km/hr)	Storm Surge height (Metre)
30 October	1960	211	4.6-6.1
30 May	1961	160	6.1-8.8
28 May	1963	203	4.2-5.2
11 May	1965	160	6.1-7.6
15 December	1965	211	4.6-6.1
1 November	1966	146	4.6-9.1
23 October	1970	163	3.0-4.9
12 November	1970	224	6.1-9.1
25 May	1985	154	3.0-4.9
29 November	1988	160	3.0-4.0
29 April	1991	225	6.0-7.5
2 May	1994	210	2.0-3.0
25 November	1995	140	2.0-3.0
19 May	1997	220	3.1-4.2

Source: Chowdhury 1987, 1991 and Bangladesh Meteorological Department 1988, BBS, 1998

Cyclones in the Bay of Bengal usually move north-west in the beginning, and then gradually re-curve to move northeastwards, but this pattern is not uniformly followed. The cyclones usually decay after crossing land, causing colossal losses to life and damages to property in the coastal region.

Heavy rains accompanying cyclones, and the tidal waves due to wind effects, called storm surges, cause most of the damages. Storm surge heights are directly related to cyclone intensity. Besides that, coastal configurations and bathymetry are also related to surge heights at the time of cyclone landfall. Astronomical tides in combination with storm surges lead to further amplification of surge heights, resulting in severe flooding.

An average of 1-3 severe to moderate cyclonic storms hit Bangladesh each year, with associated storm surges as much as 13 meters higher than normal in extreme cases, which can reach as far as 200 km inland (Milliman *et al.* 1989). Catastrophic cyclones, which originated in the Bay of Bengal and hit Bangladesh from 1960 to 1997, are presented in the Table 3.5.4 along with their dates, maximum wind speed, and heights of storm surge.

3.5.3.3 Droughts

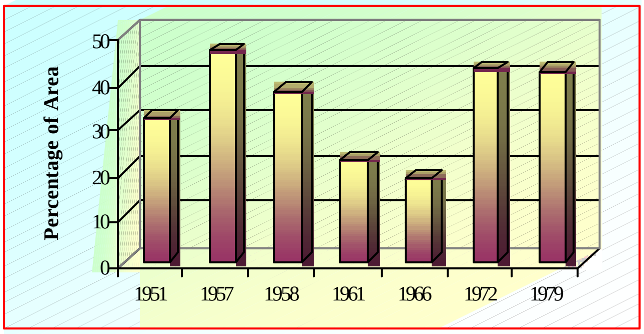
Drought is an abnormal condition where there is lack of sufficient water to meet the normal needs of agriculture, livestock, industry, or for human use. While generally associated with semi-arid or desert climates, drought can also occur in areas that normally enjoy adequate rainfall, and moisture levels (ADB, 1991). Drought is the result of insufficient or no rainfall for an extended period, and causes a considerable hydrological (water) imbalance. The ensuing water shortage leads to stream flow reduction, depletion of ground water and soil moisture, and hence, crop damage. In drought conditions, evaporation and transpiration exceed normal levels. If it continues for a prolonged period, a serious threat is posed to agricultural production. In agricultural context drought affects the rice production most. Due to drought severity, crop loss ranges between 20->60 per cent for T. Aman and other rice varieties (Iqbal, 2000). It is one of the most insidious causes of human misery.

Basically, there are three types of droughts:

- Permanent drought characterizes regions with the driest climate, having sparse vegetation that is adapted to aridity. Agriculture cannot be practised without irrigation.
- Seasonal drought occurs due to abnormal rainfall shortage in places where there are well-defined annual rainy and dry seasons.
- Unpredictable drought involves an abnormal rainfall failure, mostly in localized areas of humid and sub-humid climate.

Drought conditions due to deficiency in rainfall affect different parts of Bangladesh mostly during the pre-

Figure 3.5.3 Drought Affected Area



Source: BCAS Compilation

monsoon and post-monsoon periods. One study has shown (Figure 3.5.3) that from 1949 to 1979, drought conditions had never affected the entire country and total population in any drought year. The drought of 1979 was one of the severest in recent times. The percentage of drought-affected areas was 31.63 per cent in 1951, 46.54 per cent in 1957, 37.47 per cent in 1958, 22.39 per cent in 1961, 18.42 per cent in 1966, 42.48 per cent in 1972, and 42.04 per cent in 1979 (Chowdhury and Hussain 1981). During 1981 and 1982, drought affected the production of the monsoon crop only.

3.5.3.4 Abnormal Rainfall, Hailstorms, and Lightning

Monsoon depressions that form in the Bay of Bengal move landward, and cause monsoon rain to be spread widely throughout the country.

The mean annual rainfall in Bangladesh varies from about 1400 mm. in the western part of the country, to almost 5000 mm. in the northeast region. There are wide seasonal fluctuations, with about 90 per cent of the rainfall occurring during the four months of the monsoon period (June - September). Monsoon depressions that form in the Bay of Bengal move landward, and cause monsoon rain to be spread widely throughout the country. Based on the area of formation, structure, intensity, and frequency of the monsoon depressions, the total rainfall during the monsoon period can be predicted. In spite of an overall abundance of rainfall during monsoon, at times serious rainfall shortage leads to droughts. It is not unusual for regions in Bangladesh to experience inadequate rainfall during the monsoon, while little rain during the dry season (October-March) is quite common, too. A number of constraints are inherent in the monsoon rainfall, and climatic pattern. In addition, uncertainty in patterns of pre-monsoon showers, lightning, and hail cause a tremendous impact on human life, and agricultural production.

The month-to-month and year-to-year variations in the atmospheric parameters like rainfall, temperature, humidity, etc., cause substantial variations in crop yields. Therefore, in Bangladesh the patterns of life, and cultivation practices have traditionally been adapted to seasonal variability in climatic characteristics.

3.5.3.5 Nor'westers and Tornadoes

The two transitional periods between southwest and northeast monsoons over the Indian sub-continent are characterised by local severe storms. The transitional periods are usually referred to as pre-monsoon (March-May), and post-monsoon (October-November). It is the pre-monsoon period when most of the abnormal rainfall or drought conditions frequently occur in different parts of Bangladesh. Also there are locally severe seasonal storms, popularly known as Nor'westers *(Kalbaishakhi)*. Severe Nor'westers are generally associated with tornadoes. The tornado forms within the Nor'wester, and moves along the direction of the squall of the mother storm.

The frequency of Nor'westers usually reaches a maximum in April, whereas there are few in May, and minimum in March. Nor'westers and tornadoes are more frequent in the afternoon. Table 3.5.5 shows some of the devastating Nor'westers and Tornadoes that hit Bangladesh. Nor'westers may occur in late February due to early withdrawal of winter from

Table 3.5.5 Some of the Devastating Nor'westers and Tornadoes

14 April 1969	Demra (Dhaka)
17 April 1973	Manikganj (Dhaka)
10 April 1974	Faridpur
11 April 1974	Bogra
09 May 1976	Narayanganj
01 April 1977	Faridpur
26 April 1989	Saturia (Manikganj)

Source: SoE Study Team

Bangladesh, Bihar, West Bengal, Assam, and adjoining areas. The occasional occurrence of Nor'westers in early June is due to delay in the onset of the southwest monsoon over the region (Karmakar, 1989).

Wind-speeds in Nor'westers usually do not exceed 113-130 km/hr (70-80 miles/hr), though often their speeds exceed 162 km/hr (100 miles/hr). When the winds become whirling with funnel shaped cloud having speed at several hundred kilometers or miles per hour, then they are termed tornadoes. Nor'westers bring much needed pre-monsoon rain. They can also cause a lot of havoc and destruction. Tornadoes are suddenly formed and are extremely localized in nature and of brief duration. Thus, it is very difficult to locate them or forecast their occurrence with the present techniques available. However, high-resolution satellite pictures, suitable radar, and a network of densely spaced meteorological observatories could be useful for the prediction or warning of Nor'westers and tornadoes.

3.5.3.6 Earthquakes

The north and northeastern parts of Bangladesh are the most active seismic zones, and had experienced earthquakes of moderate to high intensity in the past. The great earthquake of 1897 had its epicentre in the Shillong Plateau of India, and caused widespread damage in adjacent areas of what was then known as Bengal. Two other major earthquakes that caused severe damage in areas adjacent to the epicentres were in 1885, known as the Bengal Earthquake, and in Srimangal in 1918. In addition, major earthquakes occurred in Bangladesh, and surrounding areas in the years 1833, 1897, 1906, 1918, 1923, 1926, 1927, 1930, 1934, 1939, 1941, 1943, 1947, 1950, 1951, 1954, 1957, 1962, 1965, and 1988 (Karmakar, 1989). Earthquakes with magnitudes between 7.0 and 8.7 on the Richter scale have been experienced in this country, but they are rare events.

3.5.3.7 Erosion

Erosion in Bangladesh is a regular and recurring phenomenon. Erosion of land surfaces, riverbanks, and coastal areas is already causing serious problems for the country. An increase in rainfall in summer is apprehended due to climate change, and this would in turn increase the surface erosion. Land erosion will intensify through current deforestation, and other land use practices (such as *Jhum* cultivation).

Riverbank erosion is a serious problem in Bangladesh. It is a process largely controlled by river dynamics. The disruption in the life of many local communities is almost a continuous process, due to riverbank erosion, and the changing course

River bank erosion

Table 3.5.6 Some Historical Changes of Physiography and River Morphology in Bangladesh

- The change of course of the Teesta from the Ganges to the Brahmaputra during the flood of 1787 (Vas 1911, Chowdhury 1959, Rashid 1977 and Pramanik and Gafoor 1981)
- Recurring floods in Rangpur, Bogra and Pabna districts between 1787 and 1830 accentuated the process of course changes of the Brahmaputra from the old Brahmaputra, which flowed past Mymensingh town and joined the Meghna at Bhairab Bazar, to the Jhenaidah, later developed into the Jamuna (Chowdhury 1959, Ahmad 1968 and Al-Husainy 1976)
- The gradual shifting of the courses of the Ganges from the Hooghly to the present course is controversial (Chowdhury 1959, 1964, Morgan and McIntire 1959 and Coleman 1969)
- The Ganges (Padma) flowed separately to the Bay of Bengal through Tetulia channel during Rennell's survey (1764 -1772). It has changed to its present course by joining the Meghna near Chandpur (Chowdhury 1959, Ahmad 1968 and Chowdhury 1979)
- The 1762 earthquake uplifted the Madhupur tract creating the Sylhet basin through subsidence compensatory to the elevation of the Madhupur tract (Fergusson 1863, Morgan and McIntire 1959). This is also controversial
- The earthquake of Assam in 1950 has caused a change in the Swatch of No Ground and other deep seated rift valleys in the Basin (Kibria 1970)

of rivers. During floods, riverbank erosion becomes very acute, and leads to loss of valuable land.

Of equal if not more concern is the coastal erosion. Globally, 70 per cent of the world's coastline has shown net erosion over the last few decades; less than 10 per cent has net degradation; and the remaining 20 per cent has remained relatively stable. Erosion in the coastal regions of Bangladesh is caused by a number of factors, such as high monsoon wind, waves, and currents, strong tidal actions, and storm surges (Ali, 2000).

3.5.4 IMPACT OF NATURAL DISASTERS

Natural disasters have a tremendous impact on the overall economy of the country. Apart from the instant impacts, natural disasters can also leave long-term impacts. Some significant historical changes induced by major disasters in Bangladesh and adjacent regions are presented in Table 3.5.6.

Almost every year due to natural disasters and climatic hazards, Bangladesh is subject to colossal loss of life and damage of property. All the national planning efforts for development are disrupted by these calamities that leave behind damaged infrastructure facilities, physical assets and land. The human suffering goes beyond description.

The impact of natural disasters not only varies with their type and magnitude, but also critically depends on institutional strength and response to disasters by different branches of the government, as well as community-based organizations. For example, the intensities of the 1991 and 1997 cyclones were of the same magnitude. In the 1991 cyclone, more than 13.7 million people were affected, approximately 138,882 people died, and 139,058 people were injured; and the total loss of livestock and poultry was about one million. On the other hand, the number of human deaths were only 134 from the cyclone in 1997, and 0.4 million people were affected. Loss minimization was only possible due to accurate and timely forecasting, adequate proper warning dissemination, social mobilization, proper coordination by the government, and other institutional backup.

The effects of the devastating flood of 1988 were enormous. According to the World Bank, 45 million people were affected - with 1600 deaths directly attributed to it, and another 735 deaths occurred subsequently as a result of diarrheal diseases. Damage to summer rice crops was estimated at about 1.6 million tons, and loss of physical and economic infrastructure was extensive. About 2,500 km of flood control embankments, 23,500 units of minor irrigation equipment, 10,000 km of local roads, a substantial proportion of national highways and railways,

Table 3.5.7 Damage to Rice Crops due to Drought

Year	Damage
1978	0.7 million tons of *Aman* rice due to rain deficit in August and September
1979	0.6 million tons of *Aus* rice, 0.3 million tons of *Aman* rice, and 0.4 million tons of *Boro* rice crops
1981	0.12 million tons of *Aus*, and 1.3 million tons of *Aman* rice
1982	0.4 million tons of *Aman* rice due to rain deficit in October

Source: Hamid, 1991

several hundred bridges, over 19,000 educational institutes, 1,468 health structures, and 7.2 million housing units were affected by the flood.

In the 1998 flood, 918 people lost their lives, and 242,500 people were sick. Standing crops of 32,31,721 acres were fully or partially damaged. The losses of domestic animals such as cattle, goats, and poultry were 3928, 7041, and 313058, respectively (DMB, 1998). According to the Disaster Management Bureau, the loss of standing crops, including paddy, was estimated at Taka 33.05 billion. BIDS studies revealed that the loss to the agriculture sector was Taka 50.52 billion, of which the losses from rice and other crops were Taka 43.77 billion; and Taka 6.75 billion for fisheries, livestock, etc. The discrepancy between the estimates is mainly due to estimation methodology, and coverage.

Drought is a spatially limited phenomenon affecting the northwestern part of the country. Loss of crop yield is the major impact of drought, and affects the economy of Bangladesh badly. Damage to crops due to drought for a few selected years is presented in Table 3.5.7.

Resources worth an estimated US$25 billion have been destroyed by natural calamities in Bangladesh from 1947 to 1991 (Rahman, 1989).

3.5.4.1 Climate Change Impacts

There is no denying the fact now that the climate system is changing across the globe. This change is attributed to the net effect of individual and interactive effects of global changes in atmospheric composition, land use, biological diversity, and climate. The present concerns regarding the greenhouse effect, and depletion of the ozone layer causing global warming will definitely further aggravate the natural disaster situation in the future.

Bangladesh is one of those poor countries which may face the irony of adapting to and mitigating the consequences of man-made global warming and climate change, which are largely not of their own making; while they have little human, societal, technological, or financial capability for such adaptation and mitigation (Huq, *et al.*, 1999). The possible sea level rise will make an impact on the country as a whole by inundating one-tenth of the total land area along the coastal belt. If this happens, about ten million people living in the coastal areas of Bangladesh will be forced to migrate further inland. This will put a tremendous population pressure on the mainland.

SLR would inundate the low-lying areas of the country, displacing human habitat and shrinking agricultural and forestlands. It is likely to inundate wetlands and lowlands, accelerate coastal erosion, increase the risk of flood disasters, create drainage and irrigation problems; and increase salt water intrusion into ground water, rivers, agricultural, and coastal forestlands. This may in turn cause damage to port facilities and coastal embankments/ structures, destroy quality farm lands, disrupt mangroves, fisheries and bird habitats, result in loss of recreational beaches, and affect cyclone and storm surge protection measures in the coastal areas (Ali, 2000).

Some of the main impacts of global warming and climate change on Bangladesh, which will be manifested as natural disasters are discussed in the following section.

3.5.4.2 Agriculture

Many natural ecosystems are likely to change as a consequence of climate change. Agriculture is a major sector of the country's economy. There is no denying the fact now that the climate pattern is changing across the globe. This change is attributed to the net effect of individual and interactive effects of changes in atmospheric composition, land use, biological diversity, and climate. Many natural ecosystems are also likely to change as a consequence of climate change. Since climate factors strongly interact to affect crop yields, it is likely that climate change will affect crop production. The question remains as to how much, where, and whether the effect would be positive or negative (Huq *et al.*, 1999).

It is believed that climate change will increase the disparities in cereal production between developed and developing countries. The production in the developed world would benefit from climate change, while that in developing nations would decline (Walker and Steffen, 1997). Farm-level adaptation would be inadequate in reducing the disparities. It is also reported that even an extensive farm-level adaptation in the agricultural sector would not entirely prevent negative effects. In general, the tropical and subtropical countries would be more vulnerable to the potential impacts of global warming through effects on crops, soils, insects, weeds, and diseases. On the other hand, elevated carbon-dioxide (CO_2) concentrations will have beneficial effects on crop production. Beneficial effect will however be less when there is rise in temperature.

Over thirty per cent of the net available cultivable land of Bangladesh is located in the coastal areas. But it has been observed that all the coastal cultivable lands are not being utilized for crop production, mostly due to soil salinity. Increased soil salinity limits growth of standing crops and affects overall crop production, and also makes the soil unsuitable for many potential crops. Soil salinity has been considered a major constraint to food grain production in coastal areas of the country (Huq, *et al.*, 1999).

It is believed that the impact of climate on physical systems, in combination with the effect of sea level rise, would cause a net increase in salinity in the already affected soils of the coastal regions. A GCM modeling approach has indicated that under changed climate conditions the index of aridity will increase during winter (Huq, *et al.*, 1999). As a result, an increased rate of desiccation in topsoil leading to higher rates of capillary action would be observed. Hence, the salinity problem would be accentuated by the impacts of climate change and sea level rise. The extent of increase in soil salinity in a particular area within the coastal zone would determine the extent of crop loss.

Less rainfall during winter due to climate change will lead to a decrease in moisture content of the topsoil, as well as less recharging of the ground water. Higher evaporation would cause worse drought-like conditions. In summer, increased precipitation will worsen the flood situation, which will have a negative effect on agricultural production. Although the increase in CO_2 will have a positive effect on food production, the other negative impacts are likely to dominate.

Studies of 10-day average behaviour of atmospheric parameters, crop phonology, and yields on a systematic basis on a localized scale could depict climatic patterns, and their effect on agricultural production.

Other factors needing study are:

- Timing of onset and withdrawal of the monsoon in a particular year, and its impact on agricultural production.
- Number of nor'westers and tornadoes during pre-monsoon periods, and the effect on the crop phonology, particularly, in the *Aus* crop-growing season.
- Adjustment of cropping patterns based on environmental and climatic variability, and an agro-ecological zoning approach.

3.5.4.3 Salinity Intrusion

Over thirty per cent of the net available cultivable land of Bangladesh is located in the coastal areas. But it has been observed that all the coastal cultivable lands are not being utilized for crop production, mostly due to soil salinity. Increased soil salinity limits growth of standing crops and affects overall crop production, and also makes the soil unsuitable for many potential crops. Soil salinity has been considered a major constraint to food grain production in coastal areas of the country (Huq, *et al.*, 1999).

It is believed that the impact of climate on physical systems, in combination with the effect of sea level rise, would cause a net increase in salinity in the already affected soils of the coastal regions. The apprehended sea level rise would bring more of the coastal area under inundation. Coastal waters are likely to become more saline, and soil salinity will increase. In addition, even groundwater aquifers will face salinity intrusion. Winter crops in the coastal area that depend on groundwater for irrigation would be negatively affected. Agriculture, forestry, and fisheries might face severe adverse effects due to increased water and soil salinity. The extent of increase in soil salinity in a particular area within the coastal zone would determine the extent of crop loss.

Reduced water flow from upland during winters will accelerate the inland saline water intrusion. A GCM modeling approach has indicated that under changed climate conditions the index of aridity will increase during winter (Huq, *et al.*, 1999). As a result, an increased rate of desiccation in topsoil leading to higher rates of capillary action would be observed.

3.5.4.4 Forests

The forests of Bangladesh are under tremendous threat due to a number of anthropogenic and natural reasons. Various activities like increased consumption of forest products, human encroachment, deforestation and deliberate thinning, combined with natural disasters, and the consequences of low flows in distributaries of the Ganges due to water withdrawn at the Farakka barrage in India during lean season, are already causing serious problems for the regeneration and growth of different forest species. In addition apprehended climate change and sea level rise together would cause adverse impacts on the remainder of the forests.

Since the productivity and well being of forest species depend on a number of climate parameters, including temperature and precipitation, there are reasons to believe that the forest ecosystems of Bangladesh would also be affected significantly due to impacts of climate change and sea level rise (Huq, et al., 1999). More frequent and prolonged floods will affect the forest ecosystems. Increased evaporation during winter will cause moisture stress in drier areas.

The only mangrove forest in the country, the Sundarbans, will mostly be affected. The rise in sea level and availability of less fresh water, particularly during winter when rainfall will be less, will cause inland intrusion of saline water. As a result, many mangrove species intolerant of increased salinity will be threatened. In addition, highly dense human settlements just outside the mangrove areas will restrict the expansion of the mangrove towards less saline areas. The shrinking of the mangrove areas will have an overall adverse effect on the country's economy and ecosystem (Ali, 2000). Many industries that depend on raw materials from the Sunderbans will have to be closed down, creating large unemployment. In addition, the survival of a wide range of biodiversity, including mammals, birds, amphibians, reptiles, crustaceans, and above all, the Royal Bengal Tiger will be threatened. The coastal length covered by the mangrove forest will be exposed to cyclones, storm surges, and erosion.

3.5.4.5 Fisheries

According to the World Bank (1989), Bangladesh is the world leader in freshwater fish production per unit area, with 4,016 kg/km2 of water bodies and a per capita fish production of about 5.5 kg In the inland open-water system of Bangladesh there exist 260 species of finfish, belonging to 55 families (Rahman, 1989); about 63 species of palaemonid and penaeid prawn; and several species of crab, belonging to the family Potamonidae, also occur. There are 31 species of turtles and tortoises found, of which 24 live in freshwater (Huq, *et al*, 1999).

From time immemorial fish and fisheries have played a very significant role in the nutrition, culture, and economy of Bangladesh. According to a local adage that reflects the role of fish in the food habit, diet, and nutrition of the people, '*Mache-Bhate Bangali'*, i.e., a Bengali body is made up of fish and rice. Currently, about 80 per cent of the daily animal protein intake in the diet of the people comes from fish. It is estimated that the fisheries sector contributes about 3.5 per cent of the GDP of Bangladesh. Within the Agriculture sector, the fisheries sector accounted for 6.9 per cent of the gross value added. Fisheries provide full time employment to an estimated 2.0 million people.

There is no study in Bangladesh to assess climate change-induced vulnerability of the fisheries sub-sector as yet, particularly on the physiology and ecology of indigenous species of finfish or prawn. Without such studies, it is very difficult to state or predict the likely effects of climate change on different fish or prawn populations, and the fisheries based on them (Huq, *et al.*, 1999).

However, it is predicted that SLR will cause a reduction in fish production by reducing the freshwater fishing area. Decreased rainfall and river runoff, and increased evaporation during winter will also reduce the winter fishing area. Pond culture in the coastal area will be affected by intrusion of salt water into the ponds, unless embankments are made around them. Shrimp farming in the coastal area is a lucrative business, but increase in salinity is likely to jeopardize it as well (Ali, 2000).

3.5.4.6 Ecosystem and Biodiversity

Climate change, with the concomitant increase in temperature and sea level rise, is a real threat to the whole ecosystem and biodiversity of the country, especially the Sundarbans. The Sundarbans might be completely inundated by a one-meter rise in sea level. The area may shrink and many flora and fauna species may face extinction. The possible water stress during winter, and excess water during summer will also have negative impacts on ecosystems and bio-diversity. The ecosystem of the only coral island, the Narikel Zinzira, will also be affected.

3.5.5 RESPONSES

The modern concept is that there exists a whole process of risk minimization activities that have been identified to address crucial elements of disaster management, which include its prevention or mitigation, preparedness, response, recovery, and development. Based on this realization, and in order to design the institutional and functional arrangements for disaster management, the Government of Bangladesh (GoB) has taken initiatives to frame a disaster management policy. This policy would take care of all aspects, such as accurate definition of disaster threats, organizational arrangements required to prepare responses to and recover from disaster events, assessment of resources available to deal with threats, and recognition of ways for the national disaster management policy to interlock with other national development policies. Along with the policy, a well planned, carefully designed, and action-oriented detailed plan for disaster management is also in the process of preparation. This is of paramount importance to Bangladesh both at national and local levels, for a coordinated and effective effort to cope with the disaster situation. Although climate change is a long-term process, the implications for Bangladesh are vital for further policy planning.

There are various Government and community-based organizations working in the field of disaster management and mitigation. The focal point of the Government of Bangladesh for disaster management is the Disaster Management Bureau (DMB), a specialized organization under the Ministry of Disaster Management and Relief. The Bangladesh Meteorological Department (BMD) is responsible for forecasting natural disasters, particularly cyclones, droughts, storms, etc. The Bangladesh Space and Remote Sensing Organization (SPARRSO) is responsible for providing satellite images to BMD, particularly as an aid to make the daily weather forecast. The Flood Forecasting and Warning Centre (FFWC) of the Bangladesh Water Development Board forecasts flood, with help from the Surface

Table 3.5.8 Summary Outline of the Key Disaster Management Bodies and their Main Function

National Disaster Management Council (NDMC)
- Establishing policies and providing overall direction for all aspects of disaster management

Defining priorities and criteria for the allocation of resources

National Disaster Management Advisory Committee (NDMAC)
- Providing advice to the NDMC, and directly to MDMR and DMB, on specific technical, management, and socio-economic aspects of disaster management, including vulnerability analysis and disaster-development links

Inter-Ministerial Disaster Management Co-ordination Committee (IMDMCC)
- Implementation of NDMC policies and decisions on an inter-ministerial basis
- Coordination of action by all government agencies and overall direction of the activities of the DMB
- Responsibility for major operational decisions during an emergency
- Decisions on allocations of relief resources though its sub-committee, the Executive Emergency Relief Management Committee

Ministry of Disaster Management and Relief (MDMR)
- Ministerial responsibility for disaster management, including the convening of the IMDMCC
- Assuring the establishment, resource management (budget), and satisfactory functioning of the DMB
- Supervision of the DRR

Disaster Management Bureau (DMB) – a part of MDMR
- Provision of expert staff services to the NDMC and IMDMCC
- Promotion of disaster prevention/mitigation and preparedness within all agencies and levels of government
- Providing guidelines, organizing training, and promoting the preparation of disaster action plans
- Providing expert services to the national Emergency Operations Centre (control room) located at MDMR at time of disaster

DIRECTORATE OF RELIEF AND REHABILITATION (DRR)
- As at present with respect to Vulnerable Group (VGD); Food for Works (FFW); Gratuitous Relief (GR) and Test Relief (TR); the management and delivery of relief supplies, and the provision of related services

DRROS AND PIOS

AS AT PRESENT UNDER THE GENERAL DIRECTION OF DRR AND THE OPERATIONAL SUPERVISION OF DC AND TNO. INCREASED ATTENTION BY DRROS IN PARTICULAR TO DISASTER PREPAREDNESS UNDER THE GUIDANCE OF THE DMB (THIS COMPENSATING FOR SOME REDUCTION IN FFW WORK)

Source: DMB, 1997

Water Modelling Centre (SWMC) and EGIS. The Department of Agriculture Extension provides different services to mitigate agricultural losses after disasters. Table 3.5.8 depicts the summary outline of the key disaster management bodies and their main function.

As the lead agency within the UN system, UNDP had a significant role in supporting the International Decade for Natural Disaster Reduction (IDNDR). The fifth UNDP Country program highlights the acute vulnerability of Bangladesh to natural disasters, and in particular the devastating impacts of disasters on the poor. The UNICEF regular program also includes many activities that contribute towards preparedness and risk reduction at the community level. UNICEF has been extensively involved in the process of preparing the training strategy that is to be implemented by the Disaster Management Bureau. The British Government (DFID) continuously supports various disaster management programs in Bangladesh. USAID-funded Flood Action Plan studies are concerned with flood response and flood proofing (FAP:14 and FAP:23), and Geographical Information Systems (FAP:19). NGOs are major contributors to relief efforts following disasters, and a number of NGOs are now developing programs for disaster preparedness and mitigation (DMB, 1998).

Bangladesh has set a pioneer example in disaster management during the cyclones of 1991 and 1997. The role of the government and non-government organizations during the pre and post-disaster periods helped shrink the number of deaths and damage. The initiatives were appreciated and recognized worldwide.

3.5.5.1 Structural Measures

The Government of Bangladesh has commenced both structural and non-structural measures for flood mitigation. With the assistance of the World Bank, a 'Flood Action Plan' with 26 components was undertaken immediately after the devastating flood of 1988.

Previously, disaster mitigation tended to be viewed as structural mitigation measures only. This concept has changed rapidly over the past few years. Structural measures for flood control like storage reservoirs, embankments of levees, channel improvements, and floodway bypasses are expensive and time consuming. The GoB gives equal importance at present to both structural and non-structural mitigation measures. It is strongly believed by the GoB that non-structural mitigation measures need to be complemented by structural mitigation measures.

As a part of structural mitigation measures the GoB with its own and external resources has so far constructed 1,841 cyclone shelters, and 200 flood shelters for evacuation of people threatened by cyclone or flood. In addition, coastal embankments about 3,931 km long have been made to protect coastal land from inundation by tidal waves and storm surges, and drainage channels of total length 4,774 km have been constructed.

A very effective cyclone warning system has been established in the country. Bangladesh Meteorological Department (BMD) has a network of four radar stations at Dhaka, Rangpur, Cox's Bazar, and Khepupara, as well as satellite ground receiving stations to receive imageries from NOAA, GMS, and InSAT to monitor cyclones as soon as they form in the Bay of Bengal. An effective communication system also exists in BMD for exchanging information both at national and international levels. SPARRSO can track cyclones every hour through the reception of imagery from GMS and NOAA satellites.

Following the devastating cyclone of 1970, the Bangladesh Red Crescent Society started the Cyclone Preparedness program (CPP) in 1972. In June 1973, the GoB approved and accepted the new program of the Red Crescent Society, and since then the Ministry of Disaster Management and Relief and the Red Crescent Society have started to operate the CPP jointly (Mohammed, 1991). CPP has a volunteer force of 27,330 trained men, and 5,466 women to disseminate cyclone information, and carry out rescue operations if a cyclone strikes the coast. Bangladesh Radio and Television at frequent intervals transmit warning messages for the events. After the devastating cyclone of 1991, the Government of Bangladesh has also established a number of multipurpose cyclone centers in the coastal areas (DMB, 1998).

The Government of Bangladesh has undertaken a Green Belt Project in the coastal areas. This is a participatory reforestation program aimed at reducing the adverse impacts of natural disasters, particularly cyclones and storm surges in the coastal regions.

3.5.5.2 Non-structural

For non-structural mitigation the GoB has emphasized on legislation, training and public awareness, institution building, and warning systems. The Disaster Management Legislation (Act) has already been designed in draft form, and is at present under the government's consideration for approval. The Act establishes a mechanism for working through State and Local Governments, and public corporations that clarifies where responsibilities lie, and provides for the formulation of a disaster management policy. A plan relating to preparedness and public awareness is an important component of the project, "Support to Comprehensive Disaster Management". Up to December 2000, the Disaster Management Bureau has conducted a total of 453 courses, workshops and seminars under the project, and about 23,000 participants have attended the programs. They include Government and Semi-Government officials of different levels, public representatives, NGO officials, local leaders, representatives of mass media, teachers, Imams (religious leaders) of mosques, and fishermen. Besides this, DMB has supported holding of disaster management training workshops in other institutes. As part of the public-awareness activities, booklets containing public information about cyclone, floods, etc., and calendars and posters with disaster information have been regularly printed and distributed at the grass-roots levels.

To raise awareness among students on various hazards and disaster management as per GoB policy, a chapter on disaster management has been included in the educational curricula from class V to XII. The GoB has also made to hold a compulsory session of at least 2 hours on disaster management in the curricula of all types of Training Institutes that train officials and non-officials.

The GoB has prioritized improving the capability of the concerned government organizations to issue early warnings, such as the Storm Warning Centre (SWC) of BMD, and Flood Forecasting and Warning Centre (FFWC) of Bangladesh Water Development Board (BWDB). As a result, there are microwave links between SWC in Dhaka to radar stations at Rangpur, Cox's Bazar and Khepupara. Under a bilateral agreement between GoB and the Government of Japan to improve warning capability, the replacement of radar in Dhaka, establishment of a new radar at Rangpur, and commissioning of a satellite ground receiving station at SWC (Dhaka) have been completed. The GoB has taken up a program to establish four seismic observatories at Chittagong (renovated the old one), Sylhet, Rangpur and Dhaka and its implementation is progressing well.

As part of the non-structural measures to cope with cyclones, the GoB is committed to improve its cyclone warning and dissemination system in all parts of the country. As part of an ongoing project support to comprehensive disaster management, initiatives have already been undertaken to review the existing warning system, and evolve simplified, easily understandable cyclone warning signals and messages that are scientific and realistic. Progress has been made to design a simple warning procedure, which is under government consideration for adaptation.

The Department of Forest, under the Ministry of Environment and Forest has undertaken a project titled "The Coastal Greenbelt Project" for the period 1995-96 to 2001-2002. The project will cover 12 coastal districts of Bangladesh such as Barisal, Jhalkati, Patuakhali, Borguna, Bhola, Bagerhat, Pirojpur, Lakshmipur, Noakhali, Feni, Chittagong, and Cox's Bazar. The main objectives of the project are to:

- Prevent loss of life and damage to property by cyclone, storms, and associated tidal surges;
- Protect and improve the coastal environment through increased vegetative cover in the project areas;
- Help poverty alleviation of the local rural population by generating supplementary income opportunities by augmenting tree cover in the coastal region;
- Contribute to the government objectives for increasing the country's forest resources;
- Help increase the stability of the coastal embankments;
- Help establish cottage industries based on forest products to be grown in plantation;
- Find multiple uses for land along the roadsides, railways, feeder roads, and embankments, rather than keeping the land fallow;
- Enrich homesteads of the coastal region with trees that produce timber, fuel-wood, and fruits; and

- Impart training to youth and elderly regarding raising nurseries and growing trees, and create awareness among people with regard to forest management that leads to income generation, and self-reliance.

The GoB and DANIDA have undertaken a project, "Consolidation and Strengthening of Flood Forecasting and Warning Services 2000-2004". The main objectives of the project are the development of flood forecast and inundation modeling for all flood-prone areas of the country; dissemination of flood forecast information and warning messages to relevant governmental institutions at the national, district, *thana*, and union levels, and to the media, NGOs and other relief organizations, and to local communities. A sustainable FFWC will be established at the end of the project.

Accurate and timely storm surge prediction is crucial for effective disaster management, and saving lives and property in the countries bordering the Bay of Bengal. This is particularly true for Bangladesh, which is the worst victim of tropical cyclones and associated storm surges. Accurate storm surge prediction is only possible by appropriate storm surge models, and through the involvement of a comprehensive storm surge prediction procedure. In view of this, a regional effort is going on in this part of the world under the sponsorship of IOC, WHO, UNESCO, and IHP. Bangladesh is closely associated with this initiative, and there has been some notable progress in giving a shape to the concept under the project titled, "Storm Surge Disaster Reduction for the Northern Part of the Indian Ocean".

For flood forecasting, a network of hydrological stations connected with telemetering gauges or by telecommunication to the Water Development Board has been established having teleprinter links with the forecasting centers. Historical records of data have been analyzed to prepare forecasting procedures. Flood forecasting in 1998 played an effective role in flood mitigation.

At present, the Disaster Management Bureau is implementing a project named, "Support to Comprehensive Disaster Management", with the financial assistance from GoB, UNDP, and UNICEF. Three basic aspects are the main focus of the project - awareness build-up at different levels of the people, enhancement of coping capabilities of common people against disaster through establishing Disaster Action Plans (DAPs), and institutionalization of the national disaster management system. An elaborate procedure has been strictly followed for the preparation of Disaster Action Plans.

The main propose of DAPs is to mobilize local communities in the most disaster prone areas to prepare and protect themselves, and to increase their own capacities to cope with and recover from disaster, without waiting for outside assistance. Initially a draft model action plan was prepared, on the basis of inputs received from 6 Zonal Disaster Preparedness Specialists (ZDPS), working at high-risk upazillas located in both cyclone and flood-prone areas of the country. While preparing the draft model the full participation of the local people and communities was ensured. The draft model was presented at a workshop in July 1998, in which a number of eminent experts of the country working on disaster management activities participated. On the basis of the expert's suggestions and recommendations, the draft model is being finalized.

Efforts are in progress for the preparation of local Disaster Action Plans for each of the 29 most disaster-prone districts, 84 upazillas, 776 unions, and 24 pourashavas. As of December 2000, the preparation of more than 600 Disaster Action Plans at union levels has been completed. The DAP basically contains three parts. The first part deals with the Union profile in language, as well as simple sketch of the hazard and vulnerability maps. The second part of the DAP contains formation of the Disaster Management Committee (DMC), and its responsibilities. The final part has all the details of the action plan, including various volunteer groups (VG) and sub-committees for the responsibilities, such as warning dissemination and precautionary response, arrangements for evacuation, arrangements for rescue and casualty care, arrangements for burial, control room, restoration of essential services, security and protection of property, damage and needs assessment, co-ordination of assistance, management of relief supplies, support to rehabilitations, logistics, training and awareness build-up, and testing and updating the plan.

The role of social capital during natural calamities cannot be ignored. Social capital is the network of adhoc organizations created during emergency situations to respond to the needs of suffering people. It has been observed during the devastating floods of 1988 and 1998, and during the cyclone of 1991 that spontaneous, value-driven relatives, organizations, and networks rendered valuable help and assistance to the victims. In the typologies of mitigation and coping mechanisms, social capital has been identified as an important resource. BIDS undertook a study on its role after the flood of 1998.

The Disaster Management Bureau has already published a guide-book comprising Standing Orders for disaster management, which was approved by the Inter-Ministerial Disaster

Table 3.5.9 Options to Mitigate Impacts of Natural Disasters in Future

Options	Out Comes	Actors
	Flood	
• Strengthening Capabilities for Flood forecasting and monitoring • Structural mitigation programs	• Real time forecast and timely possible evacuation • Mitigation of losses and sufferings • Less inundation due to embankments along the river banks	• FFWC (Flood Forecasting and Warning Centre) under Ministry of Water Resources • Surface Water Modelling Centre (SWMC) • EGIS, AFD • NGOs • Electronic media (i.e. radio, television) • MDMR (Ministry of Disaster Management and Relief) i.e. EOC, DMB and DRR
	Cyclone and Storm surge	
• Strengthening of warning and forecasting centre • Shelter construction • Awareness building • Institutional arrangements up to grassroot level	• Reliable and timely forecast • Large-scale evacuation of vulnerable people • Spontaneous response to warning • Well coordination prior to and immediately after disaster	• BMD (Bangladesh Meteorological Department) • Electronic media (i.e. radio, television) • MDMR (Ministry of Disaster Management and Relief) i.e. CPP, DMB, EOC, DRR • LGED (Local Government and Engineering Department), NGOs, Donors • MOHFW (Ministry of Health, Family Planning and Welfare), AFD • DMCs (Disaster Management Centres) at national and grass-root levels • Social Organizations
	Drought	
• Strengthening of National Forecasting Centre • Afforestation Programs • Re-excavation of local canals and ponds • Conservation of wetlands	• Long-range forecast for possible drought condition • Help availability of moisture in the atmosp-here for precipitation and removal of dryness • Storage of water for agriculture and other purposes during drought period	• BMD (Bangladesh Meteorological Department) • MOEF (Ministry of Environment and Forest), DoF (Department of Forest) • MOWR (Ministry of Water Resources), Local Government and Engineering Department (LGED) • NGOs, Donors
	Tornado	
• Improvement of observation capabilities of national meteorological service • Strengthening institutional arrangements for preparedness	• Upper air information and radar echoes leading to possible area identification • Public awareness building • Prompt rescue and relief operation with better coordination	• BMD (Bangladesh meteorological Department), SWC (Storm Warning Centre) • MDMR (Ministry of Disaster Management and Relief i.e. DMB, EDC, DRR • LGED (Local Government and Engineering Department) • MoHFP (Ministry of Health and Family Planning), AFD • NGOs
	Earthquake	
• Building code (1993) compliance • Requisite number of seismic observatories • Updating the inventory of equipment to be used for rescue after earthquake • Contingency plan to cope with earthquake for each earthquake prone area • Massive awareness building program and drill	• Reduction of building vulnerability to tremor • Systematic and accurate seismic observations for future guidance and planning • Efficient and quick rescue operation to minimize casualties and after shock • Better coordination for after shock operation to lessen human sufferings • Less confusion, casualties and injuries	• BMD, GSB • AFD • MDMR (DMB, EOC, DRR) • MoHA (CDdFB) • DAs, MC • MoHFW • NGOs, Donors • Social Organizations

Source: SoE Study Team

Management Coordination Committee (IMDMCC). The orders provided in the guide-book replace the standing orders for the flood published in 1984, and for the cyclone in 1985. Though these orders are specially made for cyclones and floods, they can be used for any type of disaster. While preparing the guide-book existing orders and responsibilities of relevant ministries, agencies, armed forces, administration units at Zilla, Upazilla, and Union levels, and disaster management committees were considered, and taken into account. This book emphasizes the coordination and cooperation between different NGOs, voluntary organizations, and relevant Government and non-government institutions (DMB, 1997).

3.5.6 SUGGESTED OPTIONS AS FUTURE MEASURES

Brief descriptions of future needs, along with potential local stakeholders responsible to undertake the measures are presented in Table 3.5.9.

3.5.7 CONCLUSION

Pre-disaster

The mechanisms to sustain institutional networking should be enhanced, and funds to sustain such programs need to be ensured. The sources of such funds can be from the donors, or can be collected from tax imposed for the sales and purchase of lands, revenue collected from auctions from *haat*, *bazaars*, and *jalmahals*, and also by the revival of the 5 per cent ADP reserved for disaster management fund. Door-to-door awareness campaigns can enhance the capacity building activities of communities. Proper pre-disaster preparedness programs should be further enhanced to empower the community on the matter. A mechanism should be in place to repair and maintain cyclone shelters regularly, so that during the disasters people can use them right away. There is lack in the communication system from the grassroots level up to the ministerial level, which should be filled through a proper system. The coordinated efforts of government and non-government agencies are essential for every type of disaster mitigation. DMB has already submitted a DM Legislation and Plan to the government, which should be approved, and properly implemented. Anticipatory research on forecasting natural disasters specific to Bangladesh should be encouraged. The National Building Code 1993, and micro zoning should be enforced in the urban development system to reduce fatal impacts of earthquakes. Re-excavations of the water bodies in rural areas are essential. Continuous drill practices, and exercises on mock disaster management will help volunteers be prepared for any immediate action.

Post Disaster

Capacity-building activities of various institutions and agencies for implementation of relief and rehabilitation programs should be strengthened. The capacity building for grassroots and national level monitoring needs to be enhanced. Evaluations should be done through postmortem analysis of disaster management after every disaster, which will act as a learning guide for future. Case studies on major man-made disasters should be taken up, and put on record for future guidance towards avoiding such events. Continuous research on modern innovative coping and mitigation measures to reduce the devastating impacts of all kinds of natural disasters should be encouraged.

List of some severe Natural Disasters affecting Bangladesh are presented in the following Annexure, which depicts the time, magnitude of damages and other impacts of various types of natural disasters on human life.

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Annexure

List of Some Severe Natural Disasters Affecting Bangladesh

Types of Disaster	Subset of Disaster	Year	Month	Day	Persons Killed	Persons Injured	Home-less	Affected	Total Affected	Damage in US$('000s)
Wind storm	Cyclone	1970	11	12	300000	n.a.	n.a.	3648000	400000	86400
Wind storm	Cyclone	1971	5	8	163	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Tornado	1972	4	2	200	n.a.	n.a.	25000	25000	n.a.
Flood	Flood	1972	6	25	50	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1973	3	n.a.	427	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1973	4	9	700	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1973	4	12	200	15000	10000	25000	50000	n.a.
Flood	Flood	1973	8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Cyclone	1973	12	9	1000	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1974	7	n.a.	28700	n.a.	2000000	36000000	38000000	579200
Wind storm	Cyclone	1974	8	15	2500	n.a.	n.a.	n.a.	n.a.	n.a.
Drought	Drought	1974	10	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Cyclon	1974	11	28	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1974	3	n.a.	300	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Tornado	1976	4	10	46	200	n.a.	n.a.	200	n.a.
Wind storm	Tornado	1976	5	9	1	n.a.	n.a.	n.a.	n.a.	201
Flood	Flood	1976	6	15	103	n.a.	n.a.	4000000	4000000	n.a.
Wind storm	Storm	1977	4	1	600	n.a.	n.a.	10000	10000	50000
Wind storm	Cyclone	1977	4	24	13	100	n.a.	n.a.	100	n.a.
Flood	Flood	1977	9	n.a.	5	n.a.	n.a.	200000	200000	n.a.
Flood	Flood	1977	10	6	21	500	n.a.	n.a.	500	n.a.
Flood	Flood	1977	10	13	8	n.a.	n.a.	13650	13650	n.a.
Wind storm	Storm	1978	4	9	1000	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1978	5	5	30	100	n.a.	n.a.	100	n.a.
Flood	Flood	1978	8	n.a.	17	n.a.	n.a.	400000	400000	n.a.
Wind storm	Cyclone	1979	5	2	3	150	n.a.	n.a.	150	n.a.
Drought	Drought	1979	6	n.a.	18	n.a.	n.a.	2000	2000	n.a.
Wind storm	Cyclone	1979	8	17	50	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Cyclone	1980	4	n.a.	11	50	n.a.	1000	1050	n.a.
Flood	Flood	1980	8	n.a.	655	n.a.	n.a.	10000000	10000000	150000
Flood	Flood	1980	9	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Tornado	1981	4	15	70	12000	n.a.	n.a.	12000	n.a.
Wind storm	Cyclone	1981	3	6	15	n.a.	25000	n.a.	25000	n.a.
Wind storm	Cyclone	1981	12	10	1000	n.a.	n.a.	2000000	2000000	n.a.

Types of Disaster	Subset of Disaster	Year	Month	Day	Persons Killed	Persons Injured	Homeless	Affected	Total Affected	Damage in US$('000s)
Flood	Flood	1982	9	7	0	n.a.	25000	283000	308000	n.a.
Wind storm	Cyclone	1983	3	21	6	150	n.a.	n.a.	150	n.a.
Flood	Flood	1983	4	n.a.	78	n.a.	n.a.	60000	60000	n.a.
Wind storm	Tornado	1983	4	26	12	200	n.a.	n.a.	200	n.a.
Drought	Drought	1983	7	5	n.a.	n.a.	n.a.	20000000	20000000	n.a.
Flood	Flood	1983	7	n.a.	12	n.a.	100000	4000000	4100000	n.a.
Flood	Flood	1983	8	n.a.	41	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1983	9	n.a.	114	n.a.	n.a.	3000000	3000000	n.a.
Wind storm	Cyclone	1983	10	15	600	n.a.	n.a.	5000	5000	n.a.
Wind storm	Cyclone	1983	11	13	67	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1984	5	n.a.	1200	n.a.	n.a.	30000000	30000000	n.a.
Flood	Flood	1984	6	25	0	n.a.	n.a.	n.a.	n.a.	n.a.
Earth-quake	Earthquake	1984	12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1985	3	28	50	n.a.	n.a.	18000	18000	n.a.
Wind storm	Cyclone	1985	5	25	10000	n.a.	510000	1300000	1810000	n.a.
Flood	Flood	1985	6	4	300	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Cyclone	1985	7	5	27	n.a.	n.a.	400000	400000	n.a.
Wind storm	Storm	1985	10	16	71	300	n.a.	1000	1300	n.a.
Extreme tempera-ture	Cold wave	1985	12	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1986	3	n.a.	19	n.a.	10000	n.a.	10000	n.a.
Wind storm	Storm	1986	4	4	100	3000	10000	n.a.	13000	n.a.
Flood	Flood	1986	8	2	4	n.a.	n.a.	100000	100000	n.a.
Flood	Flood	1986	8	7	26	n.a.	60000	n.a.	60000	n.a.
Wind storm	Tropical storm	1986	9	26	40	n.a.	100000	2600000	2700000	n.a.
Wind storm	Cyclone	1986	11	9	25	100	n.a.	n.a.	100	n.a.
Wind storm	Cyclone	1987	6	4	12	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1987	6	10	1000	n.a.	n.a.	3000000	3000000	2000
Flood	Flood	1987	7	22	2055	n.a.	n.a.	29700000	29700000	330000
Flood	Flood	1987	8	n.a.	625	n.a.	n.a.	n.a.	n.a.	727500
Earth-quake	Earthquake	1988	2	6	2	100	n.a.	n.a.	100	n.a.
Wind storm	Storm	1988	5	23	28	n.a.	n.a.	n.a.	n.a.	n.a.
Wind-storm	Storm	1988	6	13	5	200	n.a.	5000	5200	n.a.
Slide	Landslide	1988	7	n.a.	200	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1988	8	n.a.	2379	n.a.	28000000	45000000	73000000	2137000
Wind storm	Storm	1988	10	19	31	n.a.	n.a.	n.a.	n.a.	n.a.
Wind-storm	Cyclone	1988	11	29	1000	n.a.	2000000	8568860	10568860	n.a.
Extreme tempera-ture	Cold wave	1989	1	n.a.	70	n.a.	n.a.	n.a.	n.a.	n.a.

Types of Disaster	Subset of Disaster	Year	Month	Day	Persons Killed	Persons Injured	Home-less	Affected	Total Affected	Damage in US$('000s)
Draught	Draught	1989	4	n.a.	0	n.a.	n.a.	5000000	5000000	n.a.
Wind storm	Cyclone	1989	4	26	800	2000	n.a.	100000	102000	16200
Wind storm	Cyclone	1989	5	26	15	2000	n.a.	n.a.	2000	n.a.
Flood	Flood	1989	8	14	180	n.a.	n.a.	200000	200000	n.a.
Extreme tempera-ture	Cold wave	1989	12	n.a.	100	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1990	3	25	166	1600	n.a.	10000	11600	n.a.
Wind storm	Tornado	1990	4	n.a.	76	200	n.a.	n.a.	200	n.a.
Wind storm	Tornado	1990	5	2	19	500	4000	0	4500	n.a.
Flood	Flood	1990	7	n.a.	65	n.a.	n.a.	2000000	2000000	n.a.
Wind storm	Cyclone	1990	10	8	370	n.a.	n.a.	13870	13870	n.a.
Wind storm	Storm	1990	12	21	250	n.a.	n.a.	n.a.	0	n.a.
Extreme tempera-ture	Cold wave	1990	12	29	67	n.a.	n.a.	n.a.	0	n.a.
Wind-storm	Cyclone	1991	4	29	138866	1390540	300000	15000000	15438849	1780000
Wind-storm	Tornado	1991	5	7	121	300	n.a.	n.a.	300	n.a.
Flood	Flood	1991	5	n.a.	200	0	0	1200000	1200000	n.a
Flood	Flood	1991	7	n.a.	n.a.	0	0	1590000	1590000	n.a
Flood	Flood	1991	9	10	100	0	200000	1000000	1200000	150000
Extreme tempera-ture	Cold wave	1991	12	24	182	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1992	1	31	7	200	0	0	1200000	1200000
Flood	Flood	1992	4	18	15	200	n.a.	n.a.	200	n.a.
Wind storm	Storm	1992	4	22	16	100	n.a.	n.a.	100	n.a.
Flood	Flood	1992	6	22	0	n.a.	45000	n.a.	45000	n.a.
Flood	Flood	1992	7	11	0	n.a.	30000	n.a.	30000	n.a.
Wind storm	Cyclone	1993	1	9	50	500	2000	n.a.	2500	n.a.
Wind storm	Storm	1993	1	12	31	2000	n.a.	750000	752000	n.a.
Wind storm	Storm	1993	2	19	8	500	70000	n.a.	70500	n.a.
Wind storm	Storm	1993	3	27	300	200	25000	n.a.	25200	n.a.
Wind storm	Storm	1993	5	7	9	250	3000	n.a.	3250	n.a.
Wind storm	Storm	1993	5	9	15	70	n.a.	n.a.	70	n.a.
Wind storm	Cyclone	1993	5	13	14	n.a.	n.a.	7500	7500	n.a.
Wind storm	Storm	1993	5	17	25	2000	5000	n.a.	7000	n.a.
Flood	Flood	1993	6	n.a.	28	0	0	3207056	3207056	n.a.
Flood	Flood	1993	7	n.a.	162	0	0	11469537	11469537	n.a.
Flood	Flood	1993	8	21	4	20	75000	1000000	1075020	n.a.
Extreme tempera-ture	Cold wave	1994	2	n.a.	29	n.a.	n.a.	n.a.	n.a.	n.a.

Types of Disaster	Subset of Disaster	Year	Month	Day	Persons Killed	Persons Injured	Home-less	Affected	Total Affected	Damage in US$('000s)
Wind storm	Cyclone	1994	3	28	40	150	n.a.	n.a.	150	n.a.
Wind storm	Storm	1994	4	2	20	200	5000	0	5200	n.a.
Flood	Flood	1994	4	19	61	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Cyclone	1994	5	2	130	3559	200000	450000	653559	125000
Wind storm	Storm	1994	5	18	15	100	n.a.	n.a.	100	n.a.
Flood	Flood	1994	5	19	12	0	0	100	100	n.a.
Flood	Flood	1994	6	3	3	n.a.	n.a.	25000	25000	n.a.
Flood	Flood	1994	8	19	40	n.a.	70000	300000	370000	n.a.
Extreme tempera-ture	Cold wave	1995	1	n.a.	120	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1995	4	12	69	1500	50000	0	51500	n.a.
Wind storm	Tornado	1995	4	12	6	70	2500	0	2570	n.a.
Flood	Flood	1995	5	15	50	n.a.	110000	351325	461325	n.a.
Wind storm	Storm	1995	5	15	525	n.a.	70000	2000000	2070000	n.a.
Flood	Flood	1995	6	15	250	n.a.	n.a.	12656006	12656006	n.a.
Flood	Flood	1995	9	n.a.	400	n.a.	400000	7600000	8000000	n.a.
Wind storm	Cyclone	1995	11	25	172	n.a.	n.a.	250000	250000	n.a.
Extreme tempera-ture	Cold wave	1996	1	23	200	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1996	4	23	17	300	n.a.	n.a.	300	n.a.
Wind storm	Storm	1996	5	8	140	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1996	5	13	525	35691	0	82600	118291	n.a.
Flood	Flood	1996	7	n.a.	33	n.a.	500000	5663319	6163319	n.a.
Wind storm	Storm	1996	7	27	60	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1996	9	2	22	n.a.	n.a.	165000	165000	n.a.
Wind storm	Cyclone	1996	10	29	24	100	n.a.	n.a.	100	n.a.
Extreme tempera-ture	Cold wave	1997	1	21	33	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Storm	1997	3	23	11	101	n.a.	n.a.	101	n.a.
Wind storm	Cyclone	1997	5	18	111	10000	1000000	2042738	3052738	n.a.
Flood	Flood	1997	7	13	79	30	100000	800000	900030	n.a.
Wind storm	Storm	1997	8	27	100	n.a.	n.a.	n.a.	n.a.	n.a.
Wind storm	Cyclone	1997	9	27	188	1529	0	750000	751529	n.a.
Wind storm	Tornado	1997	10	12	15	500	n.a.	n.a.	500	n.a.
Earth-quake	Earthquake	1997	11	22	21	200	n.a.	n.a.	200	n.a.
Extreme tempera-ture	Cold wave	1998	1	9	120	n.a.	n.a.	34000	34000	n.a.

Types of Disaster	Subset of Disaster	Year	Month	Day	Persons Killed	Persons Injured	Homeless	Affected	Total Affected	Damage in US$('000s)
Wind storm	Storm	1998	3	23	28	100	n.a.	n.a.	100	n.a.
Wind storm	Storm	1998	4	23	14	200	n.a.	n.a.	200	n.a.
Flood	Flood	1998	5	20	19	504	n.a.	108440	108944	n.a.
Wind storm	Storm	1998	7	3	60	n.a.	n.a.	n.a.	n.a.	n.a.
Flood	Flood	1998	7	8	918	50	n.a.	15000000	15000050	3000000
Wind storm	Storm	1998	11	25	200	n.a.	n.a.	121000	121000	n.a.
Wind storm	Tornado	1999	3	26	2	60	100000	n.a.	100060	n.a.
Wind storm	Storm	1999	4	7	7	200	0	0	200	n.a.
Wind storm	Storm	1999	4	10	66	100	0	0	100	n.a.
Wind storm	Storm	1999	5	7	3	150	0	1000	1150	n.a.
Flood	Flood	1999	7	n.a.	31	20	20000	421250	4412270	n.a.
Earth-quake	Earthquake	1999	7	22	6	200	15000	0	15200	n.a.
Flood	Flood	1999	8	15	17	50	0	0	50	n.a.

Source : Disaster Preparedness Centre, AIT, Bangkok