FLOOD HAZARDS IN BANGLADESH : VULNERABILITY AND HUMAN ADJUSTMENT

THESIS SUBMITTED FOR THE PARTIAL FULLFILMENT OF THE DEGREE OF MASTER OF PHILOSOPHY IN THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENT UNIVERSITY OF DHAKA

BY
MD. SERAJUL ISLAM
REGISTRATION NO. - 285
SESSION : 1996-97

UNDER THE SUPERVISION OF
PROFESSOR DR. MD. ABDUR ROB

DEPARTMENT OF GEOGRAPHY & ENVIRONMENT
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ভূগোল ও পরিবেশ বিভাগ
ঢাকা বিশ্ববিদ্যালয়
ঢাকা- ১০০০, বাংলাদেশ
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This is to certify that Mr. Md. Serajul Islam has completed the M. Phil. Thesis entitled "**FLOOD HAZARDS IN BANGLADESH : VULNERABILITY AND HUMAN ADJUSTMENT**" under my supervision and it is his own original work.

Arob
19-03-07

Professor Dr. Mohammad Abdur Rob
(Supervisor)

With best of Respects and Regards
Dedicated to my Beloved Parents

Late Md. Abdur Rahim Biswas
and
Late Mrs. Umme Kulsum Bibi

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Md. Serajul Islam

ABSTRACT

This thesis involves an in depth investigation into the critical appreciation of flood hazards and human adjustment in Bangladesh. In this thesis aspects have been taken to examine the vulnerability of flood and mode of human adjustment to floods in Bangladesh. This study is almost new and pioneering initiative in the area of environmental studies. For the present study the whole country has been selected as study area and divided into five regions on the basis of vulnerability of flood in the country. In order to achieve the objectives of the study a multistage complex analytical process of analysis and experimentation were made. Both the primary and secondary data source have extensively been used in the study.

The findings of the present study reveals some clear cut facts about the flood behaviour of Bangladesh. It is found that flood is a very common and familiar phenomenon to the people of Bangladesh. The climatic condition, geographical and hydrological situation of the country have been influencing the causes of flood. The three major rivers (Padma, Meghna the Jamuna) and their large basins originated and located outside Bangladesh which are usually a natural obstacle in controlling flood in the country of her own way. The result of the questionnaire survey shows that flood doesn't take part similarly in all parts of the country. It is also indicated that the flood situation of the country is not deteriorating gradually but the local people are not satisfied with existing flood control methods. Some suggestions were also came out to control the flood like geo-political commitment, construction of reservoirs, river treatment, afforestation, construction of embankments, sluice gates, culverts, gateways, etc.

The findings of the present study also reveals the actual scenarios of human adjustment. People of Bangladesh have become habituated with flood. They know well how to cope with the adverse effects of floods. The word flood is very familiar to all categories of people of Bangladesh as it occurs almost every year and has become a cause of sufferings of the people. It is felt that impacts of floods are immeasurable and expected achievements in this regards are still wanted.

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ACRONYMS

ADAB	Association of Development Agencies in Bangladesh
ADB	Asian Development Bank
AFPM	Active Flood Plain Management
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BCAS	Bangladesh Center for Advanced Studies
BIDS	Bangladesh Institute of Development Studies
BIWTA	Bangladesh Inland Water Transport Authority
BKB	Bangladesh Krishi Bank
BDM	Bangladesh Meteorological Department
BRDB	Bangladesh Rural Development Board
BRE	Brahmaputra Right Embankment
BWDB	Bangladesh Water Development Board
CIDA	Canadian International Development Agency
DTW	Deep Tube-Well
DFFW	Directorate of Flood Forecasting and Warning
DLE	Dhaleshari Let Bank
DND	Dhaka-Narayanganj-Demra Irrigation Project
EEC	European Economics Community
EIP	Early Implementation Project
EPWAPDA	East Pakistan Water and Power Development Authority
ERR	Economic Rate of Return
FAO	Flood Action Plan
FCD	Flood Control and Drainage
FCDI	Flood Control and Drainage Irrigation
FFYP	Forth Five Year Plan
FPCO	Flood Plan Coordination Organization

GIS	Geographic Information System
GUP	Gram Union Parishad
HYV	High Yielding Variety
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IDP	International Development Project
IECO	Institutional Engineering Company
IPM	Integrated Pest Management
IRRI	International Rice Research Institute, Philippines. This term is used for high yielding varieties of rice
ISPAN	Irrigation Support Project for Asia and the Near East
LIV	Local Improved Varieties
LLP	Low Left Pumps
LGED	Local Government and Engineering Department
MLE	Meghna Left Embankment
MPO	Master Plan Organization
MRE	Meghna Right Embankment
MTFPP	Medium Term Flood Production Plan
NERP	Noth-East Regional Water Management Project
NGO	Non Government Organization
NWP	National Water Plan
RHDIS	Recorded Highest Discharge
RHFL	Recorded Highest Flood Level
SFYP	Second Five Year Plan
TFYP	Third Five Year Plan
TYP	Two Year Plan

GLOSSERY

Aman	A term used in eastern India and Bangladesh for rice crop sown in monsoon and harvested after monsoon
Ashtomashi Ban	Embankments meant to last for eight months of the year
Aus	Rice Crop planted before the wet monsoon season and maturing immediately before or in the well monsoon
Banya	Bengali name for Flood
Barsha	Rainy season
Beel	A natural wetland which generally retains water throughout the year
Boro	Rice sawn, transplanted and maturing in the dry monsoon season
Char	Newly emerged land in a river channel through siltation.
Cross dam	An embankment built across a river
Dal	Pulses
Fitkiri	Alum to clean polluted water; one type of chemical
Haor	A bowl-shaped depression between the natural levees of a river mostly found in the eastern region of greater Mymensingh and the Greater Sylhet District
Jotdars	Large influential landowners
Kharif	Wet growing season
Khas	Under Government ownership
Mahajan	Traders who stocks
Neem	(Azadirachta indica) Indigenous medicinal plant
Rabi	Dry growing season
Ring Dam	Officially called the Dhaka Integrated Town Projection Embankme

CHAPTER - I

INTRODUCTION

CHAPTER-I

INTRODUCTION

1.0 Floods in Bangladesh ; General Considerations

Flood and Bangladesh are two very closely related phenomena. For Bangladesh, flooding is a common natural happening which has become almost an integral part of the life of the Bangladeshi people. The reverine country Bangladesh has been experiencing floods more frequently than ever before in the recent decades. It is a seasonal phenomenon in Bangladesh. The country Bangladesh is a land of monsoon rains and mighty rivers. The major part of the landscape of the country is dominated by alluvial plains with numerous huge and unstable stream channels. Geologically Bangladesh is a part of Bengal Basin. The formation of Bengal Basin is closely associated with the formation of the Himalayan Mountains during the Tertiary period. Bangladesh is subject to inundation by over bank spills due to drainage congestions, rainfall run-off and storm-tidal surges. If Egypt is called the "Gift of the Nile" then Bangladesh can be entitled "a land of rivers". These rivers, especially three mighty channels the Brahmaputra-Jamuna, the Ganges-Padma and the Meghna can be considered as the major life-saving arterial system of the deltaic Bangladesh. Needless to say that these three huge river systems are greatly responsible for the origin and evolution of the alluvial palins of the largest delta of the world- The Bengal Plains. The colossal discharges of flood-water of these fluvial systems bring enormous quantity of alluvium and silts along with their huge supply of flood waters. Floods are normally associated with the annual monsoon rains that pour into the entire Ganges-Brahmaputra-Meghna Basin that around 93 percent of which falls in the extra- territorial catchment of these rivers.

Presently flood has become a recurring natural hazard for Bangladesh. The country has to face the loss and damage of this obvious natural calamity. It is observed that the overall flood situation of the country has been deteriorating gradually. At the same time, very naturally the people of Bangladesh have also become familiar with floodings and have been trying to prepare themselves to cope with the adverse effect of it. By now flood has become almost an inseparable part of Bangladesh culture.

Almost every year floods cause huge damage to crops, habitats, road and highways, animals and trees in Bangladesh. Repeated occurrence of floods enormously damage the overall economy of the inhabitants of the country.

Floods in Bangladesh maintains some clear differences from that of other regions of the world. It has always been a recurrent phenomenon and almost every year it appears in different modes. Various types of flood can be seen in Bangladesh. Normal Monsoon floods, Abnormal floods, Flash floods, Coastal flood are some major types of the inundation of Bangladesh. The riverine country Bangladesh has been experiencing floods more frequently than ever before in the recent years. Since the partition of the Indian sub-content in 1947 the country has experienced very high floods in 1954, 56, 66, 68,,74, 84, 87, 88, 92, 96, 98, 2000 and last in 2002.

Geomorphologically about four-fifths of Bangladesh is floodplain. As a result of flat topography of floodplain, one-fifth to one-third of Bangladesh is annually flooded by overflowing rivers during monsoon when the rainfall within the country is very high. On the other hand, the country suffers from scarcity of water during the dry season. The annual occurrnce of rainfall and river floodings in and around Bangladesh has been playing an active role in shaping the landscape of the floodplains, nourishing its soil and sustaining its production system. The fertile floodplain and availability of abundant water during monsoon have made the country a predominantly agrarian one. Floods are normally associated with the annual monsoon rains that pour into the entire Ganges- Brahmaputra-Meghna Basin. Large areas in Bangladesh are normally inundated by monsoon flood water between June and October every year. However, flash flood may sometimes appear in the Sylhet region as early as the month of April and May.

Usually a flood is associated with dramatic congestion arising from the intense surface flow and heavy overland runoff caused by higher rainfall in the catchments area outside the country. The causes of occurrence and the nature of floods are highly regulated and immensely characterized by the climatic condition, hydrological situation and physical settings of an area. The monsoon or rainy season between June and October brings on the normal floods each year, normally inundating some 2.6 million hectares of land surface. During more sever floods the extent of flooding may reach over 5.2 million hectares. Recent estimates shows that about 50 percent of the total land of Bangladesh is vulnerable to floods. The flood depth to which the land is normally inundated range from 30 cm to 2.5 m.

1.1 Concept of Hazards, Vulnerability and Adjustments with special reference to Flood

Hazards

From time immemorial, various types of natural disasters have been causing immense loss of lives and properties in different parts of the world. These disasters appear in different parts of the globe in different nature, frequency of occurrence and with a varried magnitude of severity. Essentially the natural disasters and calamities exhibit their typical geographical or regional behaviour. For example, prevalence of avalanches and blizzards are common natural calamities of the higher latitudes and glaciated colder regions of the earth. Likewise, droughts, locusts and desert-stroms are typical happening of the arid and semi-arid areas. Tsunamies, tidal surges, cyclones and coastal inundations are some of the very known natural calamites that are occurred along the coastal margins of the continents. Flood, the most common and one of the most frequented natural phenomena, occur in almost every part of the land surfaces of the earth. However, the humid low-lying flat surfaces of the riverine deltaic or alluvial plains are the most vulnerable or suspectable to these kind of natural happenings.

Natural hazards calamites and disaster are always horrifying, damaging and harmful for man and environment. These are associated with destruction, loss and numerous adverse effects in the habitats. Not only man, natural hazards and disaster cause immense harm to the other living beings of the earth. Both the floral and faunal species are often subject to damage of the calamities.

In fact the terms "natural hazard" and "natural disaster" were used almost synonymously. During the last few years, a clear distinction has gradually been emerged between these two terminologies. A natural hazards is a "natural phenomenon or a combination of phenomena which threaten people or physical assets" while a "natural disaster is an event. Sudden or progressive, which impacts with such severity that the affected community has to respond by exceptional measures" (carter, 1991). It is extremely difficult to check the natural hazards. However, developments in science and technology have now made it possible to reduce the severity and magnitude of damage of the natural hazards to a considerable limits. The present day would has increasingly been experiencing different types of natural hazards. Adverse effects of global warming, floods, cyclones, tsunami, droughts, earth quakes, natural soil-erosion extensive bush-fires, etc. are on the increase in the recent decades. At the same time AIDS, tuberculosis, cavers and many other diseases are also threatening the very existence of man. The total global population has crossed the 6 billions barricade in the end of the last millennium. Needless to say that this tremendaus human population explosion has exerted huge pressure on the resources of the earth and in different direct and indirect ways this enhenchment in human population has been effecting the nature, occurrence, frequency and magnitude of different types of natural hazards and disasters. Unwise yet unabatable human interference's in nature is essentially worsening the natural hazard situation of the earth. Air, water, soil the most important components of nature that are essential for man and other living beings have gradually been polluted and degraded due to the indiscreminate human interference's.

1.2 Type of Natural Hazards

The various type of natural hazards may be classified as follows :

1.2.0 Atmospheric Hazards

Tropical Cyclone : A Cyclone is a portion of atmosphere in which the pressure is lowest in the centre. In temperate region it is generally several hundreds or even thousands of miles across. But in tropical region there are small depressions (usually called Tropical Cyclone) which may measure only 50 to 100 miles across.

Storm Surges : The Strom Surges due to tropical cyclones in the Bay of Bengal occationally cause severe disaster in the coastal areas. This flood can occure during April to June and September to November. Approximately 1,200 sq. km of coastal land is prone to cyclonic strom surge flood.

Extra tropical cyclones : The depressions in the West Indies are called *hurricanes*, in the South-East United States they are called *tornadoes* and in the West Pacific and China Seas *Typhoones*, while the whirling dust-laden stroms of the Shahara, of similar type are termed *Simoores*.

River floods : The main source of flood water is the bank over flow of the major rivers in Bangladesh. A band stripe of land adjacent to the rivers is subjected to this type of flood.

Droughts : Drought is absolute lose of precipitation in a certain area due to atmospheric differentiation. It is found mainly in the desert area for a long. The hot deserts are located on the western margins of the cntinent in both the hemespheres, between 20^0 and 30^0 latitude in the Trade Wind belt.

1.2.1 Geological Hazards

Earth quakes : The vibaration or tremors in the earth crust are known as earthquake. They are usually the result of operation of the internal forces and vulcanism.

Volcanic eruptions : S volcano is an opening in the earth`s surface through which are erupted steam, gases, molten rock, dust, ashes and other liquid and solid mater.

Landslides and River erosion : Landslides means fall of a mass of land or rock from the side of cliff or a high land. River erosion is a common feature in Bangladesh every year. A large areas of land are submerged to the reiver. As a result huge people loss their residence and other properties almost every year.

1.2.2 Hazards and suffering

There are also other hazards like River e,rosion, Wildfires, Locust infestation etc. It is estimated that about 3 million people around the world have lost their lives in the last 20 years due to different natural disasters and around 1 billion people have been affected by these (BUET, 1996).

1.2.3 Natural Hazards in Bangladesh

Earthquakes : The vibration or tremor in the earth crust are known as earthquakes. They are usually the result of operations of the internal focus and and vuleanism. Volcanic eruptions are often associated with easthquakes. In Bangladesh almost every year earthquakes takes place with laeast disastrous voleme.

Tornadoes/Thunderstorms : A cyclone wind blow inwards in the opposite direction to the hands of a clock, As the pressure gradiants are steep the winds are exceptionally strong and the resulting storms often do great damage. A Cyclone in temperate reion erated or born in the temperate region crea or born int temperate region creat or born in the land area with strong winds clled tomadoes.

Tropical Cyclones and Storm Surges : The depressions in the West Indies are called *hurricanes*, in the South-East United States they are called *tornadoes* and in the West Pacific and China Seas *Typhoones*, while the whirling dust-laden stroms of the Shahara, of similar type are termed *Simoores*.

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River Erosion : This is a common feature in Bangladesh every year. A large areas of land are submerged to the reiver. As a result huge people loss their residence and other properties almost every year.

1.3 Trend of flood hazard in Bangladesh

The country, Bangladesh has been experiencing floods since the historical past. No complete record is available on floods prior to 1922. Professor Mahalanabies, a noted statistician and meteorologist, prepared a report in 1927 on the severe flood which occured in Dinajpur, Bogra, Rajshahi and Pabna areas o f the present Bagladesh territory. This is considered as the first comprehensive report of the past flood in Bangladesh. Professor Mahalanabis in his report book "Report on rainfall and Flood in North Bengal, 1870-1922" has included a list of floods which occured during 1870-1992, a period of more than half a century, with their causes, severity and affefted areas. He also made a comparison of the normal rainfall and normal computed rainfall from 1950 to 80 which do not shows any significant change as shown below :

Table 1.1 : Comparison of Monthly Normal Rainfall (mm)

	Station	Period	Jul	Aug	Sept.
1	Dinajpur	PCM	394	330	302
		NEW	455	318	283
2	Rangpur	PCM	388	326	346
		NEW	443	329	280
3	Bogra	PCM	275	285	261
		NEW	401	321	237
4	Rajshahi	PCM	324	264	240
		NEW	334	241	221
5	Pabna	PCM	273	271	228
		NEW	281	278	218

Source : Mahalanobies, 1927

PCM – Normal computed in P.C. Mahalanobis report for the period to 1922.

NEW – Normal computed for the period 1950-80

It may be concluded from the above data that rainfall pattern has not changed significantly over this long period of more than 60 years.

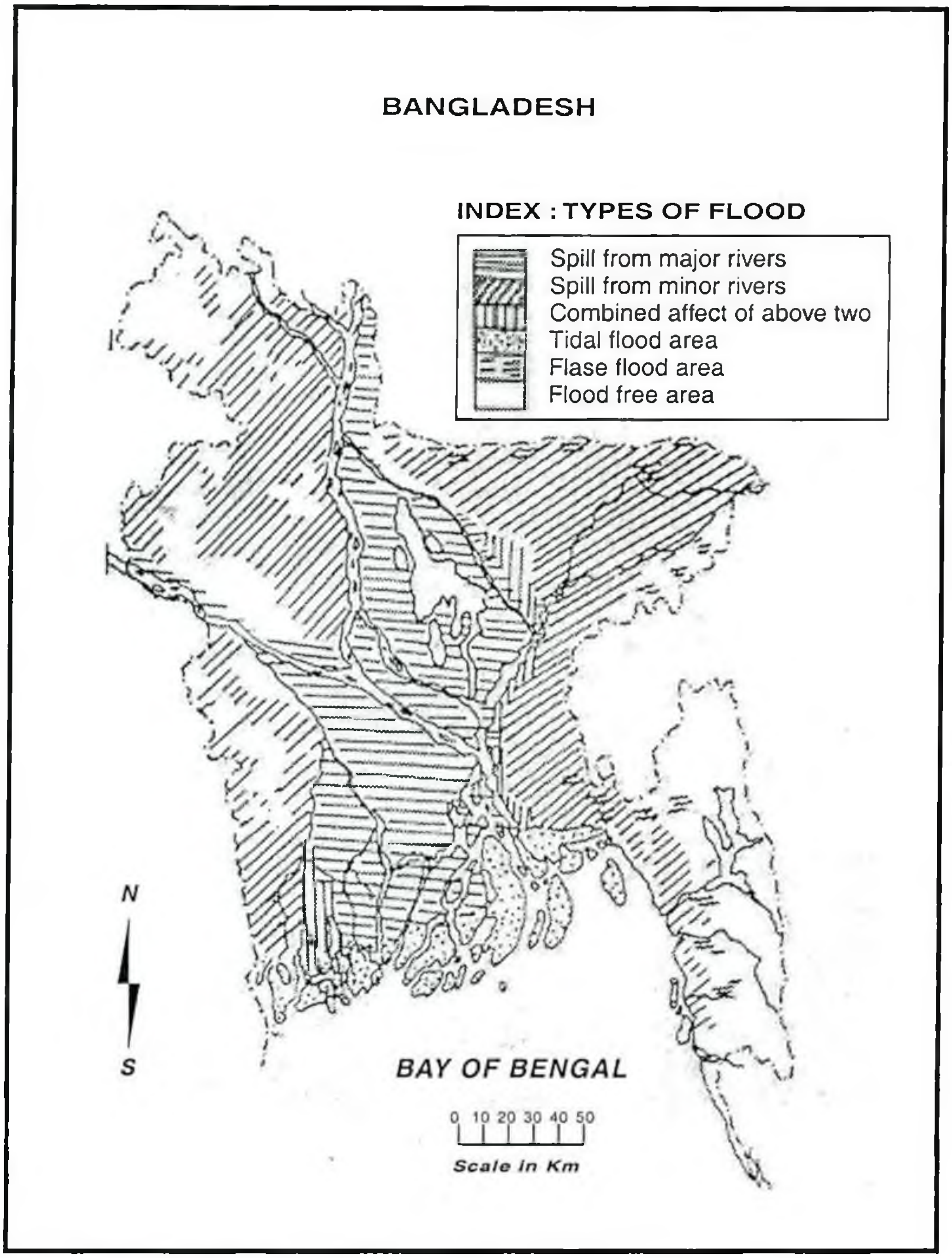
In the report of professor Mahalanabis, isohyets of rainfall for 1922 flood for the week ending on the 27th September centering around balurghat with a central rainfall of 1269 mm (49.95inches) during one week have been furnished. Compared to this, 10 day rainstorm of July 1987 having a central rainfall of 1029 mm (40.5 inches) at Mithapukur shown that north Bengal has experienced rain flood of the said magnitude in the past also. Regarding the flood due to the rain storm of September, 1922, the following comments of Professor Mahalanobis are of interests. "Railway embankments hampered quick drainage away of the flood-water, and thus served to prolong the duration of the flood. But with such heavy falls, a flood of practically the same magnitude was bound to occur, even if there had not been a single railway line in existence."

Flood is the interaction of rainfall with the topography, vegetation and development infrastructures. Although rainfall pattern have not changed, the channel networks and the development infrastructures have brought changes in the flooding of Bangladesh. In recent years, with the increase of population, habitation is growing up in flood plain areas. Roads and embankments are also being built by different agencies. Quite often, such roads do not have proper alignment and have inadequate or no opening for drainage which causes drainage congestion resulting in localized flooding in many cases.

1. 4 Vulnerability

The word vulnerable means not adequately protected or capable of being wounded or attacked. Here we will discuss the vulnerability of flood. The coastal belt of Bangladesh is vulnerable to the cyclonic surges and tidal bores. Due to the shallow water effect and the funnel shape of the coastal belt region of Bangladesh the cyclone surges and tidal bores can easily submerge the abnormally flat and low coastal-belt region. Moreover if the pounding waves of cyclic surge coin-side with a huge tide, their amplitude may be as high as 10 to 12 meters. Such cyclonic surges ravaged the coastal parts of the country in 1960, 61, 63, 65, 70, 85, 87, 88, 97, 88 and last in 2000. It proves that flood vulnerability of Bangladesh is adequately high.

Figure –1.1 : Vulnerable Areas of Bangladesh



Source : Modified after BWDB 1994 & ROB,1996

1.5 Adjustment : The people of Bangladesh have learnt to live with the annual seasonal floods. They have built embankments locally and selected places of refuge for emergencies. While seasonal inundation brings benefits in the from of agricultural bounty and wetlands teeming with fish, floods that assume the proportions of the deluge of 1988, when two thirds of the country went under water. The 1988 flood displaced millions of people and destroyed their meager assets. In all, the flood affected close to 30 million people and 57,500 square kilometers of land cared on estimated US$ 2 billion in property damage.

Although the human misery was enormous because of the prolonged inundation, the death toll from the toll itself was relatively low. According to the official count 1.657 people lost their lives, though unofficial estimates were some what higher. Bangladesh experienced sever flood in 1954, 1955, 1961, 1962, 1968, 1969, 1970, 1971, 1974, 1987, 1988, 1998 and 2000 were particularly destroy. The feminine that followed in 1974 claimed 37,000 lives, according to the official figures. Unofficial estimates put the death toll above 100,000.

Almost half of the population was directly affected by the 1988 flood. Throughout the country, people took shelter on rooftops and embankments, road bridge and the roof of various Govt. building were covered into flood shelters. Losses in the 1988 flood were estimated at US $ 1.3 billion. In addition to substantial damage to homes and infra-structure, 64,000 cows and 57,000 goats were lost, according to a report on the flood by the Association of Development Agencies in Bangladesh (ADAB). People died by drowning, being crushed by falling walls, bitten by poisonous snakes or electrocuted. Injuries that people might have survived in normal times become fatal because they could not get timely medical attention during the flood. But 1 (one) lack of access to safe drinking water was an even bigger killer. Though the deaths from diarrhoeal diseases seem high in comparison to the total flood-related death toll, they represent quite a small proportion of the seven million people who are though to have contracted diarrhoeal diseases in the wake of the flood, according to a Health Ministry source. Awareness the importance of clean drinking water and primary health care helped prevent even more deaths and popularization both by Government and non-Government organizations of the simple remedy for diarrhoea, oral dehydration therapy, also helped save lives.

A study conducted just before the severe floods of 1987 and 1988 found that severe floods speed up the process of pauperization and widening social inequality, with few of the rural poor able to improve their situation in the aftermath of severe floods and the majority becoming poorer.

1.6 Significance of the study

Flood and Bangladesh are almost the two synonymous terminologies. Flood is an house hold phenomena in Bangladesh which is recurring as hazards almost every year in Bangladesh. Bangladesh has to face the loss and damage of this obvious natural calamity. It is observed that the overall flood situation of the country is deteriorating gradually. Its intensity and frequency of occurrences are increasing year to year. It is badly needed to reduce the loss and damage of flood. To bring an effective control over the flooding situation of the country both the long term and short term control measures should be taken. Serious research and investigation activities should be coquetted to understand the various dimension and behaviour of flood.

Till to date very little scientific studies have so far been done of this hazardous environmental disaster of Bangladesh. This study would help the General people to be conscious of flood. This study will represent a picture of overall flood situation of Bangladesh so that concern institutions or organizations can get help for planning or necessary activities.

1.7 Aims and objectives of the study

1.7.0 Aims of the study

The aim of the present study is to examine the vulnerability of flood and mode of human adjustment to flood in Bangladesh.

1.7.1 Objectives of the study

The various important objectives of the present study are:

i) To examine and analyze the different hydrological and morphological characteristics and nature of floods in Bangladesh (i.e. types, frequencies. spatial configuration of spreads of inundation, etc.)

iii) to reveal the behaviour of different types of floods in different areas of Bangladesh.

iv) to understand the causes of occurrence of different types of floods in different areas of the country with special reference to the geomorphological considerations;

v) to find out the role of rivers (fluvio-morphological) in the genesis of the floods in Bangladesh;

vi) to prepare some elaborate and indepth flood maps of Bangladesh depicting the types, nature, vulnerability, frequency, magnitudes and other relevent hydrological phenomena;

vii) to identify the levels of vulnerability of floods with reference to the duration, frequencies of occurrence, depth's of flood waters and magnitude of loss and damages of flood in different areas of the country.

viii) to examine the mode of human adjustment to the floods in Bangladesh and finally

ix) to findout the most appropriate measure to face the challenge arising in coping with the problems of flood hazards in Bangladesh.

1.8 Methods of Investigation

The methodology of investigation of the present study involves a multistage complex analytical process of analysis and experimentation. Both the primary and secondary data-source have extensively been used in the study. The primary data were generated mainly for the purpose of understand the adjustment mechanisms while the secondary data were used to reveal the various hydrological aspects of flood vulnerability in Bangladesh. The stages of methods of investigation can be categorized into the following steps:

a) Collection and analysis of the secondary data;
b) Selection of study-area;
c) Questionnaire survey;
d) Preparation of flood maps and
e) Analysis of findings using some appropriate Quantitative techniques (Multivariate Function Analysis, Chi-square test and Reliability tests)

a) Sources of secondary data

Secondary flood data and other relevant information were gathered from diferent authentic sources of hydrological data. These are

i) The SPARRSO (Space Research and Remote Sensing Organization, Dhaka), Satellite Imageries and other maps were collected from SPARRSO. Satellite Imageries of the LANDSAT (USA) covering various band and periods were collected

ii) Meteorological and climatological data were collected from the Meteorological office, Dhaka for various climatic data beginning from 1950 to 2005. However, some rainfall-data and water budget data of some specific years (Vij. Flood years) for the whole of the country as well as the extra-territorial regions (Vij. catchment) were also collected from the same source.

x) Hydrological data were collected from the Water Development Board (BWDB), Dhaka to understand the spatio-temporal configuration of inundation and to reveal the extent of flood levels in different rivers in Bangladesh for different flood years. Of-course, selective flood stations (hydrological gause reaching points) were collected and analyzed preparing different types of hydrograph and flood frequency curves.

iv) Old and new Maps and Hydrological charts were also collected and analyzed. Among these, the flood maps prepared by the BWDB, SPARRSO, Water Modelling Centre, BUET are note worthy. Books, reports and thesis prepared by different authorities and scholars are also collected and analyzed. FAP reports (1990-1992) and Research-based published articles (i.e. Rob 1992, Islam-1987, Miah 1990) were also extensively used in this purpose.

b) **Study-Area**

In the present study the whole of the country (Vij. Bangladesh) was brought under the consideration. However, some specific study areas each from the one specific flood types were chosen for the study for indepth analysis purpose. These are : Flash Flood Area, Normal Monsoon Flood Area, Coastal Flood Area, Flood Plain of great river etc. Centering these study areas flood behaviour and vulnerability have been analyzed and studied.

c) **Questionnaire Survey**

In order to generate Primary data involving flood adjustment some scientific questionnaire were prepared. Among these, questionnaires for flood affected people and schedule for expertise opinions are important ones.

Sample for questionnaire survey were selected form the flood affected people from the flood vulnerable areas of different categories. Sample were selected purpossively covering all the affected areas so that they could represent flood affected people from all categories of flood affected areas, i.e. monsoon floods, flash floods coastal floods etc. Needless to say that due to paucity of time, funds and other constraints of the present study very small sample groups (only 250 sample) have been selected from each of the 5-study areas (Vij-50 from each of the areas).

d) **Flood Maps**

Flood Maps and flood Hydrographs were prepared from the hydrological data of the BWDB and the Satellite Imageries collected by the SPARRSO, and the LANDSAT Imageries.

e) **Analysis of Findings Using Appropriate Statistical Techniques**

In the present study some advanced quantitative techniques (i.e., Multivariate Factor Analysis (MVFA), Chi-square tests, Co-efficient test etc.) were used. In order to find out the complex and intricate interrelationship between various climatological and hydrological parameters like rainfall, discharge of water, flood stages and seasonality, duration, occurrence and frequencies of floods MVFA analysis were used. In this stage a computer based ANOVA Program was Utilized. In these studies appropriate graphic/matrix techniques were also applied using GIS techniques. Arc-Info program has been found useful in these analytical studies.

1.9 Geographical Settings of Bangladesh

Bangladesh covers an area of about 1,47890 sq. kilometer, slightly smaller than Nepal and about one twentieth the size of India which surrounds it on three sides. It is situated at the confluence of three river systems that drain the southern mountain massif of Asia. The Ganges river collects water from the southern slopes of the Himalayas, the Brahmaputra river drains the northern slopes of the Himalayas and the Meghna river arises in the north eastern hills i.e. Naga and Lusai hills of India bordering Bangladesh. These three rivers combine to carry the world's largest sediment load of around 2.5 billion tons per annum to form the world's largest delta (Rob, 1996). Bangladesh consists of that delta plain of which half the land area is less than 10 meters above sea level (Rashed, 1985).

Bangladesh stands on the floodway of a very large catchments area, situated in the tropics between 20.34` to 26.40` north Latitude and 88.01 `to 92.12` East Longitudes. Geographically Bangladesh is a part of Bengal basin, flanked by the Rajmahal Hills (in west Bengal, India) to the west and the Shilong plateau (in Meghalayan, India) to the North.

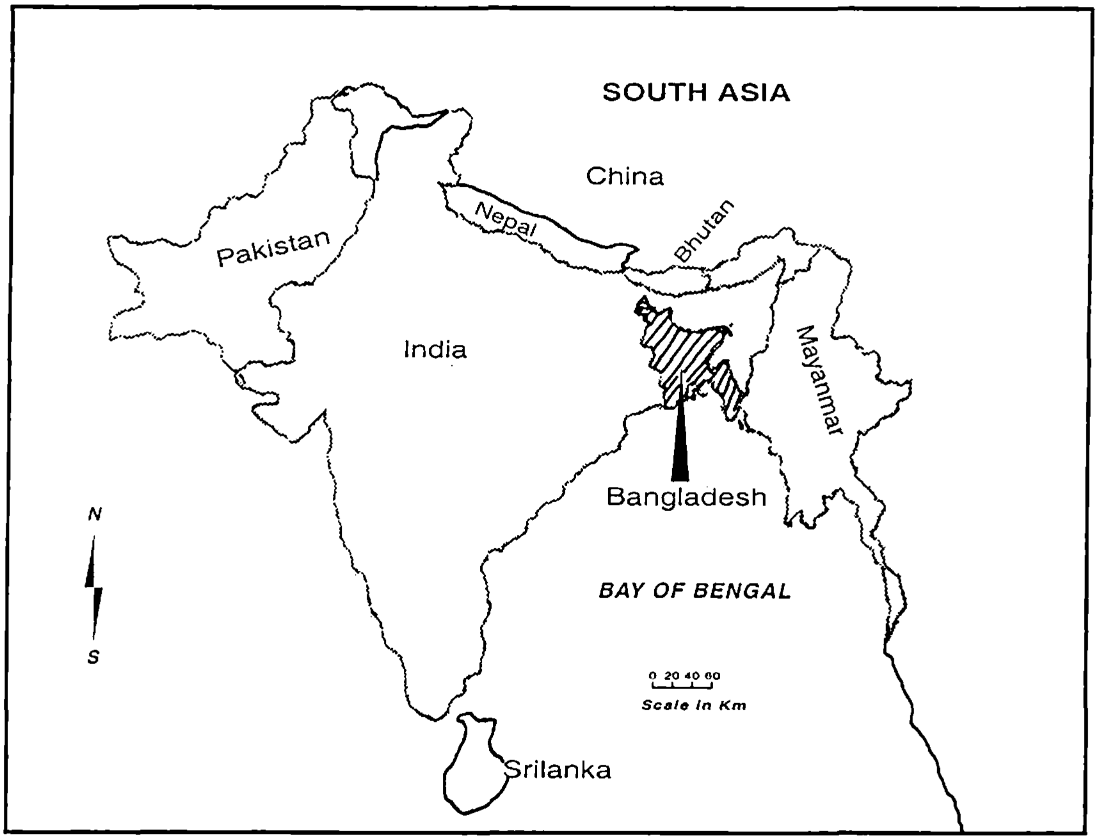
The Geographical settings of Bangladesh and its natural dynamic process present a considerable challenge for flood. The ecological relationship result from an interaction of climate, geological and physiographic features which dominate the landscape: half the land area is less than 25 feet above sea level and much of it flood-prone;

a vary active deltaic plain where the numerous ricers change courses including migration of the Ganges and the Brahmaputra;

a distinct dry season as well as heavy monsoon rainfall and seasonal flooding ;

tropical cyclones and storm surges due to the location and configuration of Bay of Bengal.

Figure- 1.2 : Geographical Location of Bangladesh



Major ecological concerns includes ;

the effect of shifting rivers on infrastructure and human settlements;

the susceptibility of agricultural production to natural disasters; and

a potential long term trend in rising sea levels that would have disastrous consequences for Bangladesh (CIDA, 1989).

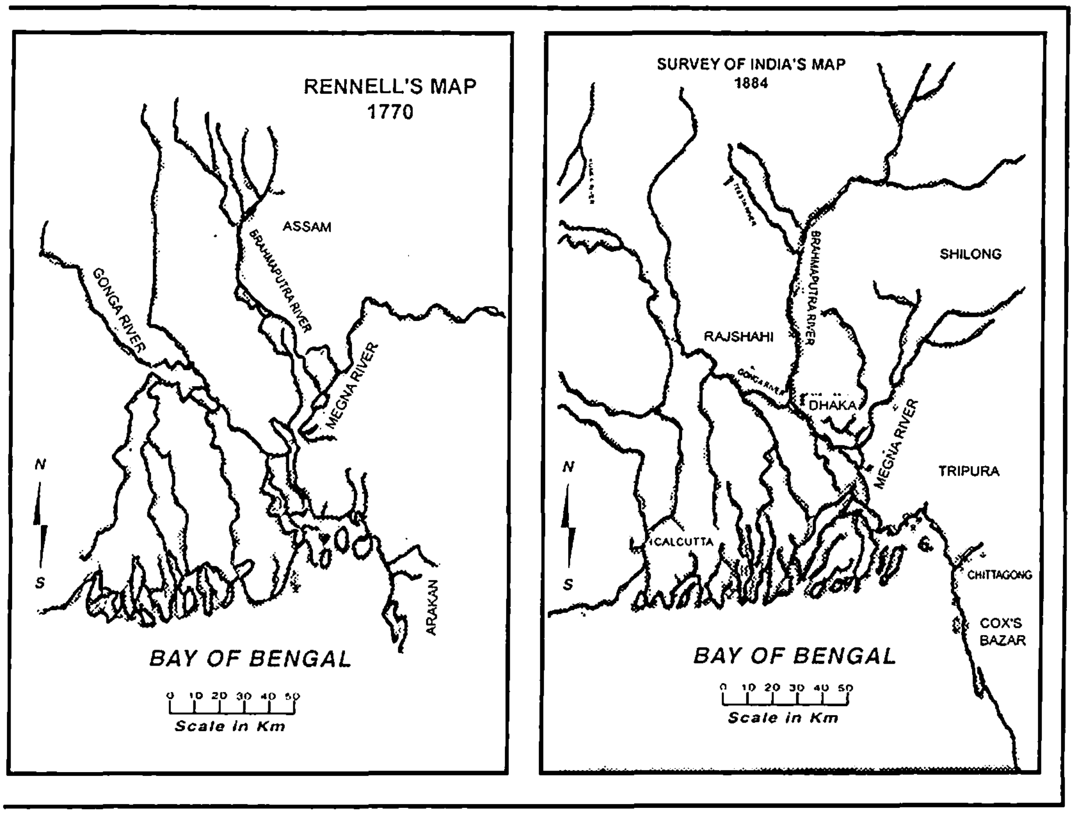
1.10 Hydrology of Bangladesh

Bangladesh is mostly a deltaic country located at the lower part of the basins of the three great rivers, the Ganges, the Brahmaputra and the Meghna. The extensive flood plain of these rivers and their numerous tributaries and distributaries is the main Physiographic feature of the country. In fact about four-fifths of Bangladesh is flood-plain. As a result of flat topography of the floodplain one-fifth to one-third of the country is annually flooded by over flowing rivers during monsoon when the rainfall within the country is also very high. On the other hand the country suffers from scarcity of water during dry season. This annual phenomenon of rainfall and river flooding has played an active role in shaping the landscape of the floodplain nourishing it's soil and sustaining its production system. The major part of Bangladesh is deltaic which was built up and gradually raised through several million years by the silt carried by the rivers from the mountain on the three sides of Bengal Basin and mainly from the

Himalayas. The surrounding mountains are Raymatial Hills on the east (ISESCO Fig 2.3 page 19). The delta building process has been mainly due to Ganges. The Brahmaputra was originally a comparatively small river, but since it connection with the Tsang Po of Tibet through its tributary, the Dihong in upper Assam and Subsequent additions of the floods of the Teesta river. It has been a formidable river of the Ganges and promisses to play more and more important part in future (Majumder, 1941).

Large areas of Bangladesh have been Uplifted in recent times and some areas are still Subsiding. It has been postulated that these tectonics may be due to the presence of several major fault. One of these fault lies along a line connecting Calcutta and Mymensingh and passes slightly above the confluence of the Ganges and Brahmaputra. Examples of areas of uplift are Barind tract in Rajshahi and some other areas in northern Bangladesh and the Madhupur tract in Mymensing-Tangail area which lie on either side of the Hinge Zone (ISESCO, 97).

Figure-1.3 : Morphological change in Bangladesh



Source : CEMPB Vol.-2. Final report P-5, STIESCAP1618

1.11 Hydrological Regions Of Bangladesh

According to FPCO (1995) Bangladesh can be divided into seven hydrological regions considering surface water flow process and major rivers as boundaries. These regions are :

i) North – West

ii) North – Central

iii) North – East

iv) South – West

v) South – Central

vi) South – East and

vii) Chittagong region.

The brief hydrological characteristics of these regions are given bellow:

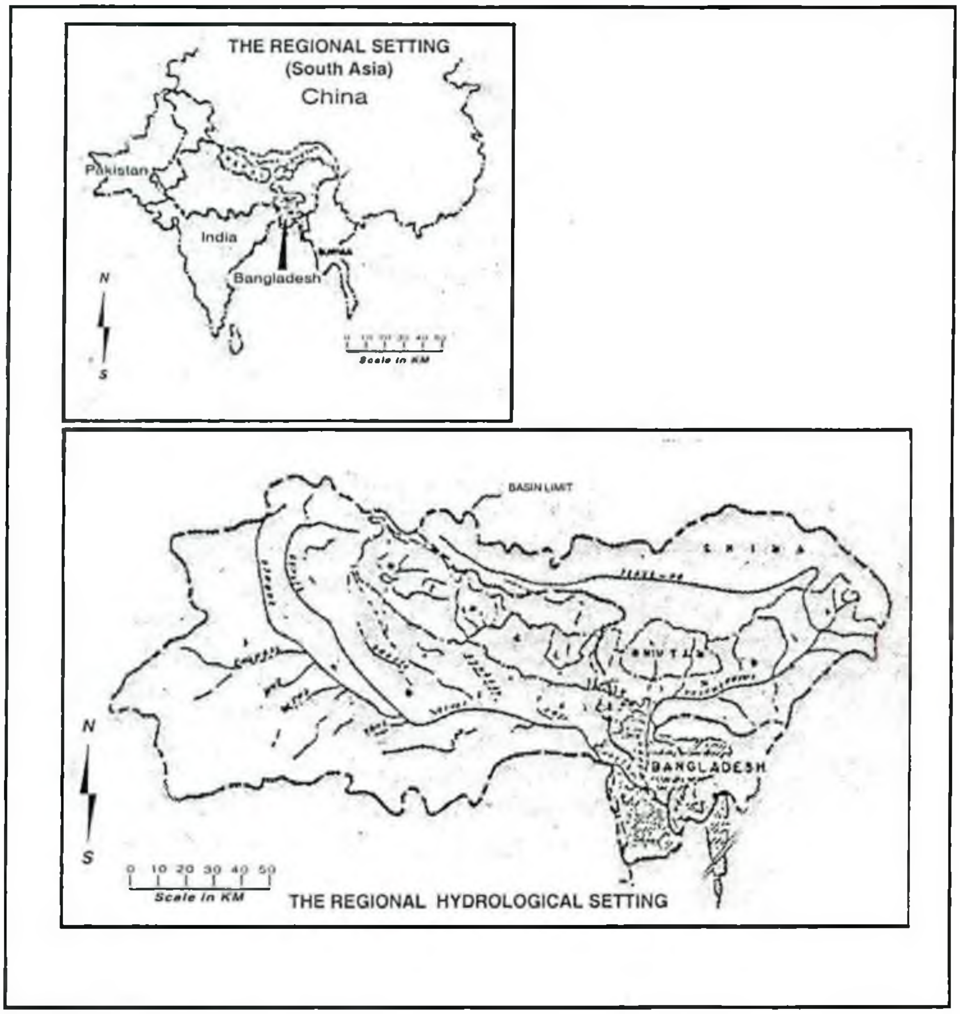
1.11.0 North-West (NW) Region : The NW region covers an areas of 34,000 sq. km. It is bounded by the Ganges in the South and the Brahmaputra–Jamuna in the east. Within the region major physiographic feature is Barind tract and chalan Beel with an area of about 4300 sq. km. and 3,120 sq. km. respectively. In this region the rivers in the extreme northern area, *Teesta, Dudhkumar* and *Dharla* have steeper gradients of 1 in 2000 and most of their catchments lies in India. These rivers freequently cause flash floods with annual peak discharges of 5,240, 1,830 and 1,610 cumec respectively. Internal rainfall flooding is therefore common in the region.

1.11.1 North-Central (NC) region : The NC region covers 12,000 sq. km in an area bounded by the Jamuna in the west , the Padma and the Meghna in the south and old Brahmaputra in the north and east. There are three interior river system : Dhaleswari-Kaligonga in the South- west, Bangshi-Turag in the centre and Banar-Lakhya in the eastwith annual maximum discharges of 3, 030,1,830 and 375 cumec respectively. The main physiographic units are the Brahmaputra floodplain; the old – Brahmaputrat flood plain; the Padma floodplain and the Madhupur tract, which is an alluvial outcrop raised above floodplain. Dhaka the capital of Bangladesh situated in the NC region.

1.11.2 North-East (NE) region : The North- East region has an area of 24,200 sq. km with the old Brahmaputra as boundary. This region is at the foot of Meghaloya and Tripura Hills. About 55% of this area is covered by lowland and floodplain. The Sylhet depression covers another 25%. The annual rainfall ranges from 2,200 to 5,800 mm with the higher values in the north-east of the region. The Major rivers are *Surma, Kushiyara, Manu* and *Khowai*. The rivers are flashy in nature and during the wet season, there is an enormous inflow of water from India in between May and November, almost 60% of the region is flooded to depths exceeding 1 metre, the deepest flooding being upto 5 metre in the Sylhet depression. Flash flood also occur in the pre-monsoon months of March and April causing widespread damage. During the monsoon the Haor basin looks like a vast inland lake.

1.11.3 South-West (SW) region : The South-West region covers about 26,600 sq. km and is bounded by the Ganges in the north, Kumer in the east and the Bay of Bengal in the south. The region is part of the Ganges Delta. The avarage annual rainfall ranges from 1500 mm in the north and to 2,900 mm in the south. A unique ecological resource of this region is Sundarban. The rivers in this region are the distributories of Ganges river. The region is relatively free from fluvial flooding, hawever, tidal flooding is quite common. The coastal zone comprises the extensive flat deltaic land which is crossed by large estuaries from Bay of Bengal.

Figure -1.4: Regional Hydrological Setting of Bangladesh



Source: Modified after Rob, 1996

1.11.4 South-Central (SC) region : The South Central region covers an area of 13,900 sq. km and is bounded by the Rumar on the west, the Padma on the north, the Lower Meghna in the east and the Bay of Bengal in the South. Like the SW region this region is also vulnerable to tidal flooding. The northern part of this region is suffers from fluvial flooding. Moreover, this region is also vulnerable to periodic cyclonic storm surge flooding from Bay of Bengal. As a result of extreme flatness of the delta storm surge can propagate as much as 60 km inland. This region is part of the Meghna delta and as such is not showing any moribund tendencies. This is the only region where there is no railway and roads are few and far in between. There are a number of large island in the estuary of lower Meghna.

1.11.5 South-East (SE) region : The South East (SE) region covers an area of 9,550 sq. km and is bounded by the Feni to the south, the Meghna and the Lower Meghna to the west, the Titas to the north and also the Bay of Bengal to the south. Almost the entire region is low lying and flat. The main internal rivers are *Gumti* and *Muhuri* with annual peak discharge of 474 and 283 cumec respectively. The northern part of the region is dissected by a number of rivers which bring flash floods from the Tippera hills above the Indian border to the Meghna. These rivers carry large quantities of sediment. The region frequently suffers from drainage congestion due to high water level in the lower Meghna. The coastal areas contain number of large island and are subject to storm surge flooding from tropical cyclones mainly in April/May and October/November.

1.11.6 Chittagong (CG) region : Chittagong region is different from the rest of the country having generally elevated relief and being independent in terms of hydrological response from the Ganges-Brahmaputra-Meghna river system. The region covers an area of 20,639 sq. km out of which 13,600 sq. km is covered with forest. All the rivers have catchment areas mostly within Bamgladesh and drain directly to the Bay of Bengal. The important rivers are *Karnaphuli, Halda, Sangu* and *Matamuhuri*. The rivers all have comparatively steeper stopes and cause flash floods. Chittagong is the only region which has hydro-electric plant in Bangladesh is sited on karnaphuli. The coastal areas are quite vulnerable to storm surge flooding. (ISESCO, 1997, Rabat, Morocco).

1.12 Physiography of Bangladesh

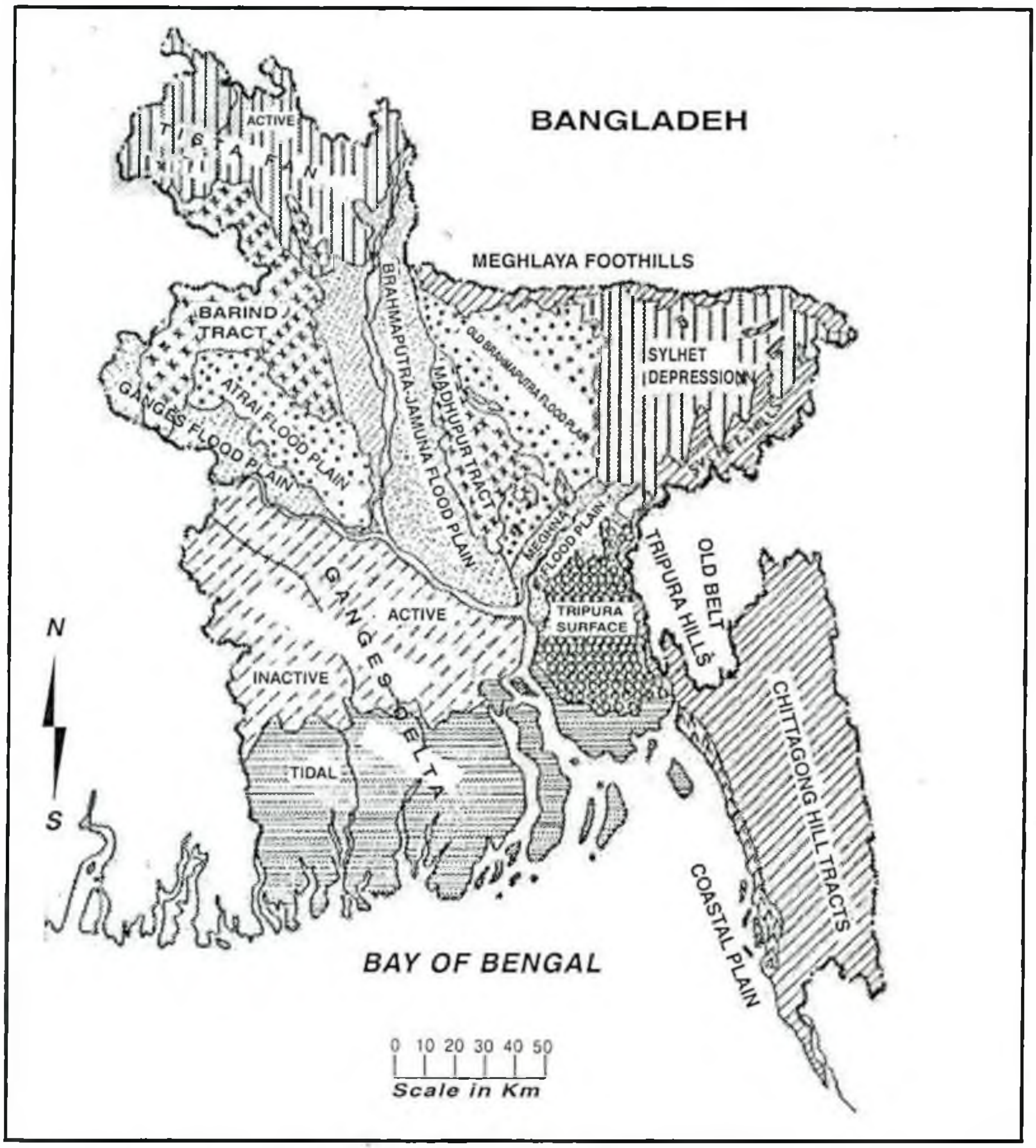
Physically Bangladesh incorporates hill, terrace and floodplain areas. Hilla of Bangladesh belongs to the tertiary region and these are occured in the north-eastern and south–eastern part of the country. The terraces of the country owe their origin to the Pleistocene glaciation and subsequent uplifment. However, the exement causes of their genesis is still observed. Some scholars (i.e. Miah,1996 and Rigvi,1964) opined that these are glaciated and uplifted deltaic lands. The Pleistocene terraces in Bangladesh occur in three separate areas in country. The Barind Tracts occur in the north-western part of the country , the Bhawal-Madhupur tracts occupy the central part of Bangladesh and are distributed in the greater districts of Dhaka, Mymensing and Tangail. A small Pleistocene tracts of land can be found in the eastern Bangladesh at Lalmi Hills in the District of Comilla. A brief description of these three broad physiographic regions is given bellow:

Hill areas : These include the northern and eastern hills and occupy about 12% of the country. These are underline by Tertiary and Quaternary sediments which have been folded, faulted and uplifted, then deeply dissected by rivers and streams. There is an overall pattern of long linear ridges running approximately north-northwest to south-southeast with the highest elevation as high as 900 m above mean sea level.

Terrace areas : These include Madhupur Tract in the centre and Barind Tracts in the north-west occupy about 8% of the country. These areas are not true alluvial terraces but are almost level surfaces appearing above the recent deposits. The Madhupur Tract is closely dissected and broke by faults. The Barind Tract is composed of an uplifted and locally titled series of fault block interrupted by a major river valleys occupying fault troughs.

Floodplain areas : These include alluvial floodplain and estuarine areas and occupy the remaining 80% of the country. They are composed of predominantly recent alluvial deposits transported from the hills by the rivers. There are numerous natural depressions some of which are abandoned channels formed as a result of change in river courses, and some have been formed in the process of delta building and as a result of tectonic movements of the earth.

Figure- 1.5 : Generalised Physiograhic Map of Bangladesh



Source : Modified after Alam et. al. 1990

1.13 Types of Floodplain Landscape in Bangladesh

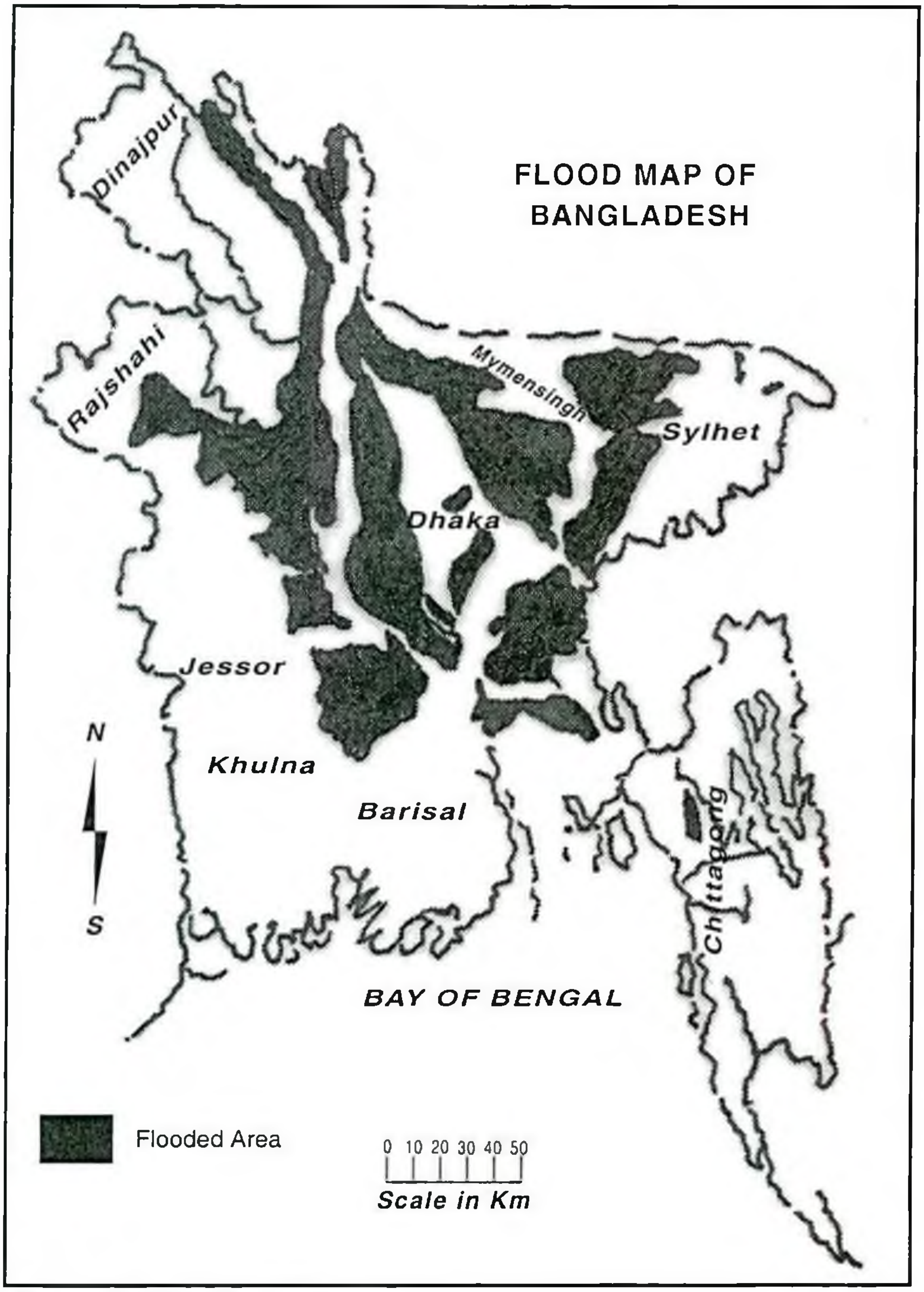
Four main types of landscape can be recognized (Brammer, 1996) in the floodplain areas discussed earlier. They are briefly discussed below :

(1) **Piedmont plains** : These are characterized by gently sloping land, composed of mainly sandy deposits, at the foot of hills with riverain colluvial and alluvial deposits and a drainage pattern of a braided river. The main areas occupied by them are most parts of Dinajpur (Old Himalayan piedmont plain) and north-western part of Rangpur region (Teesta floodplain)

(2) **Meander floodplain** : These floodplain have been formed by the big meandering rivers which deposit sediments within the channel on river beds and also alongside the channels. Gradually high river banks (levees) build up. A meandering river constantly

shifts its course, eroding the outside banks of bends and depositing new sediments on the inside bends. This process goes on repeatedly and account for the complex patterns of relief and sediments and abandoned channels. Meander floodplains cover greater part of Teesta, Atrai-Karatoya, Brahmaputra, Jamuna, Ganges and Meghna river flood-plains.

Figure – 1.6 : Normally Flooded Areas of Bangladesh



Source : Modified after BWDB, 1998

(3) **Tidal floodplains** : They cover mainly the South-West part of the country (Ganges Tidal Floodplain) and part of Chittagong Coastal Plain. These are characterized by a distinctive, almost-level landscape crossed by innumerable, interconnecting tidal rivers and creeks following zigzag patterns and flood levels lower than on meander plains. Inundation of lands happens twice a day at high tide and most of the area is flooded during spring tide.

(4) **Estuarine floodplains :** They cover most parts of Comilla and Noakhali regions, adjoining part of Barisal, Patuakhali and Faridpur and recently developing Meghna Estuary. They are characterized by almost horizontal level underlain by silts deposited uniformly both in the lateral and vertical directions under estuarine conditions.

1.14 Climate of Bangladesh

Bangladesh has a tropical monsoon climate. In general, the climate is characterized by high temperature, heavy rainfall, often excessive humidity during monsoon (June to September) and marked inter and intra seasonal variation. Winter is mild dry here. The months of November, December, January and February are cooler. In winter temperature seldom dips below 5/6 celsius.

Temperature : The mean annual temperature is about 25^{O} C within the country. Mean monthly temperature ranges between 18^{O} C in January and 30^{O} C in the month of April to May. The highest and lowest temperature throughout the year ranges between 43^{O} C and 4^{O}C with the exception in the areas near the coast where the range is narrow.

Day-Length and Sunshine : Except a little variation in the bordering areas in the east and the coastal fringe, day-length and sunshine hours throughout the whole country are in general almost same. Day-length at Dhaka varies from 10.7 hours in December to 13.6 hours in June. Sunshine at Dhaka ranges from 5.4-5.8 hours/day in the monsoon season to 8.5-9.0 hours/day in the winter (from December to February) and pre-monsoon (from March to May) seasons.

Wind, Storm and Cyclone : The wind direction is mainly south-west and south– east during the pre-monsoon and monsoon season and from between north-west and north-east during the post-monsoon (from October to November) and winter seasons. The advent of occasional Nor`westers with velocity of 50-100 km/hr changes the wind direction in the pre-monsoon season. Tropical cyclones from the Bay of Bengal with high velocity of more than 115 km/hr are liable to hit the coastal areas in the pre-monsoon and post-monsoon seasons.

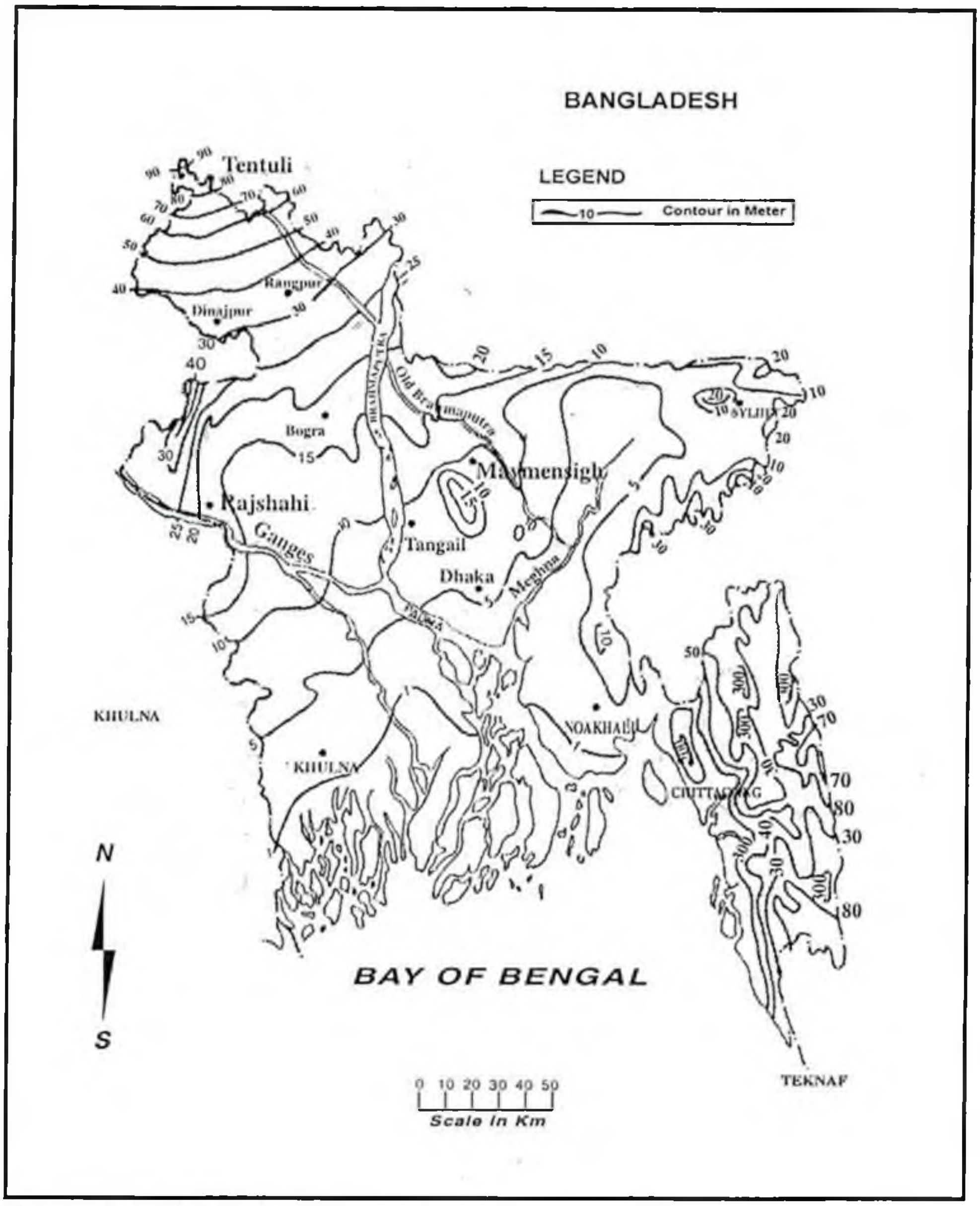
Humidity : The humidity is relatively high throughout the year. It is over 80% during the months from June to September, i. e. the monsoon months, The humidity is around 58% in most of the western areas of Bangladesh in March and April and in the eastern in January, February and March.

Evaporation : Evaporation rates range from about 50-75 mm per month in the dry season to 100-175 mm per month in the pre-monsoon season. In the monsoon, they are generally about 100-125 mm. Annual potential evapo-transpiration rates (modified Pen-man) ranges from about 1.180 mm in the north-east to 1,285 mm in the center-west. (ISESCO, 97).

1.15 Role of relief of Bangladesh in flooding

Bangladesh stretches between $20^{O}34$ to $26^{O}33$ North latitude and $88^{O}01$ to $92^{O}41$ East longitudes. The topic of cancer passes over Bangladesh. It has an area of approximately 144,900 sq. km bounded by India to the west, north and east, Mayanmar to the south- east and the Bay of Bengal to the south. The Himalayas is close to the northern border of Bangladesh. Three major rivers, the Ganges, the Brahmaputra and the Meghna meet inside Bangladesh before discharging to the Bay of Bengal through a single outfall. Most part of Bangladesh is the floodplain of these three mighty rivers.
A generalized relief contour map is shown below. It is seen that most of Bangladesh consist of extremely low and flat land. The capital city Dhaka which is about 225 km from the coast is within 8 meters above the mean sea level (MSL). The land elevation increase towards north-west and reaches an elevation of about 9 meters above the MSL. The lowest part is the coastal tidal land. The highest area in Bangladesh are the hill tracts in the eastern and Chittagong regions. Except some hilly and some tract region most of the area of Bangladesh is flood plain. Moreover, a numerical large and small rivers flow over Bangladesh. These rivers carries a lot of sediment and uplift the depth of channels.

Fig 1.7 : Generalized relief contour in meter



Source : HARZA, 1986

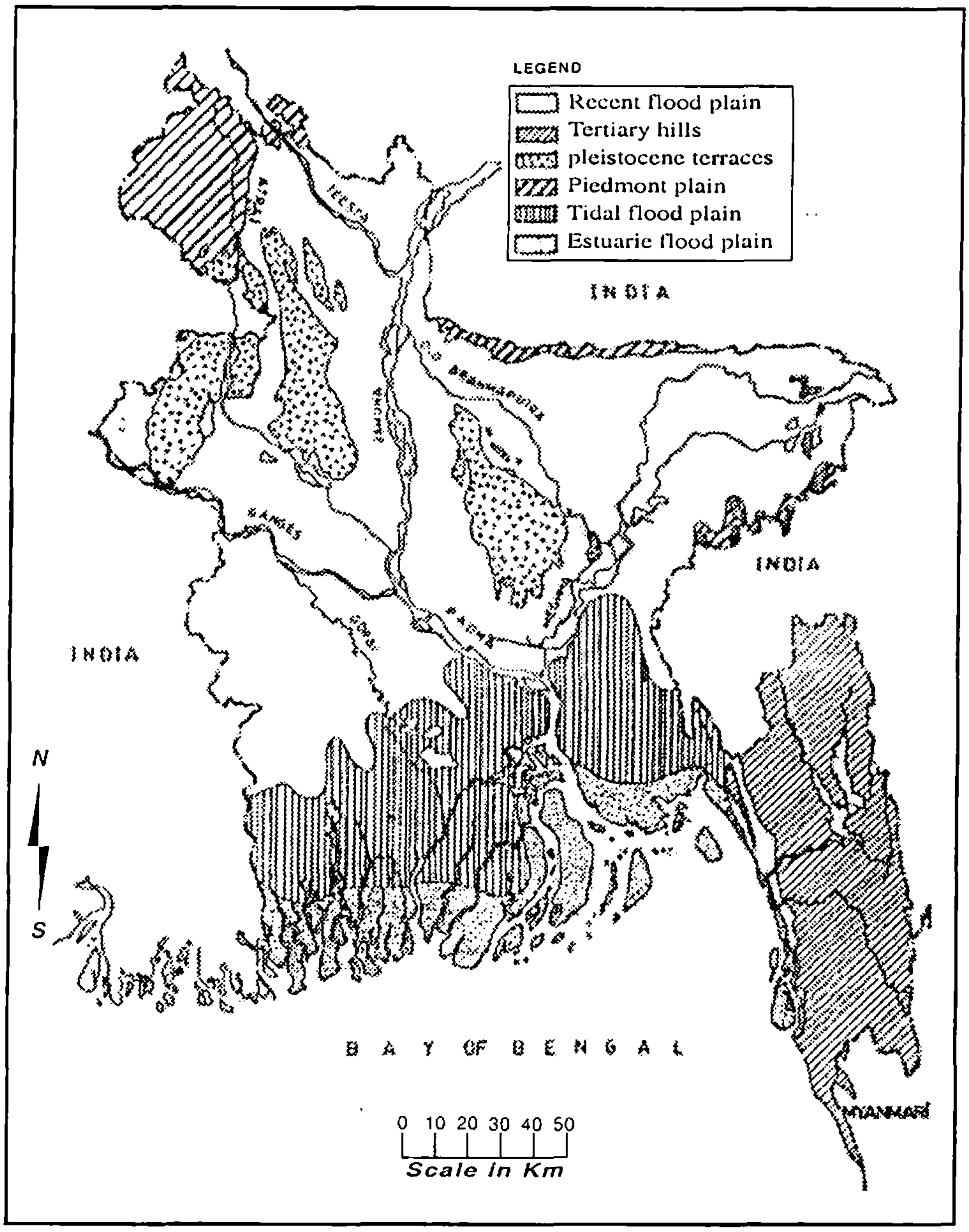
Large areas has been uplifted in recent times and some areas are still subsiding. It has been postulated that these tectonics may be due to the presence of a major fault. This fault lies along a line connecting Calcutta and Mymensingh and passes slightly above the confluence of the Ganges and the Brahmaputra as shown. This fault is called as Hinge zone.

1.16 Role of Hydrology and Drainage in Flooding

As stated earlier the causes of floods in different regions of Bangladesh are not the same ; nor do they generally occur simultaneously. Flash floods in the Sylhet-Habiganj-Maulavibazar belt usually occur during the early part of the monsoon. Because of heavy rains in the catchment area in Meghalaya, Assam and Tripura States in North-Eastern India, rivers get swollen too soon, and since they flow down from the hills, they do it with great velocity. The result is a sudden onrush of water which may inundate the localities and cause damage to crops, houses and embankments. Floods in the Jamuna-Brahmaputra basin come later than the flash floods. They usually occur in the middle or later part of the monsoon. There is always a time lag between such floods occurring in North and Eastern India and Bangladesh.

Irrespective of timing and place of occurrence the damage caused by floods is nearly the same in nature. This is well shown by the facts we gathered from the selected regions. Pabna and Kurigram, Narail and Faridpur, Comilla and Chittagong, all suffer along with Sylhet the same kinds of setback. Selection of these regions was influenced by the very fact that all of them have experienced floods in recent years. This enable us to see the nature the effects of floods in different setting more clearly. Some of the clusters in Chitttagong, Comilla and Sylhet are reported to have experienced the worst floods of a recent years in 1985. The worst fold damage for the country as a whole was, however, recorded in 1074. The elevation between different localities within a cluster do not also differ widely. Therefore, no structure can totally escape damage.

Figure- 1.8 : Floodplain Landscape Map



Source : IFCDR, 1996

1.17 Survey of Existing Literature

Research on flooding impacts and their modeling is carried out in a few advanced countries. The major contributing countries are the USA, UK, and Australia. In USA, the collection of flood damage information has been in practice as far back as 1902. In the UK, the practice started only in the late 1960s. Nevertheless, with the exception of the USA these countries started using these data for appraisal of flood alleviation schemes comparatively recently. The following section presents an overview of flood research in abroad.

In the USA, various federal agencies used to carry out rapid assessment of flood loss potentials (called windshield surveys) from only a examination of the external appearance of the affected residential buildings (US Department of Agriculture, Soil Conservation Service,1970). Flood loss potentials for future floods used to be assessed or rather projected on the basis of actual events (US Army Crops of Engineers 1979). The actual damages so assessed were used mainly for appraisals of flood control projects at regional level, having no application at national levels.

The approach of exploring future damages from actual flood were subsequently modified and the synthetic method of flood damage assessment started to be adopted in the USA. The approach initially developed by White (1964) and Kates (1965), was followed by the Tennessee Valley Authority (TVA) and the US Army Corps of Engineers (USACE). Both TVA (1969) and USACE (1970) concentrated on the generation of synthetic direct damage data in response to specific requirements of the federal flood insurance administration. The two agencies developed a series of depth-damage curves based on direct damages to a group of residences, the properties grouped according to aspect, e, g, number of rooms, storeys and construction materials. The susceptibility at each hypothetical depth for each house type was estimated from different sources, e.g. relevant builders and manufacturers. These curves from the basis of estimating potential damages to different groups of residences, which were then generalized to similar residences in other areas of USA.

James and Lee (1971) suggested an empirical linear function for shallow flooding, correlating damage with depth and property values. For a deeper flooding, they argued that the curve was likely to be of a non-liner form.

In Australia, Aitken (1976) regressed empirical damage data of depth fo flooding and floor areas to predict future flood damage for the Brisbane river. The regression analysis, based on a sample of 400 households, derived the value of percentage as 0.34 and 0.27 for the structural and contents damage respectively, was criticized by Penning-Rowsell and Chatterton (1977) for being too `poor to be used in future damage assessments`. The low coefficients of determination in all the cases indicated, not surprisingly, the presence of a large variability in the existing damage data. However, given the large sample size and degrees of freedom, the coefficient of determination for all the cases were found to be statistically significant.

In the UK, methods of modeling damages to residential buildings used in the 1960s were rudimentary. For example, Porter (1970) assessed damages as a fixed percentage of property values. Yet crude in nature, during the early 1970s, the water authorities in the UK employed a flat rate, 10 percent values, to represent losses in all depths of flooding. The Wessex Water Authority (1974) used an absolute rate of $ 500 per dwelling as potential losses, calculated on the basis of insurance payment for flood damages. Roberts (1968) was probably the first in the UK to adopt survey techniques to assess flood damage potentials. The approach was, however, criticized by penning–Rowsell and Chaerton (1977) as notorious for underestimating past damage.

Researchers, centered mainly in the Flood Hazard Research Centre, appear to have made a breakthrough in the field of flood loss modeling in the mid 1970. After years of continuous research and development, a series of approaches and methodologies were developed. In the UK (and perhaps, USA), the assessment of potential flood damages based directly upon actual events was found to be impracticable for many reasons. The major reasons related to the scarcity of observable floods over various depths or durations and large number of house types occupied by a large number of socio-economic groups. Consequently, the synthetic approach was adopted for the assessment of residential flood loss potentials (Parker and Penning Rowsell 1972; Parker 1976; Penning-Rowsell and Chatterton 1977).

The most comprehensive study of flood loss potentials in the residential sector in the UK is the one by Penning-Rowsell and Chatterton (1977), popularly know as 'Blue Manual'. Indeed, the study was a breakthrough in flood loss research in the UK, specially in the residential sector. The study adopted the synthetic approach in constructing nationally applicable standard data sets for various depths and durations. The depth variable has been explored for high levels of disagreegations, while, not surprisingly (in view of the UK flood characteristics), the duration variable has been highly aggregated. The high-level depth desegregations has warranted fine-level damage estimates with the availability of fine-level hydrological information. However, the skewed distribution of samples over depths and durations posed limitations on performing statistical tests. Some of the methods and data have subsequently been revised and updated, incorporating technological and other changes (Suleman et al 1988). Fordham et al(1994) tested the fit of logarithmic functions for the residential damage, using interview data in the UK. The study correlated damages with depths of flooding in structural damages. For content damages, depths of flooding and the proportion of recovered losses were used as explanatory variables, in addition to 'time of flooding' which was used as a dummy variable.

Research on flood losses in commercial sectors is center around indirect losses, as assessment methods for direct losses are relatively straightforward. Hitherto, a limited number of studies have been carried out on commercial flood losses. Research on indirect losses is particularly meager. Until recently, industrial flood loss potentials for future floods used to be predicted on the basis on actual events. This approach used to suffer from many estimation biases, such as those raising out of the tendency to record replacement cost rather than depreciated costs. Projections of indirect losses in future floods used to be made through obtaining crude rations between direct losses and production disruptions (White 1964; Kates 1965; Smith and Greenway 1984).

In the study of industrial losses in the Leigh Valley (USA), Kates(1965) found it methodologically difficult to obtain the relationship of production losses (indirect loss) with depths of flooding of past events. The study recognized that firm's financial losses were to be designed from national economic losses. The study also concluded that although the 'synthetic' approach is feasible, it is a highly involved task

Smith et. al (1979) addressed flood damage assessment in the Richmond River Valley in Australia based on past floods. They largely adopted the assessment techniques developed by Penning-Rowsell and Chatterton (1977). The research succeeded in constructing depth-damage curves, by which future potential damages were predicted at disagreegated levels of depths and durations. However, the approach of estimating indirect losses based on the gross trading profit turnover ratio method potentially led to an underestimation of true losses, as the best measures of indirect loss is value added on production lost. Additionally, the study has ignored production transfers and recoveries within the economy, which possibly led to an over estimation of indirect loss.

Taylor et. al's users'(ANUFLOOD 1983) recommended that crude ratios of indirect to direct losses be used to project indirect loss in the future floods in Australia. This approach is fraught with the problem that damage characteristics and susceptibility to flood water are subject to changes in technological development in the production process. Parker and Penning-Rowsell (1981) criticized the approach saying that the 'ratios' are likely to vary 'between places and between return periods in the same place.' Thus, given that indirect losses as a whole are likely to be 'highly variable' (Parker et. al 1987) due to different flood conditions and diversity in activities, it is almost impossible to appropriately standardise damage ratios.

The British methods of loss assessment in commercial sectors are based on interview techniques. The Blue Manual constructed depth-damage data for industrial enterprises in the study area of lower Severn (UK) based on site survey questionnaires.

However, the study acknowledged methodological weaknesses and recognized the need for further research into these problem's.

Based on several researches, carried out mainly by the Flood Hazard Research Centre(FHRC), a series of assessment methods were developed. The fundamental loss estimation method involved deriving damage estimates in hypothetical floods, based upon 'expert judgments' through interviewing industrial managers. The recent most pioneering research on loss assessments in commercial sectors is the one by Parker et al (1987), popularly known as 'Red Manual'. The study devised methods with special reference to indirect losses, the aspects the least covered in terms of research. This study also addressed flood loss potential in other sectors of the urban economy, e.g. communication, life-line outages and emergency services. The level of analysis ranged from preliminary desk-based to refined-level analysis and used area of the premise for standardization. The research overcame many problems associated with the approaches used in past research. The study distinguished national economic losses from firms 'financial loses, through incorporating production transfers within economy. It also addressed the problem of over-estimation of direct loss potential through incorporating average remaining values. However, the estimates of damages were heavily dependent management personnel and are likely to be subject to 'personal' bias, especially where respondents have no prior flood experience.

1.18 Flood Research in Bangladesh

In Bangladesh, especially in non-agricultural sectors, there is no attempt yet to systematically collect flood damage data. Ironically, hither to there exists little basic research on flood losses and their assessments methods. In either urban or non-agricultural losses. With a few exceptions, flood research has been mainly limited to appraisals or evaluation studies in the form of reports which focus largely on agricultural losses.

In his well-known book entitled, 'Poverty and Famine'–an entitlements and Deprivation', Sen (1981) concluded that lack of entitlements to food due to 'loss of employment associated with the lack of purchasing power, not the food shortage', was the main cause of the famine which followed the devastating 1974 flood. It can however, he argued that the losses of employment and lack of purchasing power were indirect effects caused partly by widespread flood in that year.

Paul (1984) studied post-flood agricultural adjustments. The study concluded that floods are not necessarily harmful. Normal floods are rather beneficial to agriculture.

Abnormal floods, however, cause adjustment problems to farmers. Montgomery (1985) studied crop losses caused by floods, through analyzing deviations from trend. Murshid (1987) assessed the relative role of weather hazards and technology (seed-fertilizer-water) in affecting the output instability of food grain. The study concluded that weather-related factors are still dominant in Bangladesh agriculture.

The study by HIID/ESCAP (1988), sponsored by the Planning Commission, carried out an extensive survey in order to assess flood damages and their distributional impacts caused by the 1988 flood. One of the important conclusions of the study was that the poor are more vulnerable to floods. The extent of distress sales by the poor was about 2.5 times that of the non-poor.

The study by Shahabuddin (1989), based on his Ph. D research, included econometric models to delineate the role of risk in the resource allocation of small farmers in Bangladesh. The French Engineering Consortium (1989) studied macro economic effects of flood control projects in Bangladesh. The study inferred that the average annual cost of flooding on GDP is in the rage of 0.8%. Hossain (1990) analyzed fluctuations (from estimated trends) in food grain productions at the national and regional levels to explain the production instability caused by natural hazards.

The study by Thompson (1990), which is a follow-up research of his PhD dissertation, has reviewed existing appraisal and evaluation methods, and suggested various improvements to such methods, particularly in relation to flood control agricultural projects of Bangladesh. The study suggested that appropriate standard data base can be developed towards an improvement of project appraisals and understanding of the benefits and limitations of flood mitigation choices in Bangladesh. Azam (1991) suggested a multi-sector growth model in order to analyze macro economic impact of the FAP in the short and long run, with special reference to the impact of risk on the growth path. Maurice and Diallo (1991) attempted to quantify the macro–economic impact on growth prospects. The study recommended that the long-term impact on growth prospects be taken into consideration along with the standard method of economic analysis when evaluating flood control projects in Bangladesh.

1.19 Bangladesh Flood Action Plan (FAP)

The strategic and options for flood control in Bangladesh have debated for many years. Following the proposal of a Master Plan prepared in the mind-1960s, some major embankments combining the functions of flood control, drainage and irrigation were built along the banks of the main rivers. With the side-spread advent of small scale irrigation since the early 1970s, the strategy of water control tended to change to construction of small-scale early implementation projects (EIP) that could provide rapid results towards mainly protecting agriculture. Since then, the issue of flood control has been frequently overlooked. However, the 1987 and 1988 floods –the most severe floods on record in Bangladesh, created awareness both at home and abroad and called for solutions. Subsequently, in collaboration with a few foreign countries, the World Bnak framed a Flood Action Plan (FAP) for the development of a long term comprehensive system of flood control and drainage works.

Covering a five-year period 1990-95, the Flood Action Plan in all comprised 26 components, concerning planning, supporting activities, high priority and regional studies which are expected to provide grounds for setting the foundations of the long-term program. Some of the studies are completed while some remain in progress. The reports and studies so far represent different approaches to the flood problem.

FPCO (1992, FAP-12) and FPCO (1992, FAP 13) evaluated 17 completed FCD/I projects using formal survey methods and rapid rural appraisal methods, the farmer concentrating on agricultural impacts and the latter operation and maintenance. FAP-12 stressed the need for research to provide comprehensive data and methodology which could be used consistently across FCD/I project appraisals in Bangladesh. FPCO (1992, FAP-114) aimed at assessing the flood response practices adopted by floodplain users. The GOB-UNDP (1989) projects emphasized comprehensive structural solutions, recognizing the needs of major drainage works along with the construction of flood embankments. The approach of control flooding was also recommended in some areas to facilitate normal agricultural crops and ground water recharge. Rogers et. al's (1989) Eastern Waters Study analyzed the drawbacks that the construction of embankments and dams are less feasible in economic, technical and ecological terms than other methods. The study presented a series of alternatives emphasizing non-structural measures. The Japan Ministry of Foreign Affairs (1989) found it important to protect some urban centers and areas, including the capital city.

1.20 FAP-Project Assessment Guidelines

There exists a number of documents in the from of guidelines on appraisal methods and economic analyses for FCD/I projects. These are, among others, FPCO Guidelines for Project Assessment (1991a; 1992e); Shahabuddin and Rahman (1992); MPO Investment Analysis Model (1991); and GOB-Republic of France's Pre-feasibility

Study for Flood Control in Bangladesh(1989). It is important to present at this stage a brief description of the guidelines on appraisal methods, recommended in these documents in order to provide the rationale of the current research.

FPCO Guidelines (1991a; 1992c) are designed for the principles to be used in economic and financial analysis of investment projects under the Flood Action Plan. The guidelines, however, concentrate on the evaluation methods of agricultural protection schemes that are principally aimed at reducing potential crop losses. The documents is based on the standard techniques of cost-benefit analysis (in relation to e.g. cropping pattern, costs of production, economic prices of agricultural commodities, and conversion factors) of agricultural investment projects, as used by organizations such as the World Bank. Annex-3 of the documents outlines some general principles on the post-project assessment of non-agricultural/fisheries flood damage, principally concerning direct benefits from flood protection in 'with' (W) and 'without (WO) situations. The guidelines delineate the widely accepted principles of estimating mathematical expectation of annual flood damage in W and WO cases, without spelling out any assessment methods/principles whatsoever of how to assess the non-agricultural damages (e.g. to residential and commercial sectors). Nevertheless, the direct damages (e.g. embankments and roads) are recommended for inclusion in the economic analysis. It is, however, suggested that 'direct' loss data are collected from secondary sources such as relevant Ministries /Agencies (e.g. MRR, MLF, BWDB). In particular, it is suggested that the damage data on fisheries be collected from District or lower level, available in summarized forms from the Ministry; a careful scrutiny, however, is stressed to 'reconcile inconsistencies and inaccuracies' in such data. It is also suggested that the damages caused due to economic and social interruptions of activities are 'difficult to assess and should not be included in the analysis.

The document, GOB-Republic of France (1989) (Pre-feasibility Study for Flood Control in Bangladesh) strongly suggests that the indirect benefits induced by flood protection/control to non-agricultural sectors be considered. The study maintains that although Bangladesh is generally well furnished with statistical information and documentations, the information in regard to flood damages (on particularly non-agricultural sectors) are 'incomplete, inconsistent and partially incorrect.' As also discussed in Chapter 1 on the rationale of the same research, the assessment of such losses in Bangladesh has been based on arbitrary calculations without representing any scientific basis. There is no systematic way of collecting flood damage information on annual basis on particularly non-agricultural sectors. Only in exceptional floods are some loss assessments carried out on an adhoc and emergency basis 'with a view to mobilizing external and internal support.'

However, GOB-Republic of France (1989) suggests that flood damages be collected from various 'reports' 'prepared' by various institutions and agencies, who generally maintain the damage records in physical, but not monetary terms (e.g. number of people affected, houses damaged),. As the records are largely prepared based on visual assessment of affected properties, it is suggested to 'review' and analyse such cautiously' before using this. It is recommended to use 'best possible guesses; from damage records of past floods, in appraising flood protection projects.

Shahabuddin and Rahman (1992) is a well-documented guide, however, dealing with various costs, such as economic prices of selected commodities and conversion factors for use in FAP planning purpose. MPO-Investment Analysis Model (1991) is another well-documented guide, but dealing with allocation of investment funds year by year for FCD/I projects ensuring a selection procedure from a set of investment alternatives. The model concerns only benefits from agricultural cropping.

Hence, few guidelines on methods of loss assessments, let alone for urban and non-agricultural losses, are covered in any of the guidelines.

1.21 FAP Urban Protection Studies

In the recent past, a number of feasibility studies for town protection has been carried (EPCO, FAP-8A 1991b; EPCO, FAP-8A 1991c; EPCO, FAP 9-A 1992 f ; BWDB, FAP-9B 1992; GOB-UHDP, 1992). The projects have largely differed in their primary objectives. FPCO (FAP-8A 1991b) is a master plan for protection of Dhaka Metropolitan area. EPCO-8B 1991c) is feasibility study of environmental management plan for Dhaka city. FPCO (FAP-9A 1991f) is a secondary towns integrated protection with four project components of which the flood protection is one. BWDB (FAP-9B 1992) is primarily concerned with protection from erosion. GOB-UNDP (1992) (Multipurpose Cyclone Shelter Programme) is not a flood protection scheme, but it aims at determining cost-effectiveness (as compared to public expenditures elsewhere) of constructing shelters of multiple use. The principal benefit amounts to the human and animal life savings during storm-surges, and the use of the shelters as primary schools during the remaining period. The other damage savings, if any, are not considered in the analysis. Because of various primary objectives the studies mentioned above adopted varied methodologies in the assessment of protection benefits.

In order to provide contexts to the development of flood loss assessment methods and demonstrate the justification the current research it is important to examine the methods adopted by these studies in assessing flood losses in non-agricultural sectors. The review that follows applies almost to all the above studies; special reference, however, is made of the relevant studies where appropriate. Nevertheless, the present discussion concentrates on the methodology of benefit assessment from flood protection. In general, the methodologies on loss assessments (i.e. benefits of protection) adopted by the studies appear to have suffered from many weaknesses. However, only a few main points are outlined in the following brief discussion.

Most studies have sought damage information from 'record' of past floods. An important limitation is that, in none of the studies, potential loss data sets by depths or durations, by sectors or sub-sectors are constructed. No land use survey by sub-sectors (commercial activities) or by house types (residential sector), nor any hydrological survey to determine vulnerability of individual properties is carried out. The studies use only limited land use information, collected largely from secondary sources. As demonstrated in chapter 7 of the concerned study, the information on land levels and heights of properties are crucial to the precision of flood protection benefits. As revealed in the same study in Section 7.2.2.1 flood loss estimates are very sensitive to small changes in flood levels of properties. However, in none of the studies any such land level or height surveys are undertaken. In consequence, the benefit assessment without any knowledge of the extent of inundation (in terms of depths or duration) caused to various types of properties by a range of floods has certainly led to gross errors.

Following the lack of standard potential loss data sets in Bangladesh, the study FAP-8A has sought linear relationships of damage ratios (to values) with depths and duration for 1987 and 1988 flood, which appears not to be logical. Additionally, in such a function the possibility of satiation of damages in varying depths or duration is ignored. More importantly unless any groupings to properties under investigation by homogeneity are carried out, no stable relationships are likely to exist, as there exists a great diversity in their type, stock, capital and thus damage dimension across various properties. In the commercial plants investigated in the current research, for example, enormous variations are manifested at times a few hundred times, across various types of enterprises

The study of FAP-8B relies mainly on the loss estimates and their assessment methods adopted by FAP-8A. The study also uses limited damage information collected from secondary sources. Almost all the studies (8A, 8B and 9B in particular) use flat rates (fixed rations) to assess damages to properties regardless of type and size of properties in each of the sectors. One of the most serious limitations relates to that the studies have not distinguished actual event damages from potential damages. The actual damages (which is indeed a part of the full potential damages), either in absolute or proportional terms, are not suitable to exhibit functional relationships with depths and durations, as there exists varied extent of damage reduction measures adopted by various flood plain occupants. The studies generally have not properly distinguished, if at all, between financial and economic losses to properties. Another limitation is that the studies generally have not incorporated 'average remaining values' while estimating flood damages. This will associated with substantial over-estimation of damages, because, if a damaged inventory, for example, is replaced after flood, full replacement value is not the flood damage. One needs to consider the depreciated value in the pre-flood situation

The income loss in households and profit loss in commercial enterprises are not the true reflection of indirect flood damages (8A; 8B). The production loss in industries amounts to the loss to value added, and the turnover loss in business amounts to the loss to gross margin (Parker et al 1987). Over and above, as adopted in the studies, the income losses in households and profit loss in commercial enterprises have every potentials of being double counted. Indeed, the direct and indirect losses (let alone multiplier effects) caused to emprises or households have not been properly defined or distinguished. Generally, flat rates are used to represent income losses to commercial (industrial and business) enterprises, as a whole.

In estimating indirect losses particularly, no consistent methodology is followed. A serious limitation is that output recoveries, trade adjustments and the transfer of losses have not been accounted for in the studies. In industrial /business enterprises, damage to machinery-equipment and inventories are pooled together (8A), and flat rates for the sectors as a whole are used, which is subject to significant errors as machinery and stock have completely different susceptibility to inundation.

FAP-9A, as already mentioned, contains flood protection as one of the four components. The major component is drainage, low-lying areas development and environmental improvements. Following FAP guidelines, the study uses land use and damage information (by broad sectors) from secondary sources. In damage assessment, the study considers mainly structural damage, represented by fixed ratios, irrespective of any size and type of properties. The current research, as will be seen in subsequent chapters, clearly shows that the variations of susceptibilities and damages, both within and among groups of properties, are enormous. This is more so for business and industrial enterprises. Similarly, flood damages are significantly different (at times many fold) among different socio-economic class of households and size and scale of commercial enterprise. Most studies use flat rates to assess damages. The study, FAP-9B, for example, uses fixed ratios, e.g. 15% and 25% to assess total flood damages to residential and commercial sector respectively. Even business industrial enterprises are not distinguished. The use of float rates across all properties (commercial-across business and industries, households-across all socio-economic groups) inevitably leads to a considerable over-estimate of benefits, as, for example, damage ratio for a low-cost house type is many-fold compared to that for a high-cost house. The most serious limitation of the methodology adopted in the studies relates to the use of average depths or durations of inundation by zone/area, which inevitably leads to serious errors in the benefit assessment.

In FAP 8A, only two flood scenarios (e.g. 1987 and 1988) are considered while estimating damage-frequency curve, the curve which is crucial to the precision of expected annual damage. There are other drawbacks as well. For example, the 1987-scale flood appears to have no flood impact on building structures of business, office and industrial enterprises, although depth of inundation to such properties ranges up to 1.7 meters and duration up to 32 days depending on the land use, which is unusual.

In aggregate, the feasibility studies appear to have not been based on sound and consistent methodologies and damage data, in consequence of which the benefit assessment appears to have been subject to considerable errors.

In the present study the overall situation of the country is reflected. Floods of 1987 and 1998 are elaborately discribed here as major floods in the immediate past sever floods.

CHAPTER - II

HISTORICAL ACCOUNTS, NATURE, CAUSES & STATISTICAL ANALYSIS OF FLOODS IN BANGLADESH

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2.0 Historical accounts of floods in Bangladesh

Bangladesh is located between South and South-East Asia. The issues of adjustment to nature and to other human groups residing elsewhere in the region are of vital significance for the people of Bangladesh. The country occupies greater part of the Bengal Basin. Eighty years ago, the population was less than one-third of what it is to-day. The high growth rate of the population and the interactions of the peoples of the whole of the Ganges-Brahmaputra-Meghna Basin have created profound problems for the continued progress of the people of Bangladesh. The international media have succeeded in presenting Bangladesh to the world community as "a perennial Basket Case" and as a land where natural disasters are endemic. Of these natural disasters the most frequent and devastating to the life and property are floods, cyclones, storm surges and tidal bores.

The yearly monsoon flood are much more predictable and usually less severe in terms of loss of life than the cyclonic storms and tidal bores which hit the coastal areas of Bangladesh and Eastern and the South-Eastern India.

Floods are normally associated with the yearly monsoon rains that pour into the entire Ganges-Brahmaputra-Meghna Basin. Large areas in Bangladesh are normally inundated by monsoon flood water between June and October every year.

In Bangladesh, which is mostly a vast flat land, floods have always been a recurrent phenomenon. This riverine country has been experiencing floods more frequently than ever before in the recent years. Since the partition of 1947 the country has experienced very high floods in 1954, 56, 66, 74, 84, 87, 88, 98 and last in 2000. Each year's highest flood record had been broken by the subsequent years and at the same time each year's damage has been surpassed by the next years damage. The unique geographical location of Bangladesh bordering by the Bay of Bengal to the south, the Great Himalayas and the Khashi-Jayanti-Garo Hills to the North along with the prevailing monsoon, has shaped the country as one of the most watery region of the world. Moreover, Bangladesh lies at the confluence of the three mighty rivers of the world, the Ganges, the Brahmaputra and the Meghna.

Their numerous tributaries and distributaries interlace the land. Draining a total catchment areas of about 1.6 million sq. km. these rivers join each other in the plain of Bangladesh and finally debauch into the Bay of Bengal (Tarafder,1974) of the total drainage area of these river systems, however only 7.5 percent lies within Bangladesh. The streams and rivers of Bangladesh drain an average of about 870 million maf- of water per year to the Bay of Bengal (Elahi, 1988). Moreover, the country gets another 203 million maf- rain water per year. The annual mean rainfall of the country is 1800 mm. or 70 (inches) of which nearly 80 percent of the aforesaid vas surface flow through Bangladesh is concentrated in these four months.

All the above mentioned topographic and climatic factors have made Bangladesh one of the world`s major flood vulnerable areas. The country is subjected to inundation by over bank due to drainage congestion, rainfall runoffs and cyclonic or tidal surges. Some 30 percent (26,000 sq. km.) of the total land surface of the country is flooded every year (Hossain, 1987). However, the high floods inundate an average of 40000sq. km. land of the country. From 1954 to 1998, more than a dozen flooding occurred on Bangladesh and caused serious loss and damage to the lives and property in the country. Recently flood occurred in 2000 in the South–West part of the country was also very destructive.

The country, Bangladesh has been experiencing floods since the historical past. No complete record is available on floods prior to 1922. Professor Mahalanabis, a noted statistician and meteorologist, prepared a report in 1927 on the severe 1922 flood which occurred in Dinajpur, Bogra, Rajshahi and Pabna areas of the present Bangladesh territory. This is considered as the first comprehensive report of the past flood in Bangladesh. Professor Mahalbnabis in his book "Report on rainfall and Flood in North Bengal, 1870-1922" has included a list of floods which occurred during 1870-1992, a period of more than half a century, with their causes, severity and affected areas.

Well documented flood reports are available from 1953. It is seen from the analysis of the records that floods of severe and catastrophic type are occurring more frequently in present days.

2.1 History of Floods in Bangladesh

Attempts to control floods and prevent the erosion of river banks are not new. The successes and failure of previous attempts offer an opportunity to learn from past experience and evaluate the implication for current approaches to water management planning. This chapter reviews such past experience in Bangladesh. The inhabitants of the floodplains of Bangladesh are accustomed to dealing with floods and they have been managing their water resources for countries. During this time, a variety if indigenous methods and techniques have developed and certain records of water management along the Ganges system date back to the 14^{th} century [IIED, 96].

2.1.0 Mughal Period

From time immemorial floods had been occurring in this extremely flat and riverine country. The earliest flood recorded in the history of Bengal is that of the Meghna Basin and this flood was stated by Abul Fazal in his famous Ain-e-Akbari (chowdhury,1988). This flooding occured in 1584-85 and the area which suffered most was the 'Bogla Sorkar' the area corresponded to the southern portion of the present districts of Barisal-Patuakhali of Bangladesh. This deluge had perished about 200,000 lives. It is evident that it was one of the coastal types of floods.

The next of which any record is available is the Gomti flood of 1660 (Majumder, 1970)). It was a flash-flood and it took place in the Tippera (comilla) surface. This flooding devastated the standing crops of the field, took many lives and livestock's and perished numourous homesteads, markets and roads. The then king of the region constructed an embankment along the river Gomti to check the annual flooding at that time.

In 1662, another great flood occure in North Bengle and Assam (Majumder,1978). Mir-Zumla was the Suneder of the then Sube-Bangala of the Mughul Empire. Mr. Zumla's Assam expedition was foiled due to this serious inundation and he had to return from coochBihar. This flood was due to an excess and prolonged down pour in the Brahmaputra Basin and it caused immense misery and devastated huge lives and property.

2.1.1 British Period

During the British colonial period (1757-1947) traditional forms of flood and irrigation management were dismantled or left to decay and the combined consequences of river erosion and siltation took their toll. By 1928, Sir William Willcocks, a British engineer, was lamenting their demise. He proposed a system of 'overflow irrigation' to end the 'deprivation of the country of the rich red flood water [of the Ganges] by the breaking of the existing claims of embankments at suitable points'. In effect, he was proposing to 'open-up' the floodplains to allow the spread of floodwaters.

The colonial period also saw the construction of a network of road and railway embankment . Their alignment bore little relation to the contours of the river basin, nor did they necessary facilitate the free-flow of water over the floodplains. These embankments were the first large-scale infrastructures to obstruct the free passage of water over the plains.

During the time of East India Company's rule in Bengal another serious flood took place there in 1769-70 (Chowdhury, 1988). This flood along with the previous year's drought and resultant crop failure for consecutive two years brought the famous killer famine of the Bengal caused the death of one-third of the total population of Bengal. In 1784, the Meghna Basin had experienced the occurence of another disastrous flood (chowdhury, 1988). This inundation was due to the excess of precipitation in the catchment area and it affected the districts of Sylhet and Tippera (now Tripura comilla) seriously. After only a few years, another serious flooding took place in 1787 which devastated almost all parts of the Eastern and Northern portions of Bengal (Chowdhury, 1988). During this unprecedented flood 'boats were the only means of transport which could play on all the streets of Dhaka and in the countryside. People lived on rooftops for their survival'. During this flood the river *Teesta* and the *Atrai* changed their courses to be connected with the Brahmaputra. The effects of the flood of 1987 was outstanding and this flood worked to change the courses of many rivers of Bengal.

2.1.2 Pakistan Period

During the 1950's brought the issue of flood control and water development firmly into the development agenda in the country (then East Pakistan). In 1957, a UN mission, led by J. A. Krug, investigated water management options for dealing with floods. Country to popular belief, the Krug mission's recommendation did not provide any firm endorsement for a program of flood control. The report drew attention to the shortcoming of available engineering data and the need for careful study before embanking or any large-scale conatruction of flood embankments. Comparable reservation were re-stated later by two further studies : one in 1963 by General Hardin a former chairman of the Mississipi River Commission, and the other in 1964-65 by Porfessor Thijisse of the Netherlands.

The Krug Mission recommended the establishment of a new government corporation with responsibility for water and power development, and this gave rise to the East Pakistan Water and Power Development Authority (EPWAPDA). With the assistance of various multinational consultants including the International Engineering Company (IECO), the Authority soon started work on a 20 year Master Plan (1965-85) for flood control, drainage and irrigation works, aimed at increasing agricultural output . It involved the construction of thousands of miles of embankments, nearly one hundred polders and numerous water control structures.

2.1.3 After Independence

After the liberation of Bangladesh (1971) implementation of the plan (made before the Independent) continued until the end of 1980's. EPWAPDA was dismantled and was succeeded by the Bangladesh Water Development Board (BWDB).

There are records of numerous high floods in the last century too. But the trend of occurrences of inundation has turned into an alarming deterioration in the second half of the current century. Statistics and estimates over the last 50 years show that over a dozen of high floods and 5 severe floods occurred in Bangladesh during the last 5 decades.

2.2 Statistics of Floodings

Many parts of the Asia during monsoon frequently suffer from severe floods. Some part of India and Bangladesh experience floods almost every year with considerable damage. Flood statistics for Bangladesh are available since 1954 and are summarized below. The floods of 1954, 1955, 1974, 1987, 1988 all caused enormous damages to properties and considerable loss of life. The consecutive flood of 1987 and 1988 caused heavy damage. Again during 1998, Bangladesh experienced most devastating and prolonged flood in the history and caused serious disruption on the economy of the country. During the flood 1998, the extent of damages so far estimated by disaster Management Bureau (DMB) is around 3.0 billion dollar.

Table – 2.1 : Year-wise flood affected area in Bangladesh

Year	Flood Affected Area		Year	Flood Affected Area		Year	Flood Affected Area	
	Sq. Km.	%		Sq. Km.	%		Sq. Km.	%
1954	36,800	25	1970	42,400	29	1985	11,400	8
1955	50,500	34	1971	36,300	25	1986	6,600	4
1956	35,400	24	1972	20,800	14	1987	57,300	39
1960	28.400	19	1973	29,800	20	1988	89,970	61
1961	28,400	20	1974	52,600	36	1989	6,100	4
1962	37,200	25	1975	16,600	11	1990	3,500	2.4
1963	43,100	29	1976	28,300	19	1991	28,600	19
1964	31,000	21	1977	12,500	8	1992	2,000	1.4
1965	28,400	19	1978	10,800	7	1993	28,742	20
1966	33,400	23	1980	33,000	22	1994	419	02
1967	25,700	17	·1982	3,140	2	1995	32,000	22
1968	37,200	25	1983	11,100	7.5	1996	35,800	24
1969	41,400	28	1984	28,200	19	1998	1,00,250	68

Source : BWDB, 1999

The following table shows the amount of areas affected by a few significant floods since 1954. It can see that 1998 was the worst event inundating nearly two-thirds of the country.

2.3 Nature of floods in Bangladesh

Flood in Bangladesh are normal natural happenings. Floods are normally associated with the annual monsoon rains that pour into the entire Ganges-Brahmaputra-Meghna catchment area. Large areas in Bangladesh are usually inundated by monsoon flood water between June and October every year. The yearly monsoon floods of Bangladesh are much more predictable and usually less severe in terms of loss of life and property than some abnormal high floods or cyclonic bores of the coastal areas of the country.

The flood water normally moves from the upstream to the downstream of a river in the form of a solitary wave. Therefore, it has an advanced front, a peak and the recession limb (Miah, 1988). As a flood wave moves down the river channel, the depart of water increases gradually at a station and the water spreads over the section of the station so long the peak of the flood reaches at the station in this phase, the flood engulfs first the low-lying areas and then the dwelling houses and buildings; afterwards the roads, highways. fairways and runways, etc. However, this order normally depends upon the land features of any region. In most of the flood plains and river basins of Bangladesh- flooding follow this order of occurrence and recession. On the basis of the nature and origin of inundation Bangladesh experiences different types of floods:

- general or monsoon floods
- flash floods or foot-hill types of floods
- high intensity rainfall floods
- cyclonic surges and tidal bores (coastal types) and
- accidental floods (due to breaches in embankments)

Usually, a general or monsoon flood in Bangladesh advances gradually attains peak height slowly and also recedes from a place Quite slowly. The devastating effect of this type of flood does not depend on advance, rather of the peak height of flood and the duration of the flood water. It has been mentioned earlier that the occurrences of the monsoon floods are easily predictable and normally are associated with the yearly monsoon rains between the months of July and October.

Flash flood in Bangladesh occurs in the hilly rivers and they do not give enough time for evacuation of transfer of valuable properties and move to safe place. Normally flash floods occur in the early part of the monsoon rainfall in may and June. In the hilly rivers of the North-East and the South-east region of Bangladesh this type of inundation takes place. The *Monu* (moulvi Bazar), *Khuwai* (Habiganj) and *Lure* rivers of Sylhet region (NE) and the *Feni,* the *Halda,* the *Sangu,* the *Matamuhuri* and the *Baghkhali* rivers of Chittagong region (SE) produce flash floods. These streams have steep elopes and short courses. The runoff from the heavy rainfall in the nearby hilly areas of India, Burma and Bangladesh causes flash floods in these torrents. These floods usually have short duration, super critical velocity and very high degrading effects.

High intensity rainfall sometimes causes serious localized floods in Bangladesh. Localized high intensity precipitation of short duration caused the flood of 1966 in Dhaka city. In 1984, again this types of flood inundated the city. However, this types of flood is less harmful and recesses away rapidly.

The coastal belt of the country is vulnerable to the cyclonic surges and tidal bores. Due to shallow water effect and the funnel shape of the coastal region of Bangladesh the cyclonic surges and tidal bores can easily submerge the abnormally flat and low coastal-belt region. Moreover, if the pounding waves of cyclonic surge coin-cide with a huge tide, their amplitude may be as high as 10 to 12 meters. This type of inundation is locally known as "Gorky" and it causes unbelievable damage and loss to the life and property of the coastal people of Bangladesh. Such cyclonic surges ravaged the coastal parts of the country in 1960, 61, 63, 65, 70, 85, 87, 96, and last in 98. Most severe cyclonic floods occur in the month of October and November.

2.4 Causes of flood in Bangladesh

Climatologically, the country has two distinct seasons, a dry season from November to May and the Wet (flood) rainy season from June to September (or October). More than 80% of the rainfall occurs during the monsoon or rainy season when flooding normally occurs. The normal annual rainfall of the country varies approximately from 1,200 mm in the west to over 5,000 mm in the east. Long periods of steady rainfall persisting over several days are common during the monsoon, but sometimes- local high intensity rainfall of short duration also occurs.

The basic causative meteorological condition for monsoon rainfall is the extensive, deep incursion of warm, saturated air from the Bay of Bengal over the whole northern Indian Sub-continent. Within these system, the detailed synoptic conditions vary to give periods of greater or lesser rainfall activity. The occurrence of monsoon lows passing over Bangladesh and West Bengal produces period of heavy rain, as do fluctuations in the position of the monsoon axis which at its fullest northward extent lies along the southern margin of the Himalayan.

Water level of the rivers begin to rise steadily at the onset of the monsoon and reach their peak level in July, August or September and the inundation normally may cover about 20% area of the country. Flash flood occur in the north-eastern, south-eastern and extreme northern areas of the country at any time during the monsoon. Wide spread overland flooding become severe and devastating when the peak of Ganges, the Brahmaputra and the Meghna synchronize along with spring tide and remain at high stage for long periods.

The following factors have been identified as being responsible for flood in Bangladesh :

a) Heavy and incessant rainfall in the upper catchment of the cross-boundary rivers as well as inside the country.

b) Topographically the country is situated below about 7.60 metre (about 25 ft) from above mean sea level (MSL). Floodwater spills from the rivers and accumulates on these low-lying areas.

c) Bangladesh and surrounding catchment areas lie in the heavy monsoon rainfall area that leads to a concentrated large discharge in the rivers. As a result, this channel is frequently overloaded and spills over the banks and cause flood in the plain.

d) There have been significant changes in the behavior of off-takes of the main rivers-distributaries of the Ganges- Padma and Brahmaputra after the Assam earthquake of 1950, which caused the Brahmaputra river to become heavily silted. Due to blockage at confluence and off-take of distributaries, there has been a concentration of water in the main river system.

e) Simultaneous high discharge of the upland streams and high tides in the estuaries, low topography of the country and river bed all contribute to the over bank spilling of the rivers.

f) More than 80% of the annual precipitation occurs during the monsoon. This localized heavy rainfall and runoff coincide with the high discharge in external rivers resulting in drainage congestion. Locally concentrated rainfall on more than 300 mm in 2-6 hours leads to severe flash/local flood.

g) Spring tides of the Bay of Bengal regards drainage of flood water into the sea and locally increases monsoon flooding. A rise of MSL at times during the monsoon period due to effect of monsoon winds also adversely affect the drainage and rise the flood level along the coastal belt.

h) High water level of the main rivers slows down the flow from the tributaries. In particular, the flow of the *Dharla* and the *Teesta* being backed up by the Brahmaputra and mutual backing up by the Ganges and the Jamuna affect the drainage of the *Hurasagar*. This increases the flood intensity in the adjoining areas. The backing up the drainage of the Sylhet-Mymensingh haors through the Meghna due to high water prevailing in the lower Meghna at Chandpur is a well-known phenomenon.

i) A series of geographical faults have created depression in Rajshahi, Pabna, Bogra and the Sylhet-Mymenshingh haor area. These areas become inundated with the advent of monsoon and remain waterlogged until November. Generally, the Brahmaputra records its peak flood during the month of January-July and the

Ganges in the August-September, while the Meghna remains high from May to September. Some years it may happen that these rivers reach peak-flood level simultaneously and aggravate the fold situation in the country.

These are the main factors those influenced the flood in Bangladesh. About one-fifth to one- third of the country is flooded to varying degrees each year during May to September when about two-thirds of the food grain (mainly rice) are produced. Such a large extent of flooded area is due to extreme flat topography of the country.

2.5 Types of Flood in Bangladesh

Different types of flood can be found in Bangladesh in different time. According to their source or origin, characteristics, severity etc. the flood of Bangladesh can be categorized as follows :

i) **River flood :** The main source of this flooding is the bank overflow from the major rivers the Ganges, the Brahmaputra and the Meghna and their tributaries and distributaries during June to September.

ii) **Rainfall flood :** About 80% of annual rainfall in Bangladesh occurs during May to September when the rivers flow at high stage due to huge inflow of water from catchments outside the country. As a result drainage is impeded. Besides high intensity and long duration rainfalls cause local flooding when the local river cannot drain quickly.

iii) **Flash flood :** In the northern and eastern hill streams, flash flood occurs during the pre-monsoon months of April and May. Flash floods in the NE region cause damage to dry-season Boro rice crop just before or at the time of harvesting and also to towns and other infrastructures.

iv) **Tidal flood :** The areas adjacent to estuaries and tidal rivers in the South-East and South-Central regions get flooded twice a day due to astronomical tide from the bay of Bengal. During spring tide which occurs fortnightly, large area is flooded by tidal water.

V) **Storm-Surge flood :** The storm surges due to tropical cyclone in Bay of Bengal occasionally cause severe disaster in the coastal areas. This flood can occur during April to June and September to November. Approximately 12,000 sq. km. of coastal land is prone to cyclonic storm surge floods.

River flood and rainfall flood are frequently aggravated by the following two factors :

1) **Backwater effect from Sea :** The spring tide and the monsoon wind setup in the Bay of Bengal cause strong backwater effect in the Lower Meghna river which is

the single drainage outlet of the Ganges-Brahmaputra-Meghna river system. As a result, drainage is slowed down causing increase in the duration of flood.

2) **Time of peak flows in major rivers :** An important phenomenon that determines the extent of river flooding is the time difference between the occurrences of peak flood flows on the Ganges and the Jamuna (the Brahmaputra) rivers. When the peak flows of these two major rivers reached their confluence almost at the same time. In the first week of September,1988 more than half of the country was flooded. Occurrence of this phenomenon during the time of spring tide resulted in long duration of the flood. Occurrences of simultaneous flood peaks in the Ganges and the Jamuna is not a rare event (French Engineering Consortium, 1989).

A key feature of flooding in Bangladesh is that each flood is different . There are a number of reasons for this ;

- The monsoon rains and snowmelt in the Himalayas are, to some extent, unpredictable in terms of both timing and absolute quantity. This, in turn, influences the basin.
- The river systems themselves are highly dynamic in nature – changes in the levels of the river beds may radically alter patterns of flooding.
- Episodic events in the catchment, such as seismic activity and landslides, may have a sudden and marked influence of flooding patterns.
- Human intervention on the floodplains may alter radically the patterns of water flow and sedimentation, It is these human-induced causes of flooding and the 'second generation' problems they create that are so often overlooked in contemporary approaches to flood control.
- The out flow of flood water from the basin is controlled ultimately by sea level. Many of the drainage 'problems' experienced in the lower delta are a reflection of the fundamental difficulties inherent in draining extremely low-lying land.

The ultimate solution of these difficulties, as one pioneering scholar pointed out as long ago as 1927, can only be a continuation in the natural process of land building. Some of the principle categories of floods that occur in Bangladesh are outlined before. It should be stressed that most 'abnormal' floods result from a combination of one or more of the factors listed above (IIED,1996). The major types of flood in Bangladesh are River flood, Rainfall flood, Flash flood, Tidal flood, Storm-Surge flood, Accidental flood (Breaches in Structures) and Man-made flood.

2.6 Discharge of water: Surface water hydrology

Some major rivers of Bangladesh play a great role in flooding. Water flows are not at the equal stage all seasons. Monthly maximum and minimum water levels of some major rivers of Bangladesh are shown below:

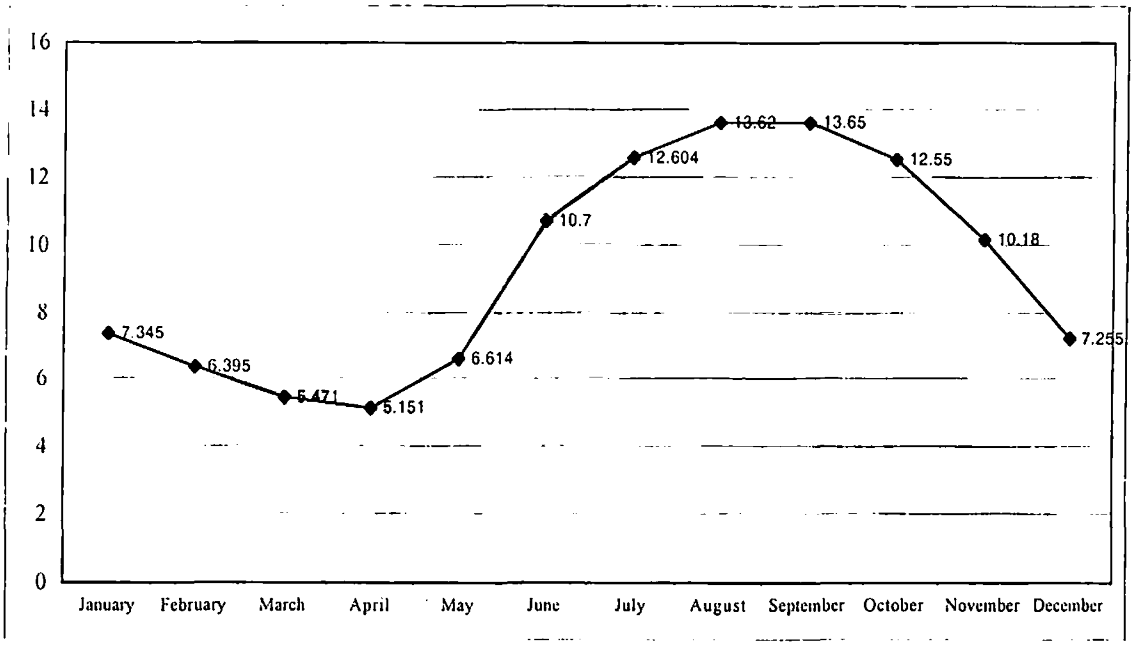
Table 2.2 : Monthly maximum water levels (m/PWD) 1970 - 2000

Station : 99 Gorai Railway Bridge, River : Gorai

Year	Jan	Feb	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1970	5.640	5.400	5.065	4.930	5.645	9.045	12.105	12.485	12.485	11.255	7.900	6.295
1971	-	-	-	-	-	-	-	-	-	-	-	-
1972	5.730	5.280	4.820	4.515	5.650	7.715	10.870	11.385	12.040	10.760	7.285	6.365
1973	6.155	5.530	5.015	5.125	6.085	10.20	12.555	13.000	12.930	12.070	9.465	7.255
1974	6.210	5.180	4.630	4.990	6.075	8.230	12.360	13.090	12.975	10.950	8.235	6.490
1975	5.120	4.505	3.945	4.680	5.345	8.710	12.575	12.785	12.720	11.135	8.375	6.170
1976	5.440	4.990	4.655	3.370	4.655	7.910	10.330	12.525	13.130	10.865	7.490	6.225
1977	5.669	5.471	5.471	4.923	5.563	7.559	11.765	12.756	12.314	11.293	8.458	6.736
1978	5.456	5.258	5.029	5.151	6.614	9.662	11.948	13.274	12.908	11.887	8.443	6.325
1979	4.846	4.084	3.780	4.846	5.517	5.928	11.964	12.055	10.927	9.098	6.629	5.334
1980	4.404	3.719	3.109	3.932	5.029	7.803	12.604	13.381	13.427	11.095	7.712	5.625
1981	4.015	3.530	3.220	3.688	4.679	6.111	12.363	12.713	12.573	11.163	6.714	5.174
1982	4.500	4.145	3.920	3.730	4.510	8.100	10.670	12.580	13.130	10.580	6.580	5.600
1983	5.630	5.495	4.950	3.880	4.950	6.115	10.800	12.120	12.550	12.550	9.200	6.750
1984	5.200	4.860	4.410	4.500	8.780	10.70	12.560	12.950	13.290	11.190	7.700	6.070
1985	5.200	4.050	4.130	4.190	4.430	6.420	12.170	12.720	12.720	12.530	10.18	7.120
1986	5.800	4.740	4.170	3.450	3.690	7.390	12.200	12.710	12.710	11.000	8.100	6.400
1987	3.460	3.280	3.280	4.350	4.600	6.890	11.800	13.380	13.380	11.420	8.830	4.660
1988	4.110	4.150	4.000	3.200	4.600	6.400	11.650	13.620	13.620	9.860	6.500	5.070
1989	4.510	4.440	4.380	3.950	5.320	8.200	11.750	11.860	11.860	11.430	7.270	5.690
1990	4.400	3.880	3.670	4.470	5.480	8.370	12.450	12.430	12.430	11.870	7.870	5.790
1991	4.660	4.450	4.340	3.640	4.970	8.980	10.500	12.140	12.140	10.270	6.400	5.360
1992	4.170	4.110	4.070	4.260	4.270	5.580	9.310	11.670	11.670	9.310	7.710	5.340
1993	4.260	4.210	4.190	4.080	4.910	6.950	10.550	11.670	11.670	11.850	7.630	5.750
1994	4.360	4.320	4.280	4.170	4.270	0.000	11.280	12.440	12.440	9.790	5.920	4.820
1995	4.950	4.610	4.530	4.230	5.420	8.620	11.130	12.080	11.860	11.520	7.590	6.480
1996	-	-	-	-	-	-	-	-	-	-	-	-
1997	6.580	-	4.980	4.630	4.630	6.130	11.420	11.920	12.000	10.350	6.720	7.520
Recorded HWL	7.435	63950	5.471	5.151	6.614	10.700	12.604	13.620	13.650	12.550	10.180	7.255

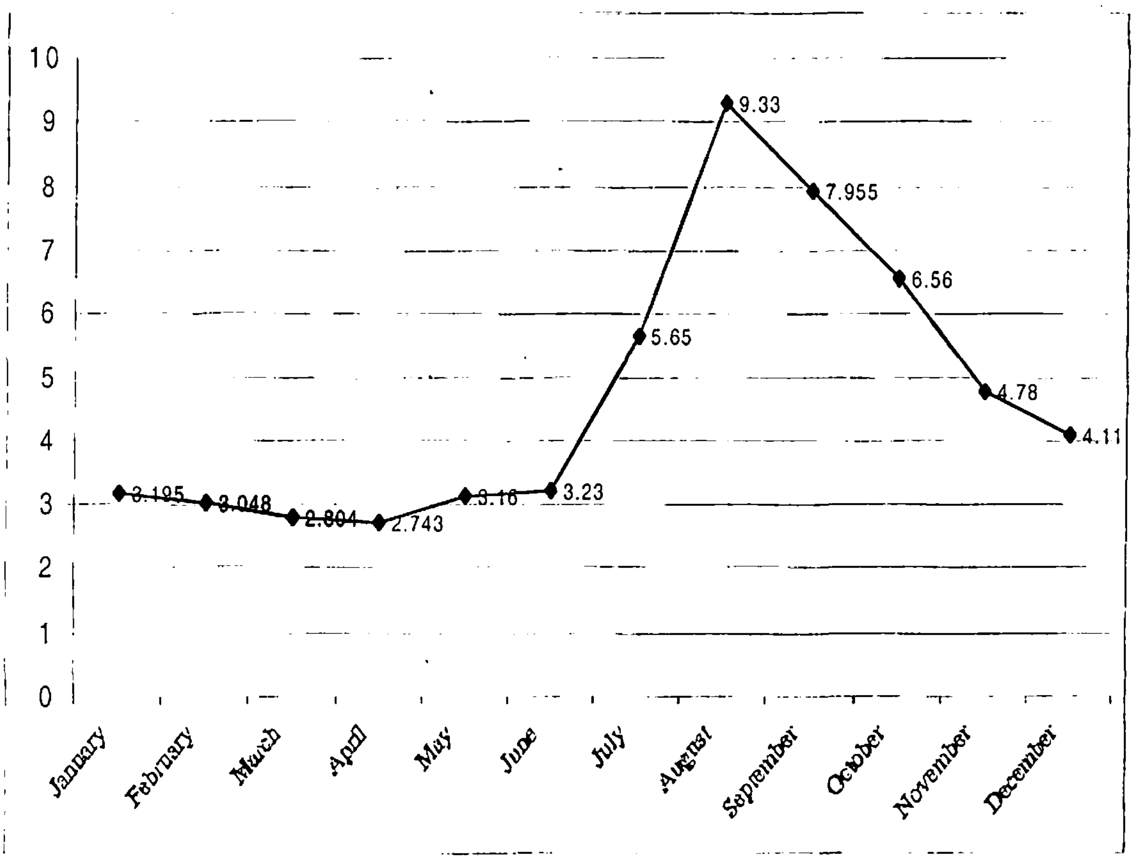
Source : BWDB, Dhaka.

Figure No : 2.1 Monthly maximum water levels (M/Pwd) 1970-2000
Station : 99 Gorai Railway Bridge, River : Gorai



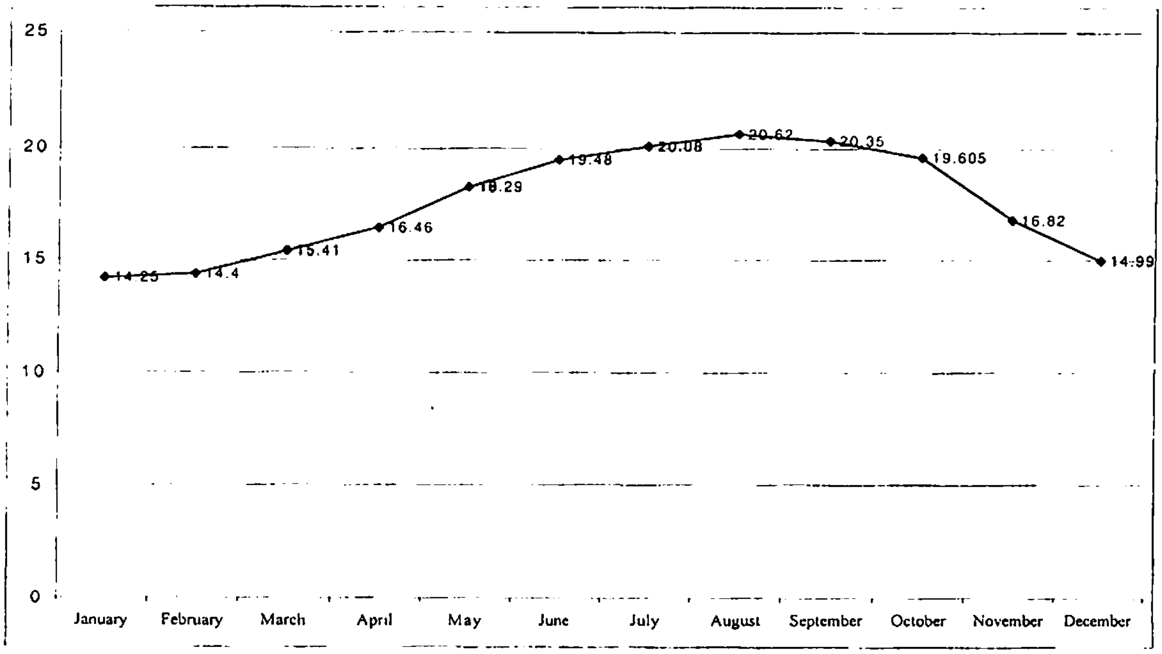
Source: Prepared from the BWDB data-2002

Figure No : 2.2 Monthly minimum water level (M/Pwd) 1970-2000
Station : 99 Gorai Railway Bridge. River : Gorai



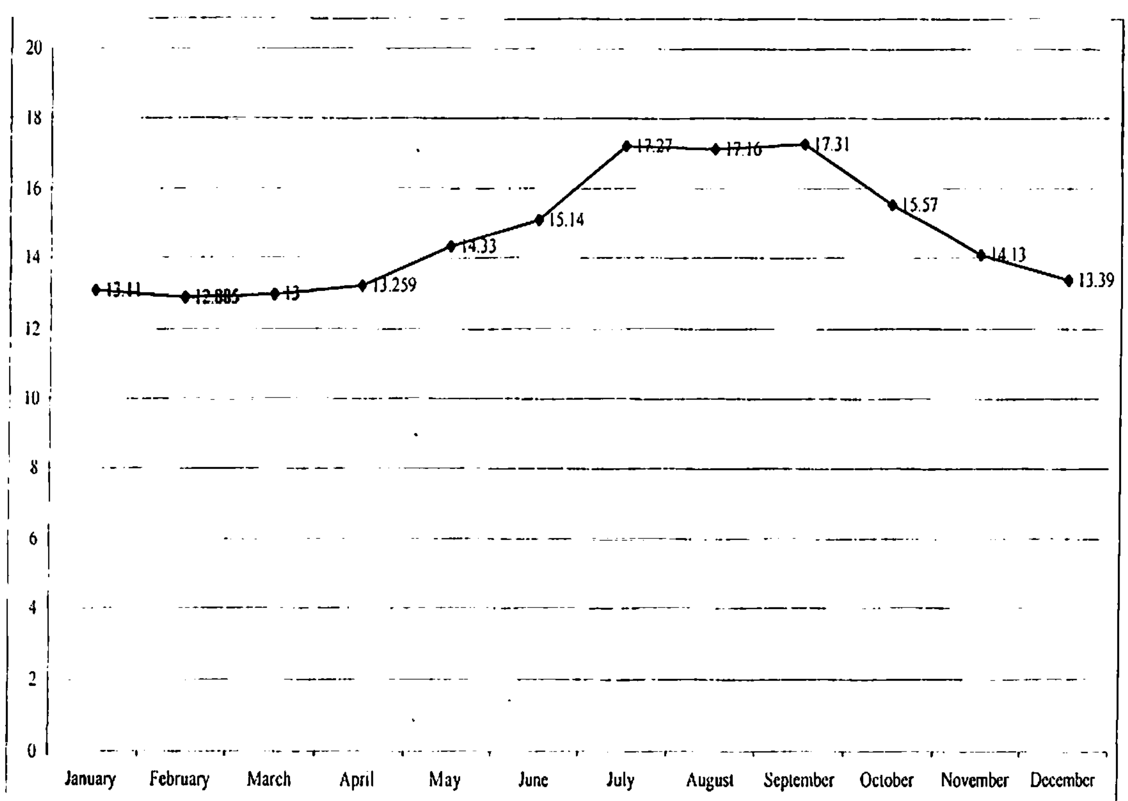
Source :Prepared from the BWDB data- 2002

Figure No : 2.3 Monthly maximum water levels (M/Pwd) 1970-2000
Station : 46 9L Bahadurabad, River : Brahmaputra-Jamuna



Source :Prepared from the BWDB data- 2002

Figure No : 2.4 Monthly minimum water levels (M/Pwd) 1970-2000
Station : 46 9L Bahadurabad, River : Brahmaputra-Jamuna



Source :Prepared from the BWDB data- 2002

Table -2.3 : Recorded monthly maximum water level in different year
Station : 46 9LBahadurabad, River : Brahmaputra-Jamuna

Year	Month	Maximum water level (m/PWD)
1991	January	14.250
1991	February	14.400
1993	March	15.410
1980	April	16.511
1995	May	18.290
1973	June	19.960
1991	July	20.080
1988	August	20.620
1988	September	20.350
1979	October	19.605
1989	November	16.630
1988	December	14.990

Source : BWDB ,2002

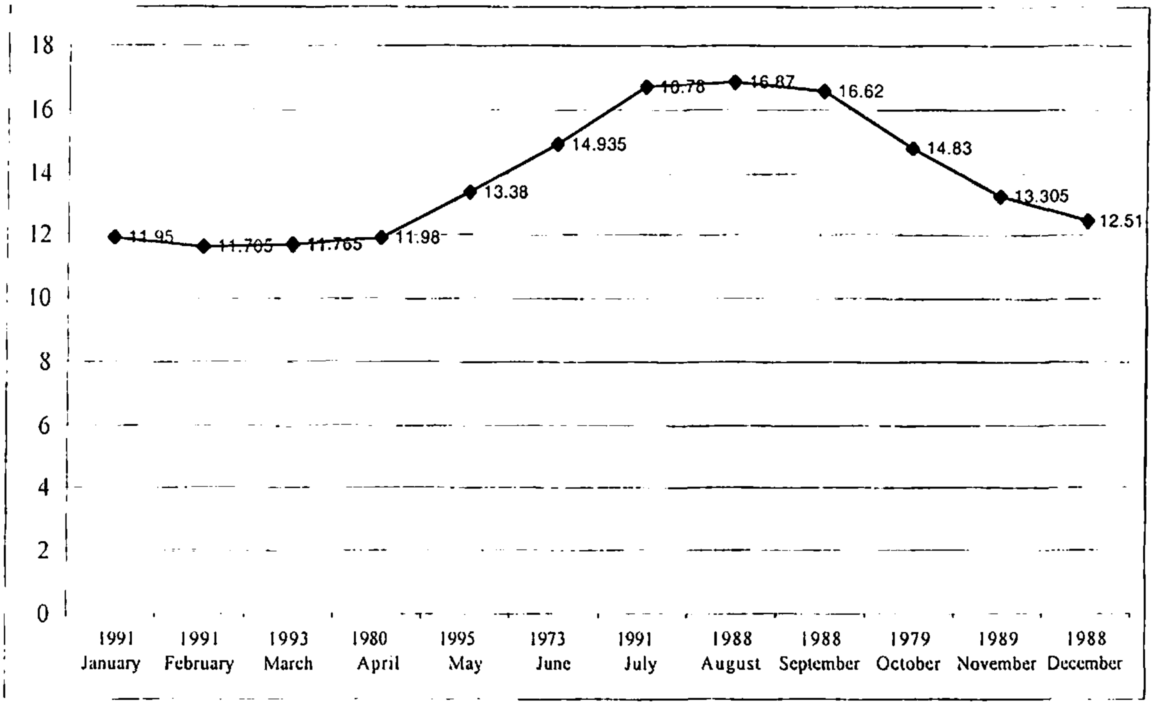
The following data and Graph shows that the flow of water increasing from March and decreasing from October in the subsequent year. The above scenario is almost common in every station with some few exception.

Table - 2.4 : Recorded monthly minimum water level in different year
Station : 469L Bhadurabad, River : Brahmaputra Jamuna

Year	Month	Recorded minimum water flows
1991	January	11.950
1991	February	11.705
1993	March	11.765
1980	April	11.980
1995	May	13.380
1973	June	14.935
1991	July	16.780
1988	August	16.870
1988	September	16.620
1979	October	14.830
1989	November	13.305
1988	December	12.510

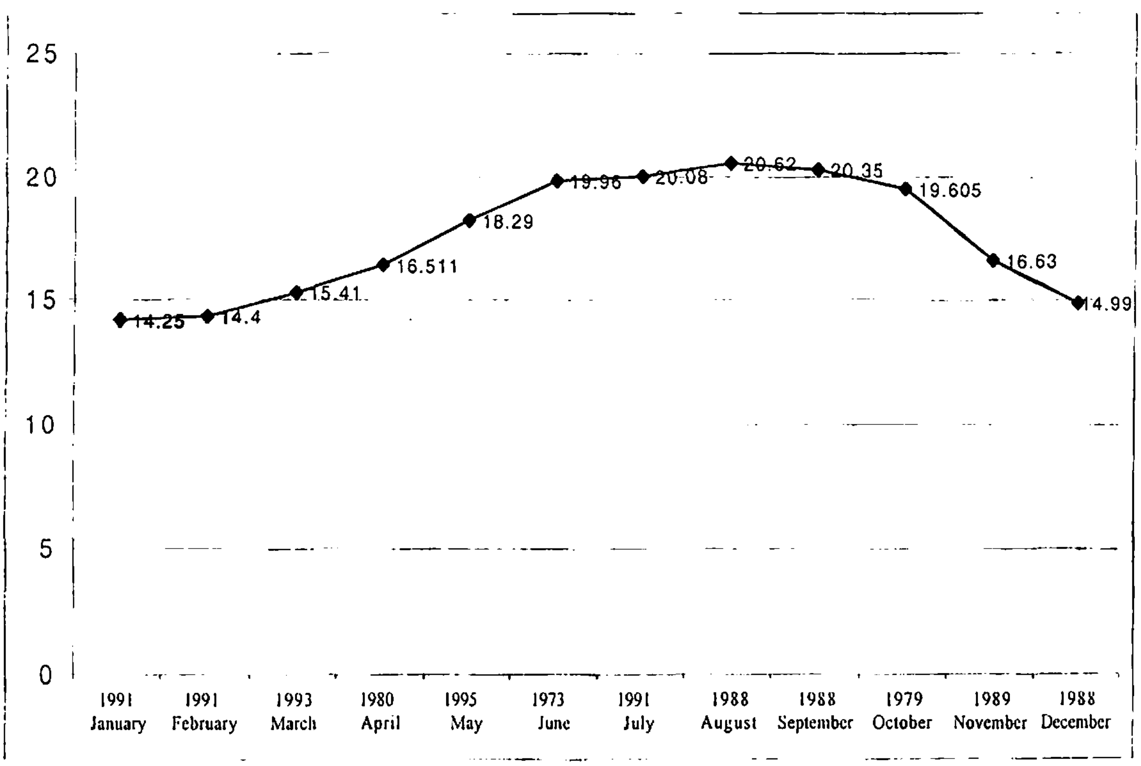
Source : BWDB, 2002

Figure No. 2.5 Recorded monthly minimum water level in different year Station : 46 9L Bahadurabad, River : Brahmaputra-Jamuna



Source :Prepared from the BWDB data- 2002

Figure No. 2.6 Recorded monthly maximum water level in different year Station : 46 9L Bahadurabad, River : Brahmaputra-Jamuna



Source :Prepared from the BWDB data- 2002

Table – 2.5 : Recorded monthly maximum and minimum water flow in 2000
Station : Bahadurabad, River: Brahmaputra-Jamuna

Month	Maximum flows	Minimum flows
January	14.250	11.950
February	14.400	11.705
March	15.410	11.765
April	16.511	11.980
May	18.530	13.380
June	19.960	14.935
July	20.360	16.780
August	20.620	16.870
September	20.350	16.620
October	19.605	14.830
November	16.820	13.305
December	14.990	12.510

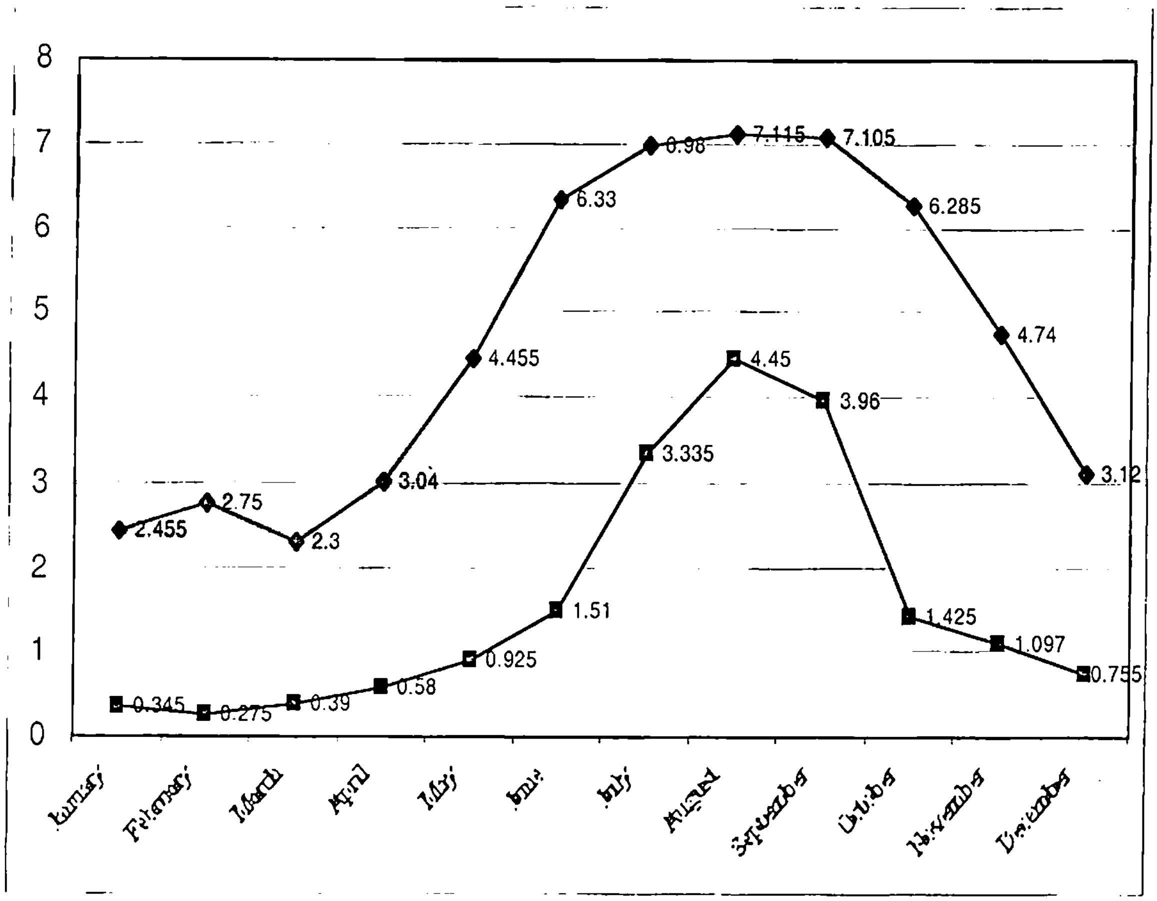
Source : BWDB, 2002

Table -2.6 Recorded monthly maximum and minimum water flows in 2000
Station : 4A off take of Arial Kha, River : Arial Kha

Month	Maximum flows	Minimum flow
January	2.455	0.345
February	2.750	0.275
March	2.300	0.390
April	3.040	0.580
May	4.455	0.925
June	6.330	1.510
July	6.980	3.335
August	7.115	4.450
September	7.105	3.960
October	6.285	1.425
November	4.740	1.097
December	3.120	0.755

Source : BWDB, 2002

Figure No : 2.7 Recorded monthly maximum and minimum water level s up to 2001
Station : 4A Off Take Of Arial Kha, River : Arial Kha



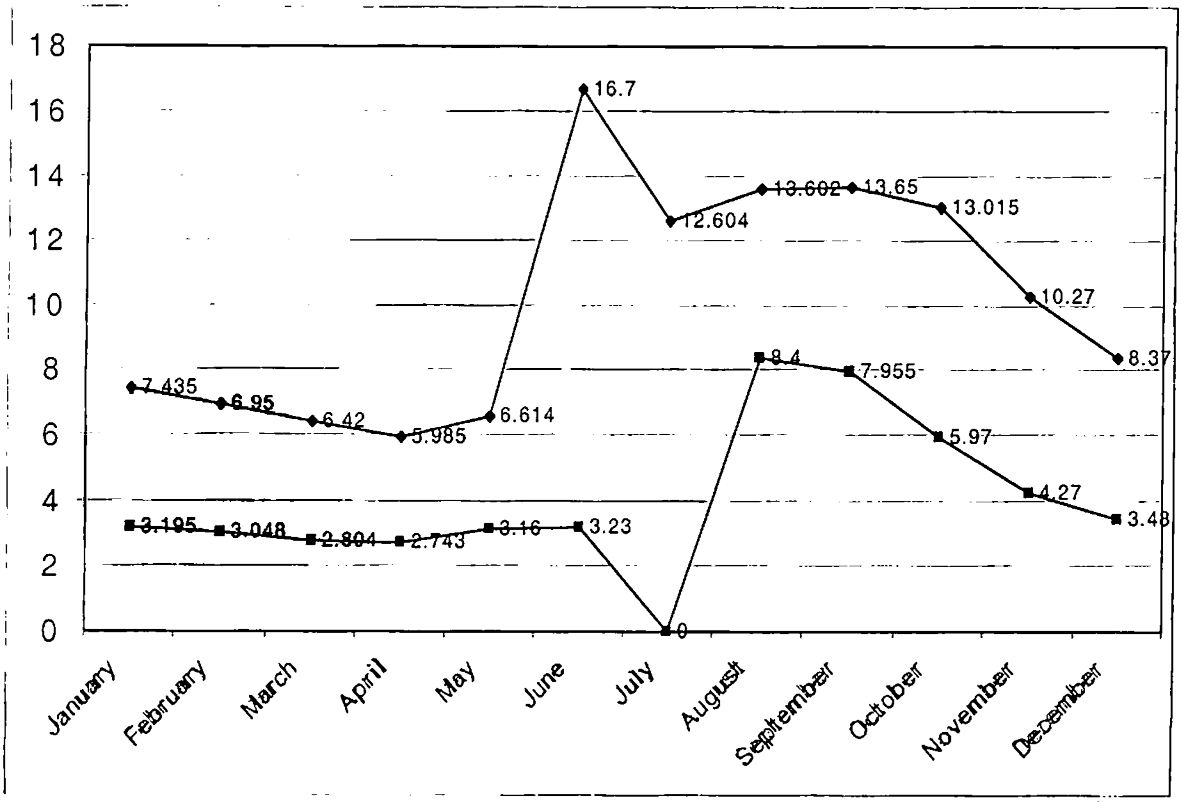
Source :Prepared from the BWDB data- 2002

Table – 2.7 Recorded maximum and minimum water levels in 2000
Station : 99 Gorai Rilway Bridge, River : Gorai

Month	Maximum water levels	Minimum water levels
January	7.435	3.195
February	6.950	3.048
March	6.420	2.804
April	5.985	2.743
May	6.614	3.160
June	16.700	3.230
July	12.604	0.000
August	13.620	8.400
September	13.650	7.955
October	13.015	5.970
November	10.270	4.270
December	8.370	3.480

Source : BWDB, 2002

Figure No : 2.8 Recorded monthly maximum and minimum water level s up to 2001
Station : 99 Gorai Railway Bridge, River : Gorai



Source :Prepared from the BWDB data- 2002

Table – 2.8 Recorded maximum and minimum water levels
Station : 99 Gorai Rilway Bridge, River : Gorai

Month	Maximum water levels	Minimum water levels
January	2.220	0.890
February	2.290	0.735
March	2.940	0.900
April	3.140	1.080
May	5.230	1.720
June	6.260	2.060
July	7.480	3.710
August	7650	4.680
September	7.660	4.500
October	6.550	2.756
November	4.910	1.670
December	3.140	1.280

Source : BWDB, 2002

2.7 Concluding Remarks : The history of floods in Bangladesh shows the increasing and continuously deteriorating situation than that of past history. The aforesaid statistics of flooding since 1954 reflect the senario on the same way. The yearly monsoon floods of Bangladesh are much more predictable and usually less sever in terms of loss of life and property than some abnormal high flood or cyclonic bores of the coastal areas of the country. The coastal belt of the country is vulnerable to the cyclonic surges and tidal bores. Climate of the country plays a vital role in flooding. Almost 80% of the rainfall occures during the monsoon or rainy season when flooding normally take part. The main inflation of flood water cause from outside Bangladesh mainly from India. Rainfall and inflation of river water causes different types of floods in the country. These are River floods, Rainfall flood, Flash flood, Monsoon flood etc.

From the analysis and study of the floods and climato-hydrological stations in Bangladesh and its neighboring countries it is evident that flood has become a recurring hazard for the country. Bangladesh has to face the loss and damage of this obvious natural calamity almost every year.

Statistical analysis of the flood of the country Bangladesh shows that flood come almost every year from mid May to mid September in the year concerned. After this peak season the people are free from this natural calamity in the year. Of course it is not absolutely true that flood will not come in the year out of this season. Other period of the year are not be treated as flood free time. It may be called that the above mentioned period is the most hazardous period. Flash flood and Tidal Surges may come any time of the year.

CHAPTER - III

HYDROLOGICAL FEATURE OF FLOODS IN BANGLADESH

CHAPTER-III
HYDROLOGICAL FEATURE OF FLOODS IN BANGLADESH

3.0 Introduction : Floods in Bangladesh exhibit some typical regional Characteristics. Here normal extensive floods occur in the monsoon rainy season. However, in some places inundations with some peculiar behaviour takes place. The monsoon floods are widespread and stays for about two months. The rainy months of July, August and September are the period of the monsoon floods. These occur in almost all the tow-lying flood plains of all the major and medium rivers of the country. Normally these floods are not that much devastating. These may stay for longer periods. Yet, the depths of these floods usually attain considerably lower heights. These floods arrive gradually, attain their peaks slowly and also recedes slowly. On the other hand, flash-floods occur in the foot-hill (Piedmont areas in the higher elevations) areas in the northern and south-eastern hill slope plains of the country. These appearance in sudden and effect is destructive and colossal. These come very fast and go in a hurry leaving behind enormous imparts of loss and destructive. Normally smaller hilly torrents (i.e. The *Mom, Khuaye* in the Greater Sylhet region and The *Chengi, Sangu* of Chittagong region) carry the huge flood water of this categories. In the coastal regions great deluge- like inundations occur during the strong cyclones. These coastal deluges, locally known as the *gorkey*, cause immense loss and destruction to life and property of the coastal people. Among these various categories of floods sometimes normal monsoon floods may turn into catastrophic deluges. The floods of 1987 and 1998 fallen these types. Although, the genesis of these two deluges were as the normal monsoon-type yet, in the course of time these turned into mammoth catastrophic floods because of the synchronization of peaks, effects of spring tides and the simultaneous occurrence of poundage effects resulting from the impounding of the cyclonic surges from the Bay of Bengal.

3.1 Analysis of 1987 Flood

In Bangladesh, which is mostly a vast flat land, floods have always been a recurrent phenomenon. This riverine country has been experiencing floods more frequently than ever before in the recent years. Flood in 1987 was one of those which broken all the previous records of flood in Bangladesh. Usually flood is associated with drainage congestion arising from the intense surface flow and heavy overland runoff caused by higher rainfall in a river basin or in the catchment areas. The causes, occurrences and the nature of floods are highly regulated and immensely characterized by the climatic conditions, hydrological situations and physical settings of an area. The 1987 flood was not exceptional one. Excessive rainfall at some places 200% above normal, in two large spells during July-August in the northern districts and the eastern hilly region occurring simultaneously with the synchronized high stages of the major rivers and the spring tide made the 1987 flood devastating both in magnitude and duration. Four kinds of flood are normally encountered in Bangladesh vij. Flash flood, Monsoon flood of major rivers, Rain flood and the Storm flood surges. All these four types of floods were encountered this year individually or in combination in 1987. Rain flood of July in greater Rangpur district area was followed by flash flood of August in all the northern rivers. This occurred at a time when both the Ganges and the Brahmaputra were in flood stage and drainage from the north-western area through *Hura Sagar* was seriously independent and as a result, flood in the area continued for a long time.

High flood stage in all the three major rivers during the end of August coincided with the Spring Tide of new moon on the 27^{th} of August and also with a depression in the Bay of Bengal. Territorial rain due to the depression caused flash flood in the greater districts of Chittagong, Noakhali, Comilla and Sylhet and the Spring Tide along with the strom surge retarded drainage from the greater Cimilla, Dhaka, Faridpur and Noakhali districts. Basin-wise analysis of the features of the 1987 flood are described in following sections.

3.1.1 Causes of 1987 flood

Extensive rainfall, at some places 200% above normal, in two large spells during July-August in the northern districts and the eastern hilly regions occurring simultaneously with the synchronized high stages of the major rivers and the spring tide made the flood devastating both in magnitude and duration. Drainage of flood water was delayed due to obstructions created by development infrastructures such as roads, embankments, bridges etc. with inadequate openings. Flooding of the FCD Project areas was caused mainly due to public cuts and breaches in the embankments and, in some cases, due to overtopping of the embankments.

3.1.2 Sequences and causes of 1987 flood

This year the earliest flood hit areas were the northern parts of Sylhet and Sunamganj districts. The hill streams in the area caused flash flood; the Surma at Sunamganj crossed danger level on the 25th June and the peak level of the year occurred on the 1st July at 9.13 m/pwd which is 0.90 m above the danger level. During July, the rainfall was much above the normal throughout the country with the heaviest fall occurring in the northern zone centered around Rangpur. The rivers in the area, particularly, the *Ghagot,Karatoa,Bengali* and *Little Jamuna* crossed their danger levels and caused wide-spread flooding in the greater districts of Rangpur, Dinajpur and Bogra. All the three major rivers were rising simultaneously form mid-June and by early July the Brahmaputra stage reached close to the danger level.

During August, rainfall was above the normal in the Ganges basin and the south eastern hill basins. The rivers *Punarbhaba, Tangon, Karatoa, Atrai* caused serious flooding in the greater districts of Dinajpur and Rajshahi. The flood flow of late July and early August traveled into *Chalan Beel* area causing severe damages to lives and properties in the districts of Naogaon, Rajshahi, Natore, Bogra, Pabna and Shirajganj.

During later part of July and early August, all the three major rivers were rising simultaneously. The Brahmaputra crossed danger level on the 27th July at *Chilmari,* the Ganges crossed danger level on the 30th July at *Goalundo* and the Meghna crossed danger level on the second August at Bhairab Bazar. So from mid July to end of September the major rivers continued to remain at high flood stage.

In the last week of August, a depression in the Bay of Bengal caused staorm surges in the Chittagong – Cox's Bazar coast and flash floods in the hill streams in the eastern rivers.

By September, while the Brahmaputra and the Meghna started falling, the Ganges started rising again on the 13th September and caused serious flooding attaining a peak level of 19.46 m/PWD at Rajshahi on the 19th September. This peak is 1.17m above the danger level and only 0.54 m below the recorded highest level in the previous year.

The river *Mohananda* crossed the highest recorded level of 1984 and the peak level of 1987 was 22.25 m/PWD which is 1.45 m above the danger level. The Chapai Nawabganj district was seriously hit by the flood of *Mohananda* and the Ganges. The greater districts of Kushtia, Pabnna, Jessore, Faridpur and Dhaka were also affected by the flood of the Ganges.

Towards the end of September, the rivers in the Sylhet area, particularly the Surma and the *Kushiyara*, again started rising. The *Kushiyara* recorded its peak flood of the year on 29th September at 14.00 m/PWD which is 0.89 m above the danger level.

3.1.3 Rainfall in 1987

Basin-wise monthly rainfall for the period from June to September of 1987 compared to the normal rainfall for the four basins in Bangladesh is shown in the table below. Basin-wise rainfall has however been calculated with a limited number of stations, vij. 33 stations for the entire Bangladesh.

For each month, lines of equal deviation indicate areas where rainfall was higher or lower than the normal rainfall. It is observed that most part of the country received normal rainfall. A narrow strip of land along the greater districts of Rangpur, Dinajpur received rainfall up to 300 mm above the normal. Another narrow strip land around Maulvi Bazar received rainfall up to 200 mm above the normal. Except another singular point at Faridpur, the entire country received rainfall much below the normal and a more or less draught condition was prevailing throughout the country.

It is also observed that, the country had four distinct rainfall zones vij. the northern zone, the eastern zone, the central zone and the coastal zone. The northern, the eastern and the coastal zones received rainfall much above the normal, whereas the central zone had about the normal rainfall.

In the Rangpur-Khulan area the rainfall was above the normal by about 900 mm. This caused rain flood in the *Ghagot* basin. Areas around Sunamganj received a rainfall about 300 mm less than the normal. Most of the remaining parts of the country received rainfall 200 to 400 mm above normal. The most spectacular rainfall distribution during the monthe was in the north-western tip of the country in the greater district of Dinajpur. If isolines of deviation rainfall in August, 1987 is examined along with rainfall isohyets for the month, it is noticed that a severe rainstorm was centred somewhere in Jalpaiguri in West Bengal. As a result, inspite of a comparatively less rainfall within the *Teesta* and the *Dharla* basins in Bangladesh, higher floods in the *Teesta* and the *Dharla* occurred due to runoff coming from beyond the border which has been depicted. The *Dharla* at Kurigram crossed the recorded highest flood level.

A very high rainfall within a short span of time in the districts of Panchagarh, Nilphamari, Thakurgaon and Dinajpur and the runoff due to a much higher rainfall from beyond the border flooded these districts with a flash flood wave that ultimately flowed into the *Atrai* basin and flooded the *Chalan Beel* Polders.

It is observed that a large part of the south-western zone of the country received rainfall below normal. The areas of subnormal rainfall also penetrated into the northern zone covering the districts of Pabna, Shirajganj, Natore and Joypurhat.

The two sub-zones of very high rainfall were located in the Sunamganj area of the eastern zone and in the greater disteict of Dinajpur of the northern zone. Another higher rainfall sub-zone was in the south-eastern region of coastal zone. Isolines of deviation and the rainfall isohyets for the month show that there had been concentration of rainfall in the northern-eastern region causing floods in the Surma and the Kushiyara. Shape of isohyets for September, 1987 shows that rainfall was concentrated within the Ganges basin in India. As a result, the Ganges river was in a very high stage in September inspite of subnormal rainfall in the Gangetic Delta in Bangladesh.

Table 3.1 : Basin wise monthly rainfall (mm 1987)

Basin	June		July		August		September	
	Normal	1987	Normal	1987	Normal	1987	Normal	1987
1. Ganges basin	330	330	415	545	332	707	251	304
2. Brahmaputra basin	434	332	423	845	327	565	267	368
3. Meghna basin	717	641	599	811	515	561	362	616
4. South-Eastern Hill basin	596	392	650	1077	494	797	293	457

Source : BWDB, 1990

From the above Table, it is seen that in June there had been about normal rainfall in the Ganges, the Brahmaputra and the Meghna basins whereas rainfall in south-eastern hill basins were below normal.

During July, rainfall was above the normal in all the four basins, but the most conspicuous high rainfall occurred in the Brahmaputra basin. July rainfall in these basins was 200% of the normal rainfall. It is observed that Kaunia and Rangpur experienced a rainfall of about three times the normal and significantly higher than 1974 rainfall. Clearly there was a concentration of rainstorm centred around Kaunia and Rangpur. The *Ghagot* and the *Teesta* basins in Bangladesh experienced the most intense rainstorm. Rangpur, Gaibandaha, Joypurhat and Naogaon towns were seriously inundated. Widespread damages were caused to crops, houses, roads and water control structures in the said basins.

During August, rainfall was above the normal throughout the country with the heaviest fall in the Ganges basin, where the rainfall was about 200% of the normal rainfall. The shape of isohyets shows that the center of storm was somewhere in Jalpaiguri of India where the rainfall concentration had been much higher. Water level hydrographs of the *Teesta,* the *Dharla* and the *Tangaon* shown sharp rise and flooding during mid August.

During September, rainfall was above the normal throughout the country. In the Ganges basin, although rainfall was only slightly above the normal, the extensive flooding of the Ganges and the *Mohananda* was due to rainfall and floods from beyond the border. July to September rainfall totals for 1974 and 1987 for the four basins together, it is seen that about 76% of the flood monitoring rainfall stations recorded higher rainfall in 1987 than that of 1974.

Table 3.2 shows 10 day maximum rainfall of 1987 with their approximate return periods and Table 3.3 shows monthly rainfall of 1987 which exceeded the maximum rainfall during the period of record from 1950 to 1980.

Table-3.2 : Return period of 10-days storm of 1987

Month	Station	Normal (mm)	Rainfall of 1987(mm)	Return period (Yr.)
July	Phulbaria	335	788	94
	Nawabganj	332	804	100
	Dinajpur	318	652	37
	Noakhali	289	496	30
	Sherpur	341	549	16
	Badarganj	350	866	100
	Gaibandha	349	726	82
	Chilmari	405	775	28
	Kurigram	393	683	16
	Lalmonirhat	422	791	72
	Mithapukur	427	1029	100
	Rangpur	354	933	100
	Saidpur	277	467	19
	Naogaon	277	467	19
August	Tentulia	512	755	17
	Panchagarh	496	874	37
	Boda	473	730	20
	Bhitargarh	553	828	42

Source : BWDB, 1990

Table- 3.3 : Stations where rainfall in 1987 exceeded the recorded maximum

Month	Stations	Rainfall in mm		
		Normal	Maximum (1950-80)	1987
July	Kaunia	504	1162	1554
	Rnagpur	443	862	1378
	Jamalpur	440	744	867
	Noakhali	629	1020	1294
August	Bogra	321	722	734
	Jamalpur	363	683	702
	Dinajpur	318	627	843
	Kushtia	292	590	775
	Jessore	309	510	753
	Khulna	301	540	666
September	Jamalpur	253	509	604
	Panchagarh	276	536	736
	Sylhet	439	741	854
	Sunamgangj	596	1130	1685
	Sheola	413	671	682

Source : BWDB, 1990

The recorded highest flood flow of the Ganges of 73 200 m_ / sec on the 1st September, 1961 was exceeded this year when a rated flood flow of 76 000 m_/ sec (provincial) was computed for the 19th August, 1987 at Hardings Bridge. The peak flow for the Brahmaputra at Bahadurabad occurred on the 12th August and the flow was 74 800 m3 /sec against recorded highest flood flow of 91 100 m_ / sec on 6th August, 1974.

The peak discharge of the Meghna at Bhairab Bazar occurred on the 16th August and the flow was 113 000 m_ /sec and this flow is just equal to the peak flow at this site on the 9th August, 1974.

On the 20th August, 1987, the flows at the major stations are shown below for the purpose of comparison.

Hardings Bridge	61 400 m_ /sec
Bahaduarabad	62 100 "
	123 500 m_ /sec
Goalanda	113 000 "
Bhairab Bazar	16 000 "

3.1.4 Features of 1987 flood

Four types of flood are normally encountered in Bangladesh vij. Flash flood, Mansoon flood of Major Rivers, Rain flood and the Storm Surges. All these four types of floods were encountered this year individually or in combination.

Rainflood of July in greater Rangpur district area was followed by flash flood of August in all the northern rivers. This occurred at a time when both the Ganges and the Brahmaputra were in flood stage and drainage from the north-western area through *Hura Sagar* was seriously impeded and as a result, flood in the area continued for a long time.

High flood stage in all the three major rivers during the July and August coincided with the Spring Tide of new moon on the 27th of the August and also with a depression in the Bay of Bengal . Torrential rains due to the depression caused flash flood in the greater districts of Chittagong, Noakhali, Comilla and Sylhet and the Spring Tide along with the storm surge retarded drainage from the greater Comilla, Dhaka, Faridpur and Noakhali districts. Basin-wise analysis of the features of the 1987 flood shows the same picture of the said flood.

3.1.5 Damage due to 1987 Flood

During July and August, the towns of Rangpur, Gaibandah, Jopypurhat Naogaon, Thakurgaon and Dinajpur were flooded. In August and September, the district towns of Chapai Nawabganj, Rajshahi, Kushtia, Rajbari, Faridpur, Maijdi and the capital city of Dhaka were flooded. Flood damaged assessment for the 1987 shown in this study do not include many minor areas and intangible aspects of national losses. A total of 5 7,270 sq km area has been affected by the flood. However, the damages were huge and a large number of people lost their lives and property.

3.1.6 Comparison of 1987 and 1974 floods

Until 1987 flood, the flood of 1974 was considered as the most severe one. But, during 1987 the whole country was in the grip of heavy rainfall during the monsoon months of July to September. Comparison of rainfall for the months from July to September, both monthly and cumulative, of 1974 and 1987 from the records of 14 flood monitoring rainfall stations of the country shows that about 74% of the monitoring stations received higher rainfall in 1987 than that in 1974.

Tables 3.4 shows dates of peak level and duration of flood above danger level for the years 1987 and 1974. It is observed that out of the samples of 35 flood monitoring stations, 1987 flood peak was higher than 1974 flood peak at 69% of the stations while 54% of the stations recorded longer duration above danger level, in 1987 than that in 1974.

Table - 3.4 : 1987 Flood level (M.PWD) & Days above danger level

Days above danger level										
Sl.No	River	Station	D.L.	HFL	Date	June	July	Aug.	Sept	Total
Brahmaputra Basin										
1.	Dharla	Kurigram	26.06	27.50*	12.08.87	-	-	9	-	9
2.	Teesta	Dalia	52.25	52.77	13.08.87	-	2	8	2	12
3.	Teesta	Kaunia	29.41	30.47*	14.08.87	-	18	14	10	42*
4.	Brahmaputra	Chilmari	23.62	24.56	12.08.87	-	6	18	-	24
5.	Brahmaputra	Bahadurabad	19.35	19.68	15.08.87	-	4	9	-	13
6.	Brahmaputra	Sirajganj	13.56	14.57*	17.08.87	-	5	24	12	41*
7.	OldBrahmaputra	Jamalpur	17.22	17.21	17.08.87	-	-	-	-	0
8.	Old Brahmaputra	Mymensingh	12.72	12.72	21.08.87	-	-	-	-	0
9.	Buriganga	Dhaka	6.10	6.64*	22.08.87	-	-	15	-	15
10.	Lakhya	Narayanganj	5.49	6.04	22.08.87	-	-	29	17	46
Ganges Basin										
11.	Karatoa	Panchagarh	71.93	71.41*	14.08.87	-	-	-	-	0
12.	Punarbhava	Dinajpur	33.53	34.31*	14.08.87	-	-	5	-	5
13.	Mahananda	C. Nawabganj	20.80	22.25*	19.09.87	=	-	21	30	51*
14.	Ganges	Rajshahi	18.29	19.46*	19.09.87	-	-	4	21	29*
15.	Ganges	Hardinge Br.	10.56	14.80*	19.09.87	-	-	28	27	55*
16.	Ganges	Goalanda	8.38	9.52	20.08.87	-	2	29	23	54*
17.	Ganges	Bhagyakul	6.10	6.99	20.08.87	-	2	29	25	56*
18.	Goral	Goral Rly. Br.	12.34	13.43*	19.09.87	-	-	19	24	43*
19.	Kumar	Faridpur	7.47	8.28*	21-08-87	-	-	16	18	34*

Meghna Basin										
20.	Surma	Sylhet	11.28	11.60*	01.08.87	-	-	3	2	5*
21.	Surma	Sunamganj	8.23	9.13	01.08.87	6	15	15	6	42*
22.	Kushiyara	Sheola	13.11	14.00*	02.08.87	3	-	11	13	27
23.	Manu	Mvi. Bazar	11.58	12.12	02.08.87	-	-	3	-	3*
24.	Khowai	Habiganj	9.62	10.80*	31.07.87	3	-	-	-	3*
25.	Someswari	Durgapur	12.50	13.71	01.08.87	-	11	4	2	17
26.	Meghna	Bhairab Bazar	6.55	6.91	16.08.87	-	-	30	-	30
27.	Gumti	Comillah	11.13	12.51*	29.08.87	-	-	7	-	7
28.	Meghna	Chandpur(HWL)	3.96	4.70	22.08.87	-	-	18	2	20*
29.	Meghna	Chandpur (HWL)	3.96	4.32	21.08.87	-	-	-	-	-
South Eastern Hill Basin										
30	Muhuri	Parshuram	11.58	14.48*	27.08.87	2	8	9	8	27
31.	Halda	Panchpukuria	9.30	10.41*	01.08.87	-	3	2	-	5
32.	Sangu	Bandarban	14.63	17.66*	27.08.87	-	-	5	-	5*
33.	Sangu	Dohazari	7.32	7.82*	27.08.87	-	-	3	-	3*
34.	Matamuhuri	Lama	12.19	15.16*	26.08.87	-	-	4	-	4*
35	Matamuhuri	Chiringa	4.88	6.78*	26.08.87	-	5	6	-	11

Source : BWDB, 2000

Values identified by "*" mark have exceeded corresponding values of 1974 flood.

3.1.7 Rain flood of Ghagot basin in 1987: A case study by BWDB

Ghagot river has a catchment area of about 1300 sq km. at Gaibandha and drains parts of Rangpur and Gaibandah distiicts. *Ghagot* basin along with adjoining areas received extremely high rainfall during July 1987 causing wide spread flooding in the basin and inundated the Rangpur and the Gaibandha district towns.

The following approximate analysis will show how the *Ghagot* basin was flooded due to the rainfall. The Rangpur town is more or less centrally located within the basin and daily rainfall recorded at Rangpur has been assumed as average basin rainfall for this approximate calculation.

Table 3.5 shows water levels of the *Ghagot* at Gaibandha. It has been assumed that the basin was fully saturated when the roisters of late July started on the 22nd month. It is shown that, cumulative rainfall platting at Rangpur from the 21st July to 31st August, 1987. The highest water level of the *Ghagot* at Gaibandha was recorded on the 15th August, 1987 and was 22.12 m/PWD. The rated discharge for the water level is 207 m3/sec and is equivalent to 14mm/day.

A runoff rate of this amount (14mm/day) has been superimposed on the cumulative rainfall graph which shows a maximum residual rainfall depth of 0.98 m on the 13th August, 1987. This residual depth if uniformly spread over the basin gives an index of basin flooding. Actual flooding can be determined by applying the residual rainfall depth over the area/elevation and vol/elevation curves. The approximate analysis however, confirms the wide spread flooding in the basin.

Drainage development in the *Teesta* Barrage Project area is being done for runoff rates ranging from 33mm/day to 44 mm/day. Such development within the *Ghagot* basin will increase outflow at Gaibandha and also the peak stage. Table 3.5 also shows drainage rates of 25, 30 and 40 mm/day and their corresponding residual flood depths. The residential depths, corresponding residual discharge and peak flood levels at Gaibandha compared to the 1987 flood level are shown below.

Table 3.5 Residual Discharge and Peak flood level at Gaibandha, 19987

Runoff rate mm/day	Residual flooding (meter)	Peak discharge (m3/sec)	Peak flow level (m/pwd)	Rise in flood stage above flood level (meter)
14.00	0.98	207	22.12	--
25.00	0.77	380	23.31	1.19
30.00	0.69	450	23.68	1.56
40.00	0.58	600	24.36	2.24

Source : BWDB, 2000

From this analysis the following conclusion may be drawn.

- From the peak discharge of *Ghagot*, at the corresponding runoff rate and rainfall distribution shown in table 3.5, the residual basin inundation of 0.98 m confirms widespread flooding in the *Ghagot* basin.
- Improvement of internal drainage network of *Ghagot* basin will reduce residual flooding in the basin. This will however increase the peak discharge and corresponding river stage at Gaibandha resulting in higher flooding there.
- The later effect may be reduced by channel improvement such as loop cutting, re-excavation where necessary. But this will again cause increased flooding in the downstream areas of old *Ghagot* and *Bangali* basin.

Presently, the major part of the flow of the Karatoa passes into the Bengali via *Katakhali Khal*. Reopening of the *Karatoa* from *Chak Rahimpur* to Bogra is likely to provide a solution of the drainage congestion and fair flood distribution between the Bangali and *Karatoa* providing a flood relief to the *Ghagot* near Gaibandha. But this will need a comprehensive drainage study at *Karatoa-Ghagot-Bangali* basin supported by a flood flow simulation model study.

3.2 Analysis of 1998 Flood

The flood of 1998 has been the highest and longest ever flood recorded for some of the major rivers of the country. In 1998 the flood situation took a serious turn as the water level was only 20 to 40 cm below the disastrous flood of 1988. However, no water entered the town like in 1988 when the town was inundated 1(one) meter deep flood water in some places.

(3.2) Characteristics of 1998 flood

3.2.0 Water Level

The water level started rising from the 1st week of June and surpassed the allowable inside level of 11m. PWD on 9 of June when the main regulator was closed. The water level upstream of the inlet continued to rise and exceeded the danger level of 12.04 m. on 15 July and remained over the danger level for 62 days reaching as high as 13.39 m. PWD on 8 September. The highest water level was only 4 cm. lower than the flood level of 1998 and it was a flood with a return period of 27 years.

3.2.1 Flood Situation

Due to the above pattern of rainfall, the Brahmaputra river experienced repetition of peak, the Ganges and the river Mahananda experienced highest magnitude and the Meghan experienced steady peaks while the effect of the spring tide (HWL) observed at Chandpur was ever-highest. This resulted flood situation severe in magnitude in some places and prolonged in most places in the country. Basically, in sense of magnitude the river Padma played a vital role while the river Brahmaputra along with the rivers of Meghna basin caused the prolonging of the flood situation in the country. The river Padma at Hardinge Bridge and at Goalundo, the river Mahananda at Chapai-Nawabganj, the river Jamuna at Aricha, the river Sitalakhya at Narayanj and the river Meghna at Chandpur, HWL (spring tide) experienced ever-highest water level records during the catastrophic flood from July to September 1998.

In fact during the year 1998 Bangladesh experienced flash floods, river floods and tidal floods. In respect of magnitude in some locations and duration in most places of the country, it was sever and of unprecedented in the known history.

3.2.2 Total Flood Status in 1998

Affected Districts – 53 (Excluding high lands)

Affected Thanas – 370 (Excluding high lands)

Thanas with Normal Flooding -78

Thanas with Moderate Flooding -148

Thanas with Severe Flooding- 144

Total Area of Bangladesh – 1,47,570, sq. km

Total Inundated Area - 1,00,250, .sq. km.

Percentage inundated - 67.93%

3.2.3 Hydrological characteristics of 1998 flood in major rivers

The flood regimen in Bangladesh is dominated by huge flow carried by three major rivers, namely the Brahmaputra, the Ganges and the Meghna. The central part of Bangladesh was the main effected area in 1998 flood. The City of Dhaka was among the most badly inundated areas. However, the waters of the Ganges catchment as well as the waters of the Meghna have had great effect on the floods of 1998 in the country. The source of flood water in and around Dhaka city was the Brahmaputra through its distributaries. The catchment of the Brahmaputra at Bahadurabad is approximately 573,500 sq km. The Ganges has a length of about 2,200 km and the reach in Bangladesh is approximately 230 km long before meeting the Jamuna, and the catchment area at Hardinge Bridge is approximately 1,09,00 sq. km. The travel times of flood waves from the border with India upto the Ganges-Jamuna confluence are approximately 5 and 7 days in the Ganges and the Jamuna respectively. The reach carrying the combined flow of the Ganges and the Jamuna is called Padma and has a length of about 120 km before meeting the Meghna.

The another major river called the Meghna, has a leangth of about 110 km between Bhairabbazar and confluence with padma. The meghna receives water flow mainly from two big rivers and the meeting point of these rivers is approximately 20 km upstream of Bhairabbazar. The catchment area at Bhairabbazar is approximately

77000 sq. km. The reach carrying the combined flow of Padma and Meghna is called Lower Meghna which has a length of about 160 km and discharges to the Bay of Bengal. Almost entire flood flow in Bangladesh is drained through the Lower Meghna which is a tidal river and has a large estuary.

3.2.4 Characteristics of Rainfall in 1998 flood

During May and June, very insignificant rainfall observed in the whole catchments both in the country and outside the country at upstream. But from the beginning of the month of July until first week of September, heavy and incessant rainfall observed in the whole catchments. In the later part of September, the country had still significant rainfall while the upper catchments had very little rainfall during the same period. During the month of July ad August, most of the monitoring stations in the country experienced more than monthly rainfall while in South-eastern Hill basin and also in North and North-eastern part of the country experienced ever-highest monthly rainfall.

Interestingly, for the whole season from May to September, the total (accumulated) rainfall at different places over the country did not experience the same pattern of rainfall. The accumulated rainfall from the month of May to September in some part of the country were significantly higher than accumulated normal rainfall but some part of the country still had quite less rainfall than the overall normal rainfall.

3.2.5 Rainfall situation in 1998 flood

Hydrologically Bangladesh falls under two distinct seasons i.e. dry season from October to April and wet (monsoon or rainy) season from May to September. Over 80% of the annual rainfall occur during the rainy season when the country normally experiences floods. The country experiences average 2,300 mm normal annual rainfall but caries from 1,200 mm in the west part to 5,000 mm in the east. Several days incessant rainfall are common during the rainy season. Local high intensity rainfalls at short duration are also common due to monsoon depression formed in the Bay of Bengal and passing across the country. There are also several land depressions formed over the country and its adjoining areas caused heavy rainfall for short duration.

Basin-wise monthly rainfall along with one day and 10-day maximum rainfall for the month from May to July is shown below. (Rainfall statistics for the months of August and September are furnished in appendix-i) Basin-wise rainfall is tabulated for 43 monitoring stations for the entire Bangladesh where 11 stations each under the Brahmaputra & the Meghna basin, 12 stations in the Ganges basin and 9 stations in the South Eastern Hill basin.

Rainfall Situation in May, 1998

Table : 3.6 Rainfall in Millimeters, Basin : Brahmaputra

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Kurigram	646.7	343.0	228.3	-114.7	80.5	195.8
Dalia	647.0	329.0	74.1	-254.9	30.0	51.0
Kaunia	795.1	334.0	104.0	-230.0	48.0	90.0
Rangpur	486.7	280.0	163.5	-116.5	71.0	122.0
Chilmari	682.2	326.0	122.0	-204.0	75.0	103.0
Dewanganj	586.0	310.0	168.2	-141.8	90.0	134.0
Gaibandha	463.6	270.0	256.0	-14.0	110.0	228.0
Mymensing	801.1	330.0	270.8	-59.2	59.6	135.3
Dhaka	754.5	405.0	405.5	145.0	118.0	313.0

Source : BWDB, 1998

Table : 3.7 Rainfall in Millimeters, Basin : Ganges

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Panchagarh	411.7	192.0	276.1	84.1	85.5	201.5
Pabna	396.6	189. 0	162.0	-27.0	52.5	86.0
Rajshahi	220.1	130.0	111.9	-18.1	40.0	66.4
Kushtia	390.4	186.0	106.7	-79.3	37.5	60.6
Jessore	318.5	180.0	230.9	50.9	108.7	131.7
Khulna	360.2	183.0	152.0	-31.0	62.0	76.0
Satkhira	270.2	102.0	108.6	6.6	62.3	77.0
Faridpur	560.6	245.0	198.9	-46.1	63.5	122.4
Barisal	520.5	211.0	182.5	-28.5	65.7	109.0
Patuakhali	694.7	244.0	218.4	-25.6	97.0	152.8

Source : BWDB, 1998

Table : 3.8 Rainfall in Millimeters, Basin : Meghna

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Kanaighat	1428.5	872.0	693.0	-179.0	161.0	490.0
Sylhet	1270.0	547.0	433.0	-114.0	59.0	235.0
Sunamganj	1218.4	548.0	450.0	-98.0	80.0	274.0
Sheola	1294.5	541.0	667.8	126.8	163.0	438.5
Moulvi Bazar	1236.0	426.0	135.0	-291.0	49.0	72.0
Manu Rly Br	450.8	587.0	220.8	-366.2	42.0	97.0
Durgapur	911.0	414.0	221.7	-192.3	45.0	123.0
Bhairab Bazar	801.0	325.0	334.0	9.0	135.0	291.0
Comilla	791.2	310.0	338.4	28.4	102.0	274.5
Chandpur	529.8	255.0	226.4	-28.6	64.0	175.0

Source : BWDB, 1998

Table : 3.9 Rainfall in Millimeters, Basin : South-Eastern Hill

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Narayanhat	597.5	255.0	160.0	-95.0	43.0	117.5
Panchpukuria	679.8	241.0	287.5	46.5	117.0	127.9
Bandarban	519.2	251.0	539.7	288.0	127.0	509.0
Lama	602.2	256.0	576.0	320.0	161.0	524.5
Chittagang	545.3	247.0	557.0	310.0	149.0	375.0
Ramgrah	994.4	280.0	351.0	71.5	117.0	263.0

Source : BWDB, 1998

Except a few stations, the country as a whole experienced below monthly normal rainfall in May. The table 3.6 to table 3.9 shows the basin-wise monthly rainfall for the month of May 1998. It is observed from the table that the Brahmaputra, the Ganges and the Meghna basin experienced rainfall less than the normal by 31%, 4% and 22% below their normal for the month respectively. The South Eastern Hill basin experiences rainfall by 16% higher than the normal. Station at Sheola of the Meghna basin observed 163.0 mm of rainfall, which is the highest recipient in the month over the country. Two stations in the Meghna and 3 stations in the South Eastern Hill basin exceeded 300 mm of rainfall in 10 day period.

Situation in June, 1998

Table : 3.10 Rainfall in Millimeters, Basin : Brahmaputra

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Kurigram	1433.7	502.0	471.2	-30.8	148.0	260.8
Dalia	861.9	595.0	496.0	-99.0	131.0	356.5
Kaunia	1155.7	504.0	493.0	-11.0	153.5	263.0
Rangpur	987.6	449.0	415.1	-33.9	83.0	203.9
Chilmari	1139.0	480.0	413.0	-67.0	105.0	246.0
Dewanganj	984.2	425.0	262.5	-162.5	123.0	217.5
Gaibandha	820.4	418.0	312.9	-105.1	99.0	239.0
Jamalpur	953.5	455.0	190.2	-264.8	73.5	190.2
Mymensing	888.9	468.0	200.9	-267.1	53.3	94.8
Dhaka	678.2	376.0	89.0	-287.0	18.0	57.0

Source : BWDB, 1998

Table : 3.11 Rainfall in Millimeters, Basin : Ganges

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Panchagarh	980.3	445.0	482.7	37.7	123.0	348.5
Pabna	584.7	279.0	116.3	-162.7	26.0	68.3
Rajshahi	662.4	251.0	63.0	-188.0	27.0	39.0
Kushtia	989.3	251.0	187.5	-63.5	49.4	108.1
Jessore	739.6	316.0	124.9	-191.1	56.7	94.4
Khulna	630.7	354.0	216.0	-138.0	78.0	153.0
Satkhira	808.9	310.0	123.1	-186.9	42.0	96.7
Faridpur	797.8	366.0	165.6	-200.4	32.0	114.1
Barisal	895.4	437.0	176.5	-260.5	48.0	89.9
Patuakhali	1166.0	590.0	230.2	-359.8	53.0	153.4

Source : BWDB, 1998

Table : 3.12 Rainfall in Millimeters, Basin : Meghna

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Kanaighat	1119.0	872.0	1278.0	406.0	236.0	962.0
Sylhet	1609.5	903.0	846.0	-57.0	150.0	596.0
Sunamganj	2465.7	1060.0	1025.0	-35.0	200.0	498.0
Sheola	1714.3	905.0	1149.3	244.3	169.0	834.5
Moulvi Bazar	1092.9	534.0	306.0	-228.0	83.0	242.0
Manu Rly Br	884.9	579.0	459.0	-120.0	118.0	275.0
Habiganj	987.1	493.0	218.0	-275.0	75.0	207.0
Durgapur	1242.1	707.0	375.5	-331.5	44.8	181.0
Bhairab Bazar	752.4	411.0	87.0	-324.0	49.0	64.0
Comilla	1049.0	429.0	98.9	-330.1	25.6	44.7
Chandpur	656.5	393.0	76.2	-316.8	30.0	65.2

Source : BWDB, 1998

Table : 3.13 Rainfall in Millimeters, Basin : South-Eastern Hill

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Noakhali	1201.0	597.0	204.6	-392.4	67.6	170.5
Narayanhat	1110.0	581.0	311.6	-269.4	60.0	176.7
Panchpukuria	1256.3	576.0	291.3	-284.7	43.0	142.4
Bandarban	938.8	576.0	291.6	-284.4	109.5	222.9
Rangamati	1420.2	780.0	283.4	-496.6	69.3	211.5
Lama	1306.2	710.0	383.5	-326.5	105.0	269.0
Chittagang	1472.0	613.0	80.0	-533.0	17.0	58.0
Ramgrah	1696.9	609.0	139.0	-470.0	75.0	95.0

Source : BWDB, 1998

The country almost as a whole suffers driest month in 1998 monsoon due to below monthly normal rainfall observed in all the four basins in June. The table 3.10 to 3.13 shows the basin-wise monthly rainfall for the month of June, 1998. It is observed from the table that all the four basins experienced rainfall less than the normal by 24%, 45%, 19% and 61% below their normal for the month respectively. Station at Kanaighat in the Meghna basin observed 236.0 mm of rainfall, which is the highest recipient in one day in the month over the country. One station in Ganges and four stations in the Meghna basins exceeded 300 mm of rainfall in 10-day period.

Situation in July, 1998

Table : 3.14 Rainfall in Millimeters, Basin : Brahmaputra

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Kurigram	969.3	519.0	532.5	13.5	93.0	273.3
Dalia	1137.5	751.0	907.0	156.0	203.0	618.5
Kaunia	1554.5	594.0	612.0	18.0	127.0	384.0
Rangpur	1378.4	490.0	477.2	-12.8	67.3	294.0
Chilmari	1265.8	496.0	737.0	241.0	100.0	495.0
Dewanganj	1158.2	503.0	684.2	181.2	100.5	441.7
Gaibandha	680.0	387.0	651.0	264.0	116.0	406.5
Bogra	680.0	420.0	745.1	325.1	132.2	534.4
Jamalpur	864.5	489.0	438.8	-50.2	66.6	295.6
Mymensing	891.0	531.0	795.8	264.8	211.8	591.9
Dhaka	673.1	360.0	515.0	155.0	85.0	407.0

Source : BWDB, 1998

Table : 3.15 Rainfall in Millimeters, Basin : Ganges

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Panchagarh	1440.2	891.0	1154.0	263.0	257.0	605.5
Dinajpur	990.3	495.0	686.3	191.3	107.3	417.5
Pabna	577.3	290.0	422.0	132.0	80.0	285.0
Rajshahi	893.6	345.0	362.5	17.5	120.0	276.0
Kushtia	439.6	297.0	429.2	132.2	78.2	285.5
Jessore	702.1	353.0	213.4	-139.6	42.0	111.6
Khulna	638.3	346.0	373.0	27.0	145.0	259.0
Satkhira	679.7	399.0	368.5	-30.5	72.7	193.9
Faridpur	660.9	335.0	312.0	-23.0	42.0	147.5
Barisal	1116.8	416.0	661.4	245.4	225.0	447.5
Patuakhali	1269.2	611.0	821.0	210.0	138.0	521.3

Source : BWDB, 1998

Table : 3.16 Rainfall in Millimeters, Basin : Meghna

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Kanaighat	1072.0	755.0	1245.0	490.0	221.0	905.0
Sylhet	1820.2	824.0	1347.0	523.0	260.0	930.0
Sunamganj	2097.3	1402.0	1591.0	189.0	160.0	984.0
Sheola	1220.5	748.0	1143.5	395.5	168.0	805.0
Moulvi Bazar	724.4	441.0	622.0	181.0	160.0	566.0
Manu Rly Br	643.1	413.0	558.0	145.0	108.0	405.0
Habiganj	816.1	417.0	557.6	140.6	170.6	352.8
Bhairab Bazar	638.0	404.0	613.2	209.2	169.0	429.0
Comilla	1144.0	470.0	812.8	342.8	139.0	590.2
Chandpur	840.7	373.0	735.9	362.9	151.5	404.3

Source : BWDB, 1998

Table : 3.17 Rainfall in Millimeters, Basin : South-Eastern Hill

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-days Maximum Rainfall
Parshuram	1133.6	576.0	830.5	254.5	110.0	514.4
Noakhali	1285.6	703.0	864.0	161.0	156.5	420.2
Narayanhat	1446.0	747.0	1212.3	465.3	209.5	713.3
Panchpukuria	1201.9	702.0	1202.5	500.5	175.5	748.2
Bandarban	1345.4	703.0	879.8	176.8	153.5	549.2
Rangamati	1491.7	642.0	1022.2	380.2	272.0	603.2
Lama	1809.5	800.0	1512.0	712.0	203.0	902.0
Chittagang	1527.0	816.0	1247.4	413.4	177.0	861.4
Ramgrah	1539.0	626.0	1117.3	491.3	238.0	620.0

Source : BWDB, 1998

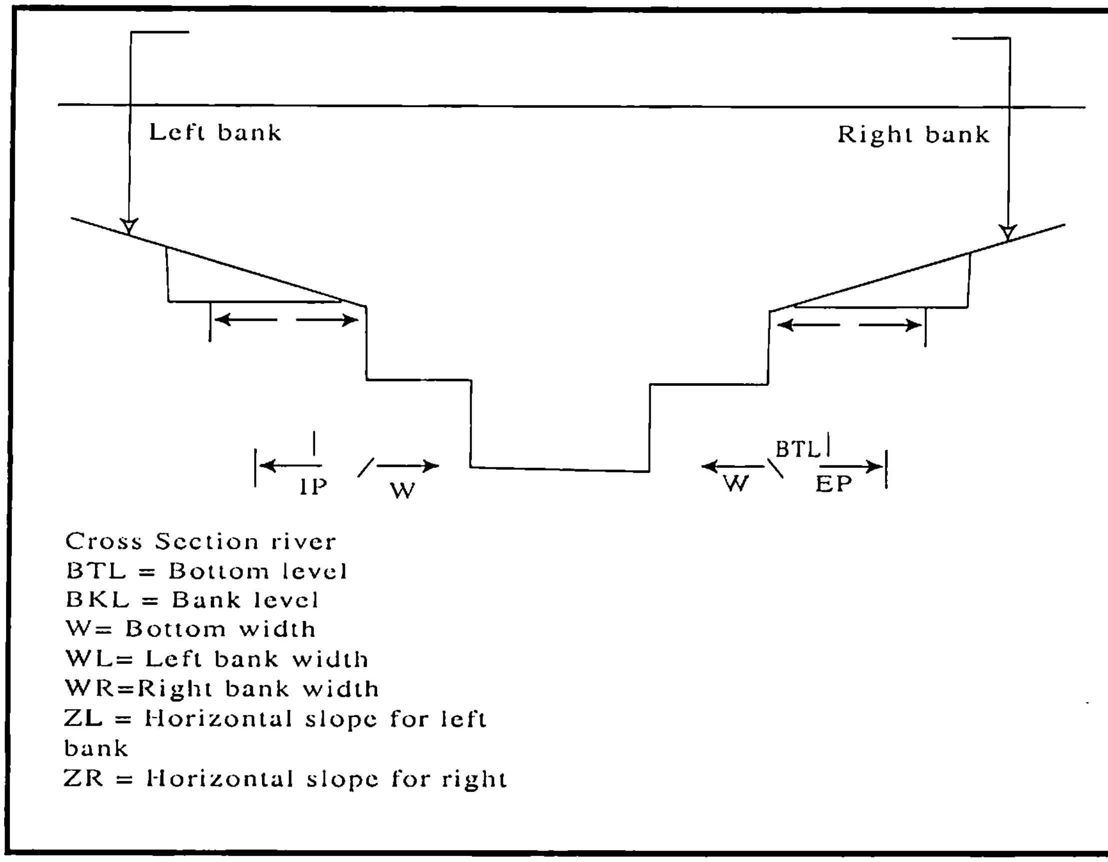
The country as whole experienced widespread rainfall during the month of July. The table 3.14 to 3.17 shows the basin-wise monthly rainfall for the month of July, 1998. It is observed from the table that the Brahmaputra, the Ganges, the Meghna basins and the South-Eastern Hill basins experienced rainfall higher than the normal by 32%, 20%, 72% and 49% above their normal for the month respectively. Rangamati in the South Eastern Hill basin observed 272.0 mm of rainfall, which is the highest recipient in the month in one day over the country. Eight stations in the Brahmaputra, for stations in the Ganges, all stations both in the Meghna and the South Estern Hill basin exceeded 300 mm of rainfall in 10-day period. More significantly Bogra on the Brahmaputra basin & Kanaighat (Sylhet) on the Meghna basin experienced ever-highest monthly rainfall during the month of July.

Again for second consecutive month, the country as a whole experienced widespread rainfall in August, 1998. It is observed from the table that the Brahmaputra , the Ganges, the Meghna and the Southeastern Hill basins experienced monthly rainfall higher than the normal by 66%, 90%. 16% and 56% respectively. Station at Sunamganj of the Meghna basin observed 325.0 mm of rainfall, which is the highest recipient in one day in the month as well as monsoon over the country. Five stations in the Brahmaputra, two stations in the Ganges, four stations in the Meghna and two stations in the South Eastern Hill basins exceeded 300 mm of rainfall in 10-day period. During the month, almost all the monitoring stations experienced more than the normal rainfall of the month. Moreover Chittagong, Lama, Panchapukuria and Narayanhat of Southeastern Hill basin experienced ever-highest monthly rainfall (BWDB, 1998).

The monsoon became less active after first week of September. The Brahmaputra and the Ganges basins experienced above normal rainfall while the Meghna and the South-Eastern Hill basins experienced below normal rainfall in September. Table 3.6 to 3.17 shows the basin-wise monthly rainfall for several months. It is observed from the table that the Brahmaputra and the Ganges experienced rainfall above the normal by 6% & 18% respectively. The Meghna and the South Eastern Hill basin experienced below normal rainfall by 35% & 25% respectively. Station at Kaunia of the Brahmaputra basin observed 217.0 mm rainfall, which is the highest recipient in one day in the month over the country. One station in the Brahmaputra, two stations in the Ganges and one station in the Meghna basins exceeded 300 mm of rainfall in 10-day period. In fact, up to 1^{st} week of September, heavy rainfall occurred in the country and upper catchments while quantum of rainfall reduced rapidly in the later part of September.

3.2.6 : Schematized channel section and floodplain presented below :

Figure 3.1 : Schematized channel section and floodplain



Source : BWDB, 2000

3.2.7 Flood Magnitude and Duration

Simulated hydrographs of 1998 flood at Hardinge Bridge, Bahadurabad, Baruria and Chandpur represents a picture of river flow on the year 1998. The bankfull discharges shows that the long duration of 1998 flood in Bangladesh was mainly due to continuous inflow of high discharge for more than two and half months in the Jamuna. There Were 4 major flood waves in the Jamuna while one in the Ganges. The maximum peak flood discharges at Jamuna and Ganges occurred quite closely at the beginning if September 1998. This feature cause unprecedented high discharge in Padma and Lower Meghna.

3.2.8 Environmental Impacts of 1998 flood

3.2.8.0 Impact on soil

Flood have both positive and negative impacts on soil. The positive impact results from siltation, which happens when the flood water moves from the river carrying siltation which settles as the flood achieves some static duration. The resulting productivity gain shows in the next and subsequent crops. On average between 147 to 184 acres of land in a village received siltation, more in the larger projects and less in the smaller ones. The gains in productivity ranged between 5 and 13 percent, showing higher gains in smaller projects. The siltation gains were more than totally wiped out by loses of productivity through sand deposits, which came with the heavy onrush of flood water, particularly when embankments eroded. Although the area covered by sand was about two –thirds that of siltation, the productivity losses were several times higher . On balance, therefore, the impact of the 1998 flood on the surveyed villages has been negative.

3.2.8.1 Impact on water pollution

There is often confusion about the impact of a flood on water pollution. The traditional belief was the floods 'wash away' pollution during the flood period and leads to pollution during post-flood periods when water stagnates. Question were asked therefore (by BWDB), on perceptions of stakeholders for these two periods separately. The result are shown by all the main analytical categories for drinking water and for bathing water. There seems to be more stakeholders (35%-57%) believing the 1998 flood polluted in the post- flood period. Clearly the myth of flood water 'washing out' pollution in respect of drinking water is exaggerated. Similar results, somewhat on a lower tone, is also obtained in the case of bathing water.

3.2.8.2 Impact on air pollution

Stakeholder's perceptions on the impact of the 1998 Flood on air quality is clearly an overwhelming (above 80%) of stakeholders in the medium size projects believed that air quality had worsened. In the large projects, between 63-70 percent believed it had worsened, but 20-23 percent believed it had improved. This perception seems slightly stronger in far away villages compared to the ones nearby. This may reflect a higher degree of water stagnation in these villages giving rise to bad smell.

3.2.8.3 Impact on bio-diversity

The impact of any long lasting flood on bio-diversity can be summed up in terms of its impact on trees and fish. On the whole, several tree species die during the flood, most notably jack fruit, papaya and banana. This means a loss of fruit of these species for the time it takes to reintroduce them, if future flooding is controlled. The impact of the 1998 flood on the tree species in respect of perceptions of stakeholders about more than one species of trees being extinct or threatened.

The impact of a flood on fishery is two-fold, i.e. the disappearance of cultured fish and the introduction of wild fish. The former are fewer in number but higher in yield ; the latter, the reverse. Therefore, if the flood continue, then the above will be the scenario and the overall impact will be a mixed blessing, to be liked by environmentalist but disliked by economists. In case of a one –off flood the net impact i.e. loss of bio-diversity as well as income, causing woe to both the environmentalist and the economist.

3.9 Simulation of 1998 flood discharge

Gauged discharge data at Bahadurabad, Hardinge Bridge, Baruria and Bhairabbazar are usually available at about two weeks interval during flood season. For the lower Meghna, discharge data is not available. A numerical model developed by Chowdhury (1986) was used to generate hydrograph of flood discharge in the major river system. The model is based on an implicit finite difference solution of the gradually varied unsteady flow equation given below :

$$W \frac{fh}{ft} + \frac{fQ}{fx} - q = 0 \qquad (1)$$

$$\frac{fQ}{ft} + \frac{f}{fx}\left(\frac{Q^2}{A}\right) + gA\frac{fh}{fx} + gA\frac{Q|Q|}{k^2} = 0 \qquad (2)$$

Where W is the total water surface width (m), h is the elevation of water surface with respect to a common datum, Q is the flow rate (m^3/s), A is the cross-sectional area of flow (conveyance) section (m^2), Q is the lateral flow rate per unit length of channel, k = CA_R , k is the conveyance of flow section in m^3/s, R is the hydraulic radius of flow section (m), C is the Chezy resistance coefficient ($m^{1/2}/s$) and g is the acceleration due to gravity (m^2/s).

The effective cross-sectional area of flow (conveyance) section is estimate.

$$A = A_r + A_f\sqrt{Y_f}|Y_r \qquad (3)$$

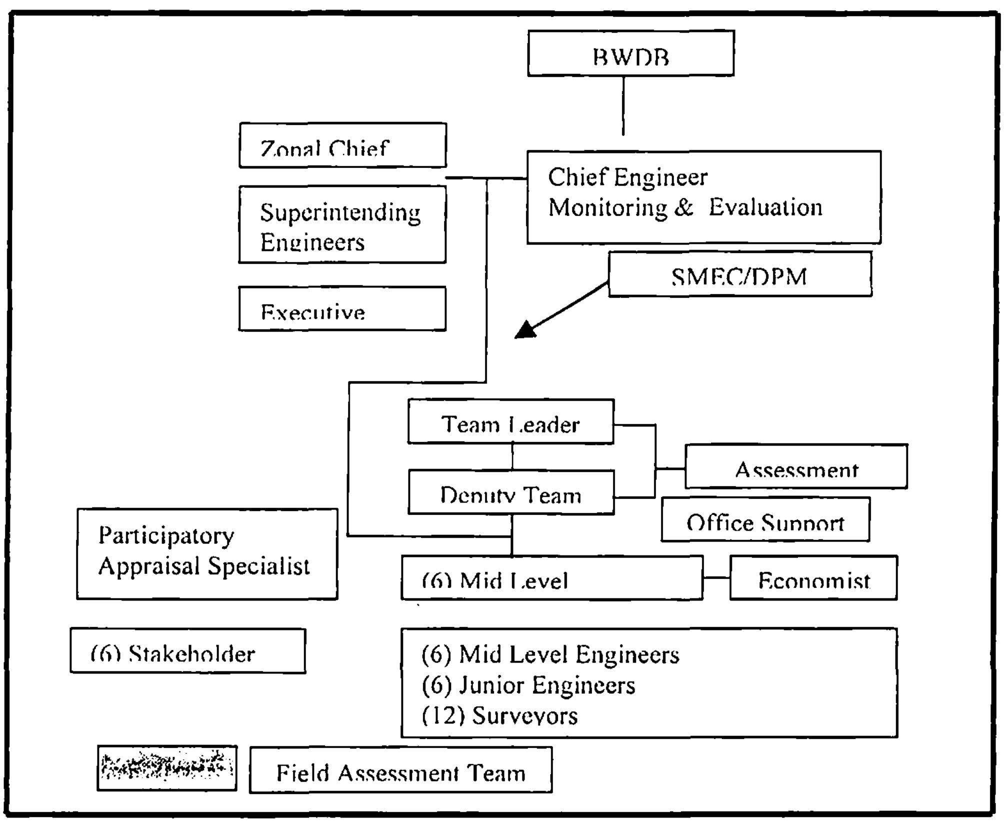
Where A_r and A_f are water areas for river section and floodplain section respectively, and $|Y_r$ and Y_f are water depths in river and floodplain respectively.

Hydrodynamic condition during flood flow in the alluvial rivers in Bangladesh is quite different from that during low flow. The cross section changes due to erosion when flow increases from low to high discharges and due to deposition when flood flow recedes. The resistance characteristics also changes when low flow changes to high flow in the river-floodplain system. Such changes in the hydraulic condition create difficulty for simulation by numerical model based on Eqs.(1) and (2) where fixed cross is assumed. To reduce these difficulties, the simulation was kept confined to the three months period of July to September when about two-thirds of annual discharge occurs.

3.10 : Team of flood damage assessment in 1998

Flood damage assessment of 1998, water sector Organogram under BWDB is shown below. The team worked for hard to assessed the damage of the 1998 flood :

Figure No 3.2 Organogram



Sorce : 1988 Flood Damage Assessment of BWDB

3.11 Time Trend of flood stages of some important rivers

In order to study the long term trend in the flood stages of the important rivers, annual highest water level (HWL) of 8 rivers and 14 stations have been plotted against respective years in listed in the table 3.18 below :

Table 3.18 : Time Trend of flood stages of some important rivers

Sl/No.	River	Station	Exhibit
1.	Brahmaputra	Chilmari Bahadurabad Jagannathghat Serajganj	36 37 38 39
2.	Teesta	Kaunia	44
3.	Dharla	Kurigram	44
4.	Ganges	Rajshahi Hardinge Bridge Baruria Transit(Goalundo) Mawa	40 40 41 42
5.	Kushiyara	Sheola	43
6.	Monu	Maulvi Bazar	43
7.	Khowai	Habiganj	43
8.	Meghna	Bhairab Bazar	43

Source : BWDB, 1998

Review of time trend of the flood stages shows the following characteristics:

(a) The Brahmaputra from Chilmari to Goalaundo (Exhibits 36-39), the Ganges from Goalando to Mawa (Exhibits 41-42) and the Meghna at Bhairab Bazar (Exhibit 43) do not show any rising or falling trend in their flood stages.

(b) The Ganges at Rajshahi and Hardinge Bridge (Exhibit 40) has been showing quite a significant rising trend of flood stage since commissioning of the Farakka Barrage in 1975.

(c) The regional rivers like *Teesta* and *Dharla* in the north (Exhibit 44) and *Kushiyara*, *Monu* and *Khowai* in the east (Exhibit 43) are all showing rising trend of flood level.

Table - 3.19 : Comparison of the three months average (July to September) and annual maximum flood discharge at gauge stations of major rivers.

Parameter	Year	Harding e Bridge	Bahadurabad	Baruria	Bhairab Bazar	Chandp ur
Average flood Discharge (m3/s)	1998	42,808	67,100	1,04,177	12,601	1,06,665
	1988	37,844	52,358	82,499	15,513	81,458
	28 Years Average	30,764	43,025	65,900	11,060	
Peak flood Discharge (m3/s)	1998	80,330	93,658	1,36,481	14,037	1,38,283
	1988	71,800	98,300	1,32,000	71,900	1,19,464
	28 years Average	52,358	67,100	89,742	13,946	

Source : IFCDR, 1999

The above table shows comparison of the three months (July-September) average discharge and annual maximum discharge during 1998, 1988 and long term. It is seen from table 3.19 that the average flood discharge at all stations except Bhairab Bazar during 1998 was much higher than that during 1988, and around 150% of the long term average discharge. Data in above table indicates that approximately 55% of total flood discharge during July to September 1998 was carried the Jamuna while approximately 34% by the Ganges.

Duration of 1998 flood is compared with precious large floods as well as long term average values. The previous floods having large magnitude or long duration have been identified by analyzing data since 1996. The duration has been assessed in terms of flow above mean bank level (MBL) and bank-full discharge (BFD). Values of MBL and BFD were determined by Delft Hydraulics and Other (1996). Result for flood level analysis are summarized here.

Table – 3.20 : Flood level and duration in major rivers

River	Gauge Station	Mean Bank level, MBL(m, PWD)	Maximum flood level in specified years (m, PWD) .				Continuous duration of flood in days above MBL			Flood of longest continuous duration above MBL before 1998
			Year 1998	Year 1988	Year 1987	28 years Avg.	Year 1998	28 years Avg.	Year	Duration in days.
Jamuna	Bahadurabad	18.93	20.41	20.61	19.68	19.74	87	23	1977	59
Ganges	Hardinge Bridge	14.01	15.19	14.87	14.79	14.28	28	12	1980	42
Padma	Baruria	7.05	10.74	9.8	9.5	8.89	118	84	1990	119

Source : IFCDR, 1999

Table – 3.21 : Flood discharge and duration in major rivers

River	Gauge Station	Bank full discharge, BFD (103 3/s)	Maximum discharge in specified years (103 m3/s) .				continuous duration of flood in days above BFD			Flood of longest continuous duration above BFD before 1998
			Year 1998	Year 1988	Year 1987	28 yrs Avg,	Year 1998	28yrs Avg	Year	Duration in days
Jamuna	Bahadurabad	48.0	93.6	98.3	73.0	67.1	77	21	1966	46
Ganges	Hardinge Bridge	43.0	80.3	71.8	75.8	52.3	34	14	1980	40
Padma	Baruria	75.0	136.5 .	132.0	113.0	89.7	115	21	1980	57

Source : IFCDR, 1999

It is seen from the table 3.20 and 3.21 that the peak flood level and discharge of 1998 flood exceeded previous records for the Ganges and the Lower Meghna but not for the Jamuna and the Meghna. However magnitudes of peak floods in Jamuna and Meghna rivers are quite close to the previous records. Using the results of freequency analysis in IFCDR (1995), the estimated return period of the peak of 1998 flood are 100 years and much greater than 100 years for annual maximum water level at

Bahadurabad (Jamuna) and Hardinge Bridge (Ganges) respectively, and 75 years and greater than 100 years for annual maximum discharge.

The most remarkable feature of 1998 flood is its very long duration as can be seen from the table 3.20 and 3.21 The long duration of high discharge during 1998 flood in the Jamuna, Padma and Lower Meghna is unprecedented. The flow duration graphs for 1998 flood at Bahadurabad and Chandpur are superimposed on the stage-duration frequency graphs given in IFCDE (1995). The 1998 flood level at Bahadurabad corresponding to a duration of 30 days or more has a return period of greater than 100 years. At Chandpur, the return period of both peak magnitude and duration for 1998 flood has exceeded 100 years.

3.12 : Concluding Remarks : This chapter represents the hydrological features of flood in Bangladesh. The floods of the country normally occurs in the monsoon rainy season. Sometimes the normal monsoon flood may turn into catastrophic deluges. The flood of 1987 and 1998 were these kinks of floods. These two floods are elaborately described in this chapter. It is observed that flood in 1987 took part due to extensive rainfall at some places 200% above the normal rainfall. During July to August in 1987 the northern districts and the eastern hilly region inundated simultaneously with the synchronized high stage of major three rivers and the spring tide made the flood devastating both in magnitude and duration.

In 1998 flood recorded the highest and longest ever before. The water level started rising from the 1st week of June and exceeded the danger level for 62 days. In some places the duration of flood and peak magnitude have exceeded 100 years before in the same year.

CHAPTER - IV

FLOODS IN BANGLADESH : EFFECTS, CONTROL AND MANAGEMENT

CHAPTER-IV

FLOODS IN BANGLADESH : EFFECTS, CONTROL & MANAGEMENT

4.0 Introduction

The flood problems of Bangladesh is not simply locally created hazard. The problem has both local and international dimensions. The hazards of flood of Bangladesh are related to the climatological, tectonic, and ecological situation of the Himalayan Sub-continent and the solution or control of the flood problems of the country obviously incorporates a joint multilateral and integrated initiative by the countries sharing the catchment basin of the rivers of Bangladesh. However, in order to reduce the loss and damage and to enforce possible control over the floods in Bangladesh some long-term and short-term flood control measures can be taken. In this measures both the preventive and curative methods of control should be applied. The preventive methods are indirect in nature and involve those work which reduce the runoff rate, coefficient of runoff and increase time of concentration. The accurate flood forecasting is also required in solving the problems of flood in time. It is also need close and extensive monitoring of the impact of tidal situation during the flood time. Moreover, for the rapid action and affective post-flood relief and rehabilitation operation, sufficient reservation of flood-stuffs and medicine should be developed along with other precautionary arrangement. Mainly impact of flood and flood management in Bangladesh discussed in this chapter. Firstly impact of floods in Bangladesh are narrated below :

4.1 Impact of flood

Flood is a common natural hazard in Bangladesh which create a mixed impact in the country on environment and human lives. High intensity of flood causes severe losses on the people of the food stricken areas. The death of vital livestock and poultry also compelled many poor peasant to loss their economy. Severe flood destroy physical property and structure such as roads, railway, ferry-ghat, school, mosque, bazar, electric line etc. Moreover, river erosion at the time of flooding is one of the most important negative impact. Large volume of land and other resources are destroyed through river bank erosion. Furthermore, lack of pure water, firewood and other kinds of fuel generated serious consequences for health and energy. The one set of flooding also generated a wave of crime including theft and looting in the submerged and deserted village settlements. However, the impact of flood in different sectors are narrated below :

4.1.1 Impact on soil

Flood have both positive and negative impacts on soil. The positive impact results from siltation, which happens when the flood water moves from the river carrying siltation which settles as the flood achieves some static duration. The resulting productivity gain shows in the next and subsequent crops. On average between 147 to 184 acres of land in a village received siltation, more in the larger projects and less in the smaller ones. The gains in productivity ranged between 5 and 13 percent, showing higher gains in smaller projects. The siltation gains were more than totally wiped out by loses of productivity through sand deposits, which came with the heavy onrush of flood water, particularly when embankments eroded. Although the area covered by sand was about two –thirds that of siltation, the productivity losses were several times higher . On balance, therefore, the impact of flood on the surveyed villages has been negative.

4.1.2 Impact on water pollution

There is often confusion about the impact of a flood on water pollution. The traditional belief was the floods 'wash away' pollution during the flood period and leads to pollution during post-flood periods when water stagnates. Question were asked therefore, on perceptions of stakeholders for these two periods separately. The result are shown by all the main analytical categories for drinking water and for bathing water. There seems to be more stakeholders (35%-57%) believing the 1998 flood polluted in the post- flood period. Clearly the myth of flood water 'washing out' pollution in respect of drinking water is exaggerated. Similar results, somewhat on a lower tone, is also obtained in the case of bathing water.

4.1.3 Impact on air pollution.

Stakeholder's perceptions on the impact of the 1998 flood on air quality is clearly an overwhelming (above 80%) of stakeholders in the medium size projects believed that air quality had worsened. In the large projects, between 63-70 percent believed it had worsened, but 20-23 percent believed it had improved. This perception seems slightly stronger in far away villages compared to the ones nearby. This may reflect a higher degree of water stagnation in these villages giving rise to bad smell.

4.1.4 Impact on bio-diversity.

The impact of any long lasting flood on bio-diversity can be summed up in terms of its impact on trees and fish. On the whole, several tree species die during the flood, most notably jack fruit, papaya and banana. This means a loss of fruit of these species for the time it takes to reintroduce them, if future flooding is controlled. The impact of the 1998 Flood on the tree species in respect of perceptions of stakeholders about more than one species of trees being extinct or threatened.

The impact of a flood on fishery is two-fold, i.e. the disappearance of cultured fish and the introduction of wild fish. The former are fewer in number but higher in yield ; the latter, the reverse. Therefore, if the flood continue, then the above will be the scenario and the overall impact will be a mixed blessing, to be liked by environmentalist but disliked by economists. In case of a one –off flood the net impact i.e. loss of bio-diversity as well as income, causing woe to both the environmentalist and the economist.

Fig. No. 4.1- Diarrhoeal diseases protection in the period of flooding

Source : Picture M. Rahman, 2001

Fig. No. -4.2 : A thatch at a village in Pabna

Source : M. Rahman, 2001

Fig. No. 4.3 : Sufferings of both men & cattles at the period of flooding

Source : WeeklyendIndependent, 12 July, 1996

Fig. No. - 4.4 : Senario of sufferings of the people at Narinda

Source: The Daily Inquilab, August 2, 2002

Fig. No.- 4.5 : Houses are being inundated

Source : M. Rahman, 2001

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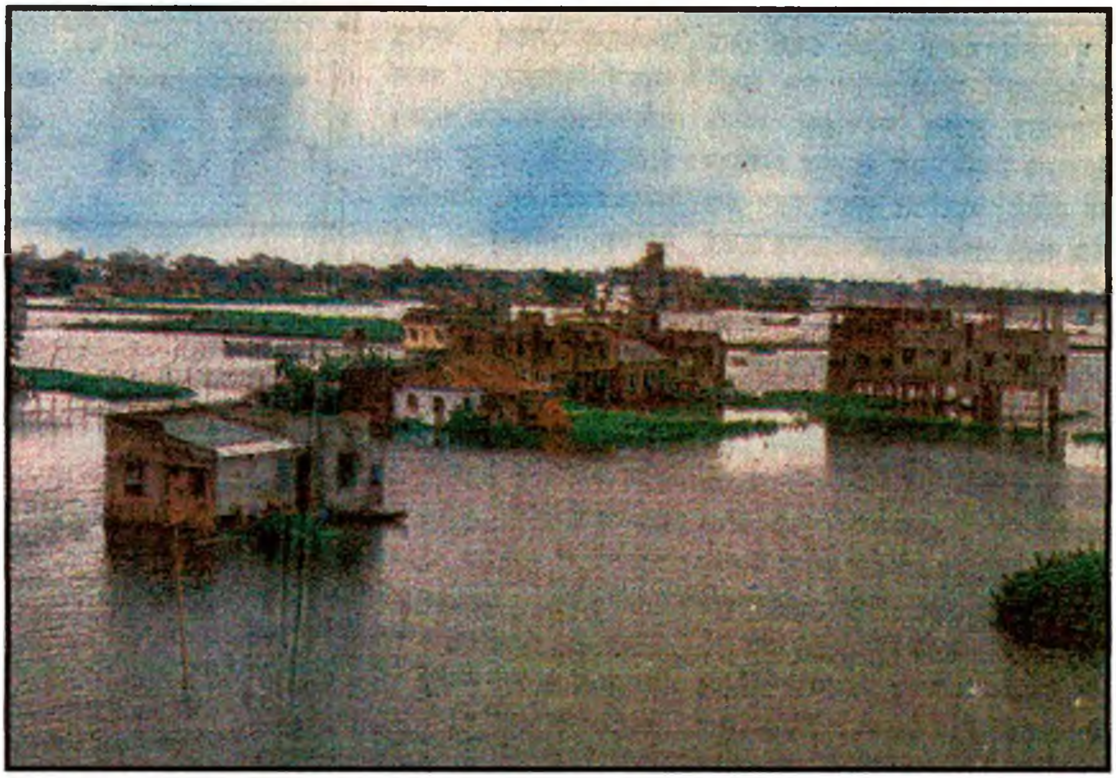
Fig. No. 4.6- Roads are being inundated at Sonatala in Gaibandha District

Source : The Daily Jugantor, 13 August,2002

Fig. No. 4.7- Inundated areas at Kamrangirchar in Dhaka

Source: The Daily Ittefaq, July 30, 2001

Fig. No.- 4.8 : Inundated Areas at ChandpurDistrict



Source: M. Rahman, 2002

Fig. No.- 4.9 : Crops field are sweeping away in the District of Sirajgonj.

Source : M. Rahman, 2001

4.2. Flood controlling in Bangladesh

Bangladesh is badly needed to control the problems of flooding which takes part almost every year. Soon after the major flood of 1954 and 1955, the Government adopted a policy of protecting agricultural land from the river flood in order to secure agricultural production Since then about 8,000 km of earthen embankments parallel to the river bank and 500 sluices and regulator have been built. After the disastrous floods of 1987 and 1988, the flood hazard has again become the major concerns to the policy makers. However, the overall scenario of flood control activities in Bangladesh are narrated below :

4.2.0 Review of flood control plan in Bangladesh

The devastating flood of 1954 and 1955 affected the eastern part of India also. The then Government of Pakistan and India agreed upon to investigate jointly the problem. However, nothing substantial came out except a few meetings at Experts and Ministers level.

The East Pakistan Flood Commission was set up in December, 1955 to look into the flood problem and suggest remedial measures. A Flood Control Organization was created under a separate Chief Engineer in the Irrigation Department of the Provincial Government.

4.2.1 : Krug Mission's Report

Towards the end of 1956, the Government obtained the services of a UN Technical Assistance Mission (Krug Mission) for the study of the flood problems of the country. The Mission dealt with the history , causes, frequency, magnitude and effects of floods and practicability of various methods of protection against flood damages in the country and submitted its report in the year 1957. The report pointed out the need for hydrological investigations and recommended for setting up a Water and Power Development Authority for taking up implementation of water and power development projects on a comprehensive and unified basis. The principles points of recommendations of Krug Mission were as follows :

Feasibility study of flood dykes on the banks of major rivers including flushing sluices and drainage regulations and if found feasible, implementation of these on a priority basis.

- To take up and implement smaller flood control, drainage and irrigation projects.
- To take up a feasibility study of construction of barrage on the Testa for irrigation

and flood control

- To raised the level of homesteads in flood affected areas above flood level or to rehabilitate them on flood dykes.
- To identify areas where flood control cannot be effectively done and industries, vital installation etc. should not be constructed in such areas.

Co-operation should be established with India and other courtiers for development of comprehensive flood forecasting in the common rivers.

4.2.2 Creation of EP WAPDA

In pursuance to the recommendation of the Krug Mission the East Pakistan Water & Power Development Authority (EPWAPDA) was set up in 1959 and the Irrigation Department of the Provincial Government was subsequently merged with the EPWAPDA. With the creation of EPWAPDA, the Flood Control Organization (FCO) also ceased to exist.

4.2.3 EPWAPDA Master Plan, 1964

The EPWAPDA, with the help of the General Consultant IECO, prepared a Master Plan for water resources development of the country. This plan truly marked the beginning towards formulation of an integrated plan for flood control and development of water resources of the country. The said Master Plan organized the limited hydrological data available at that time and recommended, with emphasis for systematic and scientific hydrological data collection and processing.

The Master Plan included a portfolio of 58 water resources development projects including 3 barrages on major rivers for implementation spread over 20 years beginning from 1963. These projects envisaged flood protection for 5.8 million hectares of land. Irrigation within these flood protection area was also envisaged.

4.2.4 General Hardin's Report and Professor J. Thijsse's Report

General John R. Hardin, an Ex-Chairman of Mississippi River Commission visited the country in January, 1963 and submitted a report in February, 1963 which closely paralleled the findings of the Krug Mission in the analysis of flooding and possible means of reducing the damages. The report proposed channel improvements and confinement of river flows within embankments. Sluice and fuse – plugs in the dykes were recommended to release water into protected areas to balance the load and avoid overtopping of dykes when the flood flows exceed design limit. Such an approach recognized the need for an immediate start despite paucity of data.

Professor J. Thijsse of the Netherlands also studied the problem and submitted a report in 1964. The report rules out reservoir storage and suggested that the existing distributaries of the main river system be maintained as long as possible. Channel improvement and embankments were mentioned as means for reducing flood hazards. But he also advised against early confinement of unstable rivers between embankment without study.

4.3 Flood control plan of East Pakistan, September' 1968

In August, 1968, the planning Department, Government of East Pakistan, formed a committee to formulate a comprehensive flood control plan for East Pakistan. In preparation of the comprehensive Flood Control Plan the Committee took into consideration the Master Plan of Water Development of EPWAPDA, 1964, Flood Protection Plan of EPWAPDA, 1967, the Krug Mission report, General Hardin's report, Professor Thijsse's report and the points raised in the note of Mr. M. M. Ahmed, Deputy Chairman, Planning Commission, Government of Pakistan, dated 5.8.1968.

The Flood Control Plan presented there, it was claimed, the culmination of years of investigation, research, studies and experience in some flood control projects under implementation at that time.

The said plan proposed five types of flood protection works such as Embankment, Channel Improvement and opening of off take of spill channels, River Training, Estuarine works and Protection of important cities and towns. Recommendations were also made for investigation and Studies and for Training. Out of the comprehensive total plan a priority program was also provided. An abstract of the program is given below :

Table – 4.1 : Types of flood control plan of EPWAPDA, 1968

Project Type	No. of Project for the	No. of Project
	Comprehensive plan	for Priority plan
A. Embankment	51	24
B. Channel Improvement and Opening	29	14
of Off take of Spill Channel C. River Training	23	6
D. Estuarine Work	2	2
E. Protection of Important Cities and Towns	10	10

Source : Review Report, EPWAPDA, 1968

Most of the Embankment Projects and some of the City Protection Scheme have been done. But most of the Channel Improvement Projects and river training works have not been implemented.

4.4 Review of EPWAPDA Master Plan by IBRD

In March 1964, the Government of Pakistan officially requested the World Bank to review the EPWAPDA Master Plan prepared by IECO as the first step towards programming as action plan. The World Bank review was not completed until the autumn of 1965 and official discussion between the Government and the Bank did not take place until early 1966. Two "Agreed Statements" dated March 1 and September 23, 1966 emerged from these meetings. These statements committed the World Bank in principle to take an active role both in studying and financing of the development of the water and the agriculture sectors in the region, which is now Bangladesh.

Despite numerous Bank Missions the first significant attempt to fulfill this commitment in any comprehensive sense, was the preparation of the "Action Program" by the World Bank, Which was presented to the Pakistan Consortium in 1970. However, the War of Liberation began before the resulting investment program really could gain any momentum. Meanwhile, a major desk study was undertaken (the Nine Volume Sector Study) and was presented in 1972 by the International Bank for Reconstruction and Development (IBRD). The IBRD Mission reviewing the Master Plan appreciated the efforts towards the integrated approach, but made, inter alias, the following observations :

- The plan overestimate foodgrain requirements while underestimated production potential without such major projects.
- Data were inadequate to embark on massive investment projects along such big rivers.
- The implementation plan exceeded EPWAPDA`s capability and resources.
- The plan did not consider changes in river regimes due to problem works in India.

Subsequently, the investment program of water development received priority in small scale projects with irrigation components in comparison to investment in large scale flood control projects as was envisaged in the EPWAPDA Master Plan.

4.5 Flood Control & Planning of Bangladesh

Bangladesh has suffered from the twin problems of flood and drought for centuries past. The region has been neglected and no major development work was undertaken in this area till the departure of the British rulers and the partition of India in 1947. Apart from the Mahalanobis Report of 1927 very little documentary is available about attempts made by the Government to assess the magnitude of flooding or its consequence prior to the mid 1950s.

4.5.1 Strategy During Pre-Bangladesh Period (1947-71)

The post-partition period marked the beginning of major water resource investment in Bangladesh. Emphasis and priority were given to flood control and drainage programs and not to irrigation. After the unprecedented tragic floods of 1954 and 1955, the then Pakistan Government set up a Flood Commission in December 1955 to look into the problem and suggest remedial measures. A flood control organization was also created under a separate Chief Engineer in Irrigation Department of the Government. A few short flood protection embankment and drainage projects were implemented while some long term ones were identified for irrigation.

In 1956 a United Nations Technical Assistant Mission, known as the Kurg Mission carried out a detailed study on the problems of flood and water resource development of this region. The mission submitted its report in 1957. Flooding was the major concern of the Mission and broad principles of flood protection were discussed in the report. It stated that artificial retention storage was beyond the reach of the country and that embankment, diversion or escape routes and channel improvements might be helpful. The report discussed the principles of delta development in countries with large rivers, interdependence of projects and their impacts on river regimes and siltation. It emphasized the urgent need for a comprehensive integrated planning effort and international co operation in dealing with the problem and also recommended the setting up of a water and power development organization for implementing the program of work. Accordingly, the then East Pakistan Water and Power Development Authority (EPWAPDA) was set up in 1959 and the Irrigation Department of the provincial Government was merged with it. The EPWAPDA, an autonomous body, was entrusted with the task of planning and executing Flood Control, Drainage and Irrigation Projects throughout Bangladesh (the then East- Pakistan).

Two other experts were invited by the Government to study the water problem of the country in the early sixties. One of them, General John R. Hardin, former Chairman of

Mississippi River Commission submitted a report in February 1963, which closely paralleled the findings of the Krug Mission in the analysis of flooding and possible means of reducing damage. The report proposed channel improvement and confinement of river flows within the embankments, with the necessary sluices and fuse plugs in the embankments. Professor J. Thijssee of the Netherlands studied the hydraulic situation in Bangladesh and prepared another report in 1964. The report ruled out the possibility of reservoir storage as a flood control measure, and suggested that the existing distributaries of the main river systems be maintained as far as possible. Channel improvement and embankments were mentioned as a means of reducing flood hazards.

4.5.2 1964 Master Plan

In 1964 a Master Plan for WAPDA was prepared by its general consultant International Engineering Company (IECO). The Master Plan was prepared to provide a long term program for the integrated development of land and water resources for a period of 20 years (1965-85) aiming at attaining self-sufficiency in food production by 1975. The overall strategy of the plan was to reduce damage to crops by first providing flood protection through the construction of embankments and then by a further boosting of agriculture production through irrigation at later stages. Such a strategy essential required massive flood protection schemes from the start. The authors of the Master Plan recommended the systematic and scientific collection and processing of hydrological data. They suggested the implementation of 51 development projects and 3 barrage projects on major rivers as alternative schemes to supply surface water. The plan proposed the construction of embankments on both sides of the Ganges, the Brahmaputra and the Meghna. A total of about 2,000 miles of embankments were to be constructed to provide flood protection to about 3.24 million hectors of land. Drainage was to be achieved by either gravity flow or with pumps. As a second phase, irrigation facilities were to be provided to 0.41 million hectares by 1975 and to 1.62 million hectares by 1985.

Bangladesh is a country with a complex hydrology. Unfortunately, hydrology data collection was initiated on a country wise network only from 1962. Very limited rainfall data is available from about 77 stations from 1902 but almost nothing is recorded on water level, stream flow, subsoil and groundwater recharge on a historical basis. For a reasonably good estimate of surface and groundwater availability at least 20 years records of hydrologic data are essential.

There were many ungauged rivers. Other essential data on soil, agronomy, fishery, navigation etc. did not exist. Without such data and without adequate engineering know-how, the resource assessment made in IECO Master Plan lacked the information necessary to come to a proper understanding of the problems.

In 1954, `55 and `62 there were severe floods in Bangladesh. Extensive damage to crops took place. The food crisis was also acute. In the IECO Master plan, top priority was given to flood control though the main objective was self-sufficiency in flood. Irrigation was not given the same importance. The objective was mainly to protect crops but not to expand crop areas or to increase crop yields by irrigation. This was because almost everyone then believed that floods acted as the major constraint to growth in agricultural productivity.

In 1964, there were several sizeable water development projects under implementatio. These are the then East Pakistan including the Fanges-Kobadak Irrigation Project, the Karnafuli Multipurpose Project, the Chandpur Irrigation Project, the Dhaka-Narayanganj-Demra Project, the Coastal Embankment Project and the Brahmaputra Right Bank Embankment Project. Conflicts among the different water users were also emerging such as those between farming and no farming populations and between farmers benefiting or not benefiting from flood control. There was no agreement about the relative importance of surface water and ground-water irrigation, nor about the needs of fishery, navigation, hydro-power, recreation etc. Shallow tube-well irrigation was almost non-existent. Traditional irrigation with doons, (lifting buckets) was mainly undertaken by the peasants. The Master Plan did not attempt an analysis of all uses of water. It did not bring up alternative option plans involving various uses of water. It considered only flood control, irrigation and power production on the basis of the limited data available at the time. As discussed earlier, fifty water development projects mainly of flood control and irrigation type were identified. The decision makers were not provide with alternate choices. The IECO Master Plan was not a complete water plan. However, despite these shortcomings it could be regarded as the beginning of a new approach to flood control and water development in the country. It was to have significant influence on Government policies regarding the management of water resources investment strategies outline in the 1965-70 and 1970-78 development programs of the country.

4.5.3 IBRD Land & Water Resources Sector Study, 1972

Several water development projects were implemented during the sixties and many of these were financed by international donor agencies and bilateral aid arrangements. Enough data had also been collected by the late sixties to justify a major new analysis of the water situation. An IBRD team prepared the Land and Water Resources Sector Study in 1970-71. This was published after the Liberation of Bangladesh in 1972. In the face o the ever growing population problem and declining financial resources, the study recommended that priority should be given to small and medium sized quick-yielding, low cost and labour intensive projects so as to achieve self-sufficiency in food grain production in the shortest possible period of time. Concurrently, long term projects were to be continued as far as practicable.

4.5.4 Post-Liberation Strategy

Bangladesh was liberated in December 1971. For the first one and half years (January ' 72 to June ' 73) relief and rehabilitation occupied the attention of the Government. The Water Wing of WAPDA was separated from the power wing and the former was named Bangladesh Water Development Board (BWDB), a semi-autonomous body. The responsibilities and functions of the organization, however, remained the same. As action program for the water sector developed in 1970 by the World Bank could not make any headway because of the War of Liberation. In the meantime, the IBRD Sector Study, `72 was published which necessitated a through review of all the policies, programs and projects in the water sector. Unfortunately, the Government was far too busy with the program of rehabilitation and the reconstruction of the economy to attempt such a comprehensive review.

4.5.5 First Five Year Plan (FFYP) 1973-78

1973 may be taken as a new starting point in the water resources development activities of the country. The country`s First Five Year Plan (FFYP 1973-78) was launched. The recommendations of 1972 IBRD Land and Water Sector Study played an important role in the formulation of investment strategy for the water sector in the FFYP. The highest priority was given to increasing the efficiency of existing irrigation projects. Emphasis was given to low cost, quick yielding projects particularly Low Left Pumps (LLP) and Tube well irrigation schemes. During this period programs of installation of Shallow Tube wells funded by the Krishi Bank, were started. Major projects which had been undertaken during 1960`s also continued (e.g. the G. K. Chandpur, Coastal

Embankment, Brahmaputra Right Bank Flood Embankment, etc.). During this period the strategy was to increase food production through minor irrigation and low-cost Flood Control and Drainage (FCD) projects. Minor irrigation systems (DTW, LLP) were given top priority and the initial years were marked by a spectacular growth in LLP irrigation followed by a rapid growth in tube well development. The low cost FCD projects in shallowly flooded areas also started receiving increasing attention. Under IDA financing, FCD studies started in 1976.

Two years into the First Five Year Plan (1973-78) it was found that achievements were going to be far short of expectations. The changed international economic situation which followed the rise in oil prices in 1973 brought about significant changes in resources availability and project costs. A more conservative – 3 year Hard Core Program was drown up. The low Cost Flood Control and Drainage projects in shallow flooded areas began to receive more serious attention.

4.5.6 Two Year Plan (TYP 1978-80)

The Two Year Plan period i. e. 1978-80 was viewed as a time to complete as many on-going scheme as possible and weed out uneconomic projects. In 1979, the Government of Bangladesh and the World Bank jointly reviewed the program of the Water Development Board and BADC and arrived at the conclusion that more emphasis was needed on small-scale projects on irrigation, flood control and drainage. As a result the pace of development of Flood Control and Drainage projects undertaken earlier slowed down to some extent.

Although minor irrigation received priority during the seventies, works on large FC projects such as the Coastal Embankment Project, the Chandpur Irrigation Project etc. continued as before. The implementation of the Meghna Dhonogoda Project and Paban Project were under taken during this period which shows that large flood control and drainage projects were by no means abandoned by the Government.

4.5.7 Second Five Year Plan (SFYP 1980-85) and Medium Term Food Production Plan (MTFPP)

In the SFYP period major emphasis was given to agricultural development and changes in the economic conditions of the people of the country. The plan attached primary importance to irrigation facilities, and to the non-water inputs required for the full development of the water resources potential. The core investment programs of the SFYP was contained in a separate document called the Medium Term Food Production

Plan (MTFPP) and was published in 1981. The MTFPP aimed at achieving the goal of self-sufficiency by price incentives to the growers, encouragement of private trade in food grains, improved water control through minor irrigation, flood control and drainage schemes and the steady supply of non-water inputs. The second oil price shock in 1979 made its full impact on Bangladesh in the early eighties. This necessitated revising the SFYP. The changed economic condition of the country and lack of sufficient foreign aid resulted in the second plan being revised in 1983. A drastic reduction in the size of the plan greatly affected fund allocation to all sectors including Flood Control and Drainage.

4.6 Implementation of Flood Control & Drainage Projects

Several flood control, drainage and irrigation projects envisaged in the Master Plan (1964) were well underway during the mid sixties. Though such projects were taken up in order of priority, the lack of appropriate funding delayed their competition. Only eight of these projects with flood control components have so far been completed. Some ongoing projects such as Dhaka-South-West and the Faridpur-Barisal Project have been deferred for want of funds. Reviews and revision of some projects become necessary because of available data and imposed engineering knowledge. Apart from the Projects including in the Master Plan, a number of Small Scale Flood Projects have been completed or are continuing under the assistance of EIP, CIDA and IDA and other agencies. The work on some project is also proceeding under the self financing program of the Government. The achievements so far in flood control are :

4.6.1 Improved Acreage

Flood vulnerable area in Bangladesh	- 82103 sq. km. (31700 sq. miles)
Flood protection provided as on June `84	- 18443.39 sp. km. (7121 sq. km)

4.6.2 Physical achievements

1. Embankment	-	5790.65 km. (3598.24 miles)
a) Coastal	-	3672.42 km. (2282 miles)
b) Other	-	2118.25 km. (1316.24 miles)
2. Drainage canal	-	2353 km. (1658 miles)
3. Drainage sluice	-	1209 Nos.
4. River closures	-	955 Nos.

4.6.3 Completed Projects

BWDB has undertaken and completed many flood control and drainage projects. Many irrigation projects also have flood control and drainage components. A detailed discussion of all the flood control activities is beyond the scope of this study. However, names of some flood control projects are given below :

1. Coastal Embankment Project, Phase – I
2. Ganges-Kobadak Projet, Phase – I
3. Ganges Kobadak Project, Phase – II
4. Brahmaputra Right Bank Flood Embankment
5. Teesta Right Embankment Project
6. Chandpur Irrigation Project
7. Dhaka-Narayanganj-Demra Project
8. Comprehensive Drainage Scheme for Faridpur District
9. Comprehensive Drainage Project in Noakhali sadar
10. Dredging of the River Gumti
11. Strengthening the Gumti Right and Left Embankment in Comilla District
12. Re-excavation of the Ghungur-Salda and Burinadi in Comilla District
13. Preventation of Flood in Feni Sub-division in Noakhali District
14. Improvement of the Old Dakatia and Little Feni River in Comilla and Noakhali
15. Improvement of the Gazaria Ichamati River.

4.7 Flood Control Achievements

The performance of BWDB during First Five Year Plan (FFYP), Two Year Plan (TYP) and Second Five Year Plan (SFYP) in respect of flood control activities is presented below :

Table 4.2 : Flood Control Achievements in Bangladesh

Items	Target	Achievement	Cumulative chievement (in million hectares)
Bench mark coverage Are as of June, 1973			1.21
FFYP (1973-78)	0.87	0.61	1.82
TYP (1978-80)	0.28	0.12	1.94
SFYP (1980-85)	0.68	0.56	2.50

Source : BWDB, 2001

By the end of the SFYP, BWDB aimed at providing flood protection and drainage facilities to 2.62 M. ha of land and estimated achievement by the end of SFYP is 2.50 M ha.

However, it is not known to what extent the work that has been done is satisfactory. There has been little information on whether flood risks to the cultivation of Local Improved Varieties (LIV) or in the use of HYV technology on the lands claimed to have been protected have been effectively minimized.

4.7.1 Role of Master Plan Organization (MPO)

Water development is considered as the key to growth in agriculture production, and as such in recent year, water sector activities are completely dominated by investments for the increase in agricultural output. The number of agencies responsible for water development in Bangladesh is large. Unfortunately, adequate arrangements for the coordination of the activities of these agencies are absent. All the agencies thus felt the need for a comprehensive national water plan to coordinate the activities of different agencies, to ensure efficient use of water resources, and to see to it that water is used or controlled in such a way that the conflicts among users are avoided.

In the revised SFYP (1983) the Government proposed a long term water resources development strategy and stated that "preparation of national water plan will be undertaken within the plan period" To carry out the National Policy and long term strategy, a Master Plan Organization (MPO) was created in 1983 under the Ministry of Agriculture (now Ministry of Irrigation, Water Development & Flood Control). MPO has been entrusted to prepare the "National Plan" which includes the followings:

i) Assessment of water resources

ii) As agriculture-centred project investment portfolio in the water sector for the Third Five Year Plan (TFYP, 1987-90)

iii) As perspective plan for the period 1985-2005 for the comprehensive water resources development of the country.

Draft National Water Plan (NWP) was completed by MPO in July, 1985. Development policies for all water use sub sectors have been proposed in the NWP. These sub sector policies include policies for international rivers, regional rivers, ground water flood control and drainage.

4.7.2 Decentralization for Development

It is now as an accepted policy to give as much responsibility as possible to local bodies in relation to the management of irrigation and drainage projects. It is, therefore, imperative :

I) to encourage the establishment of farmers associations ;

II) to ensure involvement of these associations with development projects from the very early stages of project planning ;

III) to assist the farmers in the construction and lay-out of the field channels ;

IV) to ensure a representation of the farmers in the management of the project ;

V) to ensure that expert advice from BWDB is available to the local bodies involved in designing water projects ;

VI) to assist the farmers in procuring credit facilities ;

The current effort at decentralization and development of the upzilas as both planning and executing bodies for local development efforts are expected to provide an operational framework for designing a large number of drainage channels and embankments in rural areas for controlling floods and rapid drainage of rain water during periods of heavy downpour. The success will, however, largely depend on the real democratization of the rural power in rural Bangladesh does not have much room for high optimism in this respect.

4.8 Flood Management in Bangladesh

Soon after the major floods of 1954 and 1955, the Government adopted a policy of protecting agricultural land from the river flood in order to secure agricultural production. Since then about 8,000 km of earthen embankments parallel to the river bank and 500 sluice and regulators have been built. After the disastrous flood of 1987 and 1988, the flood hazard has again become the major concern to the policy makers. The impacts of flood control interventions on the water regime, environment and society in a floodplain country have become apparent in the meantime. The water regime has also been significantly affected by the construction of about 16,000 km of highways and feeder roads, 12,000 km of rural roads and 3,000 km of railways. Based on the experiences with flood control and other infrastructures, new insights have been gained and consequently new concepts of flood management have evolved.

Large scale investment on flood control projects began with the adoption of a 20 year Master Plan in 1964. The objective of plan was to increase agricultural (mainly rice) production to satisfy increasing national demand. The plan had a portfolio of 58 large scale projects many of which have since been implemented. The International Bank for Reconstruction and Development conducted a land and water sector study in 1972. It recommended quick yielding small scale projects and subsequent investment program of water sector received priority on small and medium scale projects. In 1983, the Government of Bangladesh initiated a National Water Plan (NWP). The objective of the NWP was to maximize agricultural growth and production and contribute to achieving foodgrain self-sufficiency. After the floods of 1987 and 1988, the Government initiated a Flood Action Plan (FAP). At the initial stage of FAP, the focus was on flood mitigation. Gradually it was recognized that FAP should pay attention to integrated water management covering issues relevant to not only flood but also drainage, irrigation, navigation, environment and socio-economy. A framework for the development and implementation of a strategic National Water Management Plan (NWMP) for Bangladesh has been approved recently. The NWMP project of three years duration is expected to start from January, 1977.

On average, the coverage by flood control and drainage projects has grown by approximately 120,000 hectares per year over the last 30 years which resulted in a decreasing trend of approximately 80,000 hectares per year in the flooded area. More than half of total project benefited area have 25 to 100 km of embankment with 2 to 8 km of embankment per 1,000 ha of benefited area. The experiences of flood control interventions in a floodplain country have proved that it is difficult to attain stated objectives of intervention without giving due consideration to the hydro-morphologic features of the floodplain and the socio-economic condition of its inhabitants.

While many projects have been successful in raising agriculture output which is the major objective of flood control projects, the impact of these projects on the overall foodgrain production is rather ambiguous. Flood control projects with the irrigation component have been more successful. The objective of increasing rice production by providing flood protection to agricultural land get so much priority that the consequential stress on the flood plain eco-system received little attention. Interventions are causing increase in flood risk elsewhere, reducing post monsoon flow in the river and deteriorating morphology of the river. They are depleting floodplain resources such as fisheries and impending floodplain functions such as water transport. This is turn is causing conflict between different users of floodplain such as river bank erosion and floodplain sedimentation which are difficult to contain have frequently compromised project performances.

It is seen that prevention of flood in floodplain has many negative environmental consequences. On the other hand, population has repercussion on the water use during dry season. Therefore a balanced approach requires a shifting of policy from flood control to flood management that even under a boarder framework of round-the–year water management.

The flood control projects were undertaken mainly on their technical and economic viability. Experiences have shown that environment, society and culture play equally strong role in their sustenance. Therefore calculation of economic return should not be the only guide in selecting water resource projects. Decisions should be based on multicriteria framework of economic costs and benefits, and social and environmental impacts. Indigenous technologies and production system should get priority, participation in planning decisions should be ensured for the sake of efficiency and equity. Vulnerability of the society to large floods can be reduced by making communication lines, essential utility services and other infrastructures flood proofed. There should be coordinated planning and construction of flood control projects and other water regime affecting infrastructures especially roads. A floodplain land use regulation can be formulated so that planning, design, construction and maintenance of infrastructures account for flood factor and preservation of floodplain resources and environment.

It is essential to take an integrated view of the hydrologic cycle and the interactions of human interferences. Multi-objective water resource planning approach is required to optimize the water needs of agriculture, public health, fisheries, ecology, navigation and industries. Proper macro-planning of water resources projects requires development of an institution capable of dealing with a task which is multi-dimensional and multidisciplinary in nature. Finally, sustainable development in the floodplain can be ensured only when flood management itself is addressed from the context of overall development of the country.

Bangladesh currently employs a variety of flood management options such as flood control, controlled flood, flood proofing and flood forecasting. This study discusses the experiences with these flood management options during the unprecedented flood. It has been observed that flood control measures have been able to protect large areas from inundation. The study recommended to institutionalized various flood-proofing measures. Lack of such institutionalization caused untold sufferings to the inhabitants of Bangladesh. Flood proof measures of infrastructures should be based on risk based analysis. Flood forecasting need to forecasting of river water levels, flood level with respect to vulnerable areas and key linkages need to be forecasted.

4.9 Flood Management & Planning in Bangladesh

The flood problem of Bangladesh is not a simple locally created hazard. This problem has both the local and international dimensions. The hazards of floods of Bangladesh are related to the climatological, tectonic and ecological situation of the Himalayan Sub-continent and the solution or control of the flood problems of the country obviously incorporates a joint multilateral and integrated initiative by the countries sharing the catchments basin of the rivers of Bangladesh. However, in order to lessen the loss and clam age and to enforce possible control over the floods in Bangladesh some long-term and short-term flood control measures can be taken. In these measures both the preventive and curative methods of control should be applied.

The preventive methods are indirect in nature and involve those work which reduce the runoff rate, coefficient of runoff and increase time of concentration, Practically the aforesaid parameters can be achieved through covering bare and fallow lands by grass and plantation ; by adopting such conservation practices as terracing, contouring, grass-seeding and afforestation, and by creating detention reservoirs, constructing small conservation structures, and controlling erosion in the upper catchment areas of different river systems.

The curative measures are direct methods of flood control. These methods include :

i) Construction of structures for stream bank protection such as spurs, groins, porcupines and brick metressing.

ii) Construction of embankments, levees, polders, dikes, sluices, regulators barrage etc.

iii) Excavation of river channel, dredging and removing sediments from outfall and drainage channel, etc.

iv) Construction of special flood shelters for each of the localities in the flood vulnerable areas, and

v) Special town or village protection works.

All these prevention and curative measures should be on the basis of a scientific and appropriate feasibility study considering the climatological as well as the socio-economic situations of the affected and the vulnerable areas.

Besides, for mitigation of flood damages, effective system should be developed. International and regional cooperation is required in this regard. Moreover, for a rapid and affective post-flood relief and rehabilitation operation, sufficient reserve of food-stuffs and medicine should be developed along with other precautionary arrangements. Since the occurrence of floods in Bangladesh is becoming as annual aspect, the agricultural and other economic practices of the vulnerable areas should be shaped and adjusted in accordance to the inundating situation of the areas. People of the country should be motivated and made aware of the consequences of floods. Accepting the obvious and natural trend of recurrences of floods easily, the people of Bangladesh will have to be prepared to face the future hazards courageously and, of course, unitedly.

4.10 Strategy of Flood Control Activities

The geographical location of Bangladesh is such that the country has no control on the huge monsoon runoff of her three major river systems. With active cooperation among the co-riparian, if reservoirs are constructed in the upper reaches of the river basins, it will lead to flood moderation and at the same time can solve the dry season deficits of water availability.

However, due to the flat topography and hydrological conditions, it may not be possible in every case to eliminate flood inundation completely. The recent experience from the flood shows that the localized, intensive rainfall in the country and the adjoining areas in Eastern hill basins can cause early as well as extensive flooding. Intensive rainfall has also caused extensive damage in the Ganges and Brahmaputra basins. Therefore, despite extensive flood control measures, intensive rainfall and drainage problem during monsoon may cause flooding. The other experience from the recent flood is that some of the completed flood control projects have not yielded any appreciable benefit due to river erosion and breaches.

The question of regional co-operation hinges on the pivot of political considerations among the co-riparian nations which are uncertain, unpredictable and hence more complicated than any engineering/technical solutions to the problem. It should by no means stall our development efforts. We should, therefore, formulate our own contingency plan based on parameters within our control and initiate development with our humble and modest means. The basic philosophy behind such development should be to live with flood by reducing their magnitude as much as possible and increasing the productivity of the land. This is an essence means controlled flooding and not flood control. However, it does not mean that the study suggests the possibilities of regional cooperation which must be sought by the policy makers of the country.

Keeping in view the above factors, ours strategy for flood control may be as follows :

1) Flood control projects should be speedily executed. At least one-third of the flood control vulnerable areas should be protected by the end of the next decade (up to

date the flood protected area is roughly 20 percent of the flood vulnerable area.) The emphasis must be on small scale projects which can be implemented within a short time.

2) A thorough study should be undertaken about the adverse effects of flood control projects on river morphology, hydrology, navigation, fishery, socio-economic condition, national ecosystem and environment etc. in and around the projects.
3) Flood control projects should preferably include an irrigation component; and where it is not possible, irrigation facility should follow immediately.
4) Completed projects should be properly maintained to derive full benefit.
5) Bank protection should be provided to eroding banks to save embankments from being engulfed by rivers. Retirement should be avoided as far as possible.
6) Improvement and maintenance of channels should be a core activity for better drainage capacity.
7) Encroachments on river channels should be discouraged.
8) For mitigation of flood damage, effective flood forecasting and warning system should be developed.
9) The Government should set up physical planning agencies in all the regions of the country, where possible non-agricultural uses of land should be determined by taking account of flood magnitude, its depth, duration and occurrence. Appropriate land use should be ensured by discouraging the growth of infra-structural facilities, trade center etc. on river bank.
10) Increase the incentives of the farmers of the normally flooded areas to undertake cultivation of HYV and increase land productivity during the flood-free seasons. Widen opportunities of employment for the flood affected people.

4.11 Concluding Remarks : Though Bangladesh has a vast experience in floodings, the country yet to take the appropriate measure to control the problems of flood in due time. Due to some unavoidable circumstances the flood control and management system of the country is still in primary level in compare with the developed countries of the world. However, the measures taken to control the problems of floodings are not sufficient for the country. But those measures (taken to control and management of flood) helps the peoples to save partly from the hazards of flood. Further, the Government of Baangladesh should have a precise national flood control policy. In this regards the international and regional importance for cooperation in this region could be ignored in order to reduce the loss andß damage of flood and to bring and effective control over the flooding situations.

CHAPTER-V

FLOOD CONTROL, MANAGEMENT AND HUMAN ADJUSTMENT WITH SPECIAL REFERENCE TO DHAKA CITY

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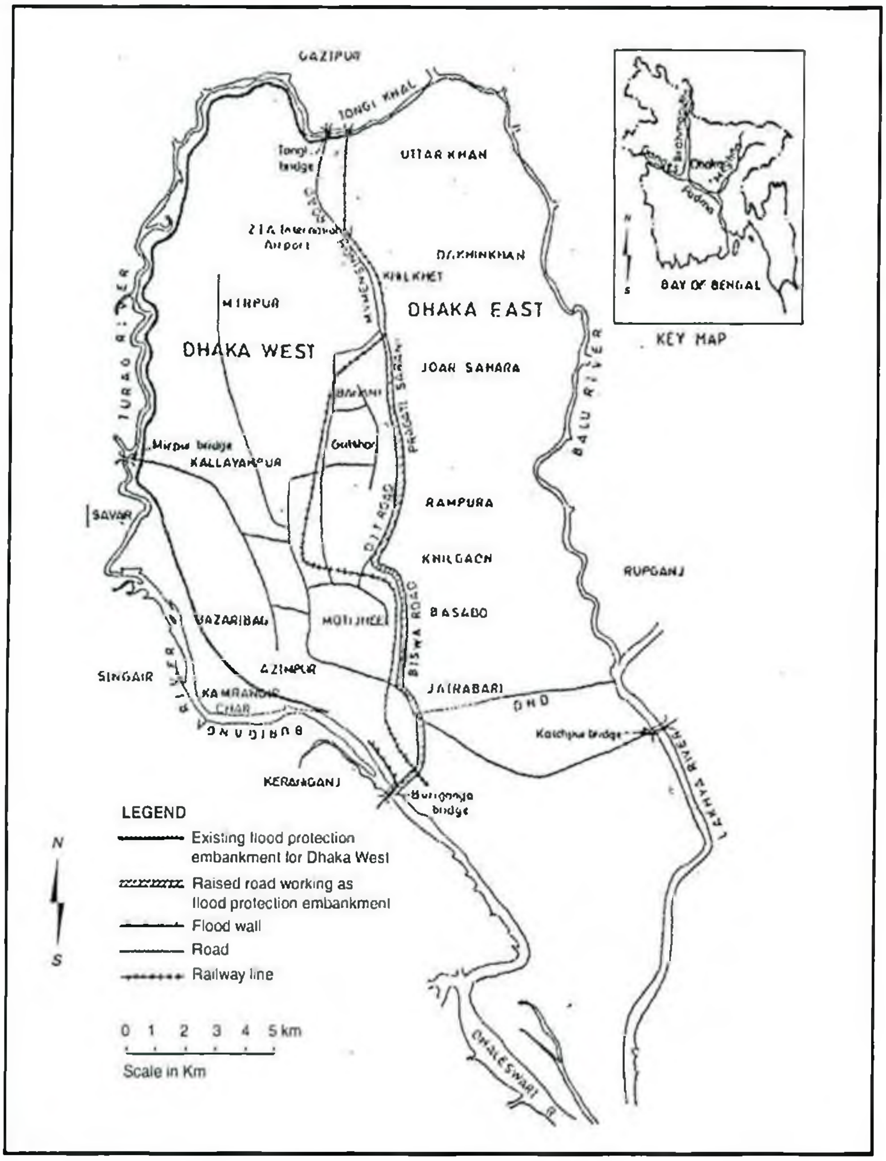
FLOOD CONTROL, MANAGEMENT AND HUMAN ADJUSTMENT WITH SPECIAL REFERENCE TO DHAKA CITY

5.0 : Introduction

The city of Dhaka is also vulnerable to floods. Dhaka City, the capital of Bangladesh is located in the central region of the deltaic plain of the three large rivers, the Ganges, the Brahmaputra and the Meghna. The city is surrounded by distributaries of these three major rivers. The surrounding rivers are Buriganga to the south, Turag to the west, Tongi khal to the north and Balu river to the east.

Figure-5.1: The City of Dhaka, East-West



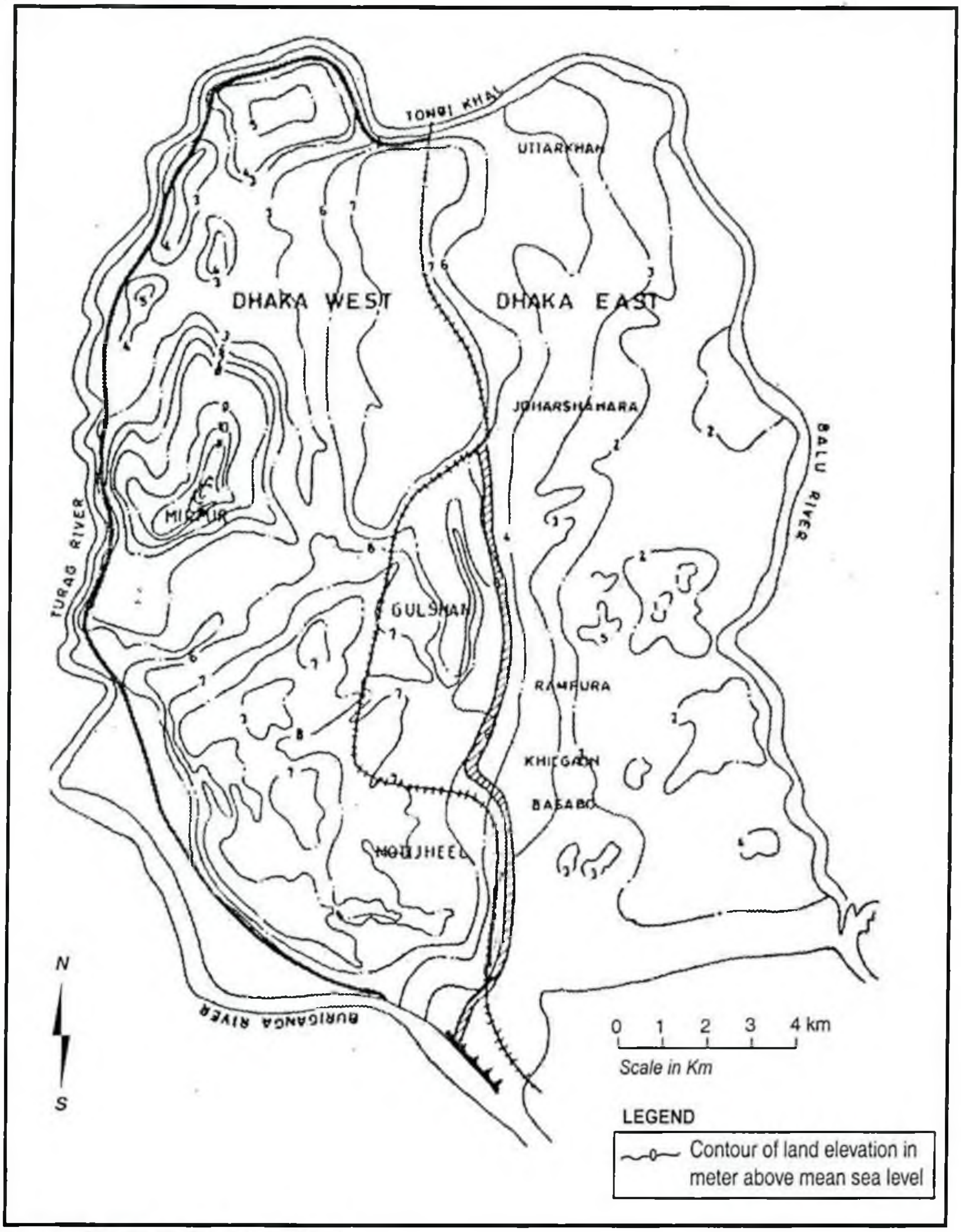
Source : Modified after PANPS/BCAS, 1996

Based on flood control infrastructures, greater Dhaka City can be divided into two parts :

1) Dhaka West and,

2) Dhaka East.

Figure 5.2 : Contour Map of Dhaka City



Source : Modified after JICA : 1987

Two parts are divided by Mymensingh Road, Progoti Sarani, DIT Road and Biswa Road that were raised after the devastation flood of 1988 to perform as road-cum-embankment. According to the Flood Action Plan (FAP) the part which is at the western side of the raised road, is called Dhaka West while the eastern part is known as Dhaka East. The combined area is called Greater Dhaka city and has an area of approximately 275 sq. km. (JICA, 1992). Dhaka East has an area of approximately 119 sq, km. So that Dhaka West has an area of approximately 156 sq km. The Dhaka West is protected from river flood by peripheral embankment as shown. After the occurrence of the devastating flood on 1998, decision has been taken to construct peripheral embankment to give protection to the Dhaka East against river flood. The city and adjoining areas are composed of alluvial terraces and low lying areas, which are part of the Madhupur Jungle Terrace. The elevation of Greater Dhaka lies between 2 to 3 m above mean sea level (msl).

Thecontour map of Dhaka City shows that most of the urbanized area lie at elevation 6 to 8 covers 75 sq. km while 170 sq km of area is below 6 m. It is seen from the contour map that Dhaka East is a low lying area.

5.1 Population and Land use of Dhaka City

The population of Dhaka City is growing rapidly. Presently the City of Dhaka is inhabited by around 12 million people (BBS, 2005). The population was 0.51 million in 1961, which rose to 5.35 million in 1991 and was exceeds the limits of 10 million in the year 2000. The density of population in Dhaka City was 20,000 persons per sq. km. In 1991 while the present density in the country is about 850 persons per sq. km. The urban areas are fore cast to be expanded from 200 sq. km. In 1990 to 366 km. By 2010 and the population is expected to reach 13.5 million by the year 2010 (CUS-2002 and JICA-1991).

5.1.1 Land use distribution of Dhaka City.

About one-fourth of the land area in the City of Dhaka incorporates residential structured area, while roads and other structured surfaces cover another one-fourth areas of the city. The elaborate land-use distribution of the city is shown in the following table

Table : 5.1 The land use distribution of Dhaka City

Land use	% of Dhaka West (area : 156 sq. km.)	% of Dhaka East (area : 119 sq. km.)	% of total area : (area : 275 sq. km.)
1. Residential Area	25	19	22
2. Commercial	3	0	2
3. Industrial	2	0	1
4. Institutional	7	0	4
5. Roads	12	-	6
6. Other urban	12	-	6
7. Agriculture	21	74	46
8. Water bodies	18	7	13

Source : BCAS, 2001

Presently most of the Dhaka West is urbanized. Moreover urban area of Dhaka West is expanding rapidly. The Dhaka East is on the floodplain of Balu river. Dhaka East, though low lying is one of the major areas where urban growth will become dominant and quite considerable growth has already taken place. The data in table 5.1 is representating the present land use distribution. GIS based analysis by Khan (1997) indicates that 62% of Greater Dhaka City was urban in 1996. Construction of proposed flood protection would accelerate urbanization in the Dhaka East.

5.2 Climate of Dhaka City

The climate of Dhaka City is classified as tropical monsoon. It is hot and humid during May to September while cool and dry during November to February. The monsoon is the rainy season from May to September. The climate condition are shown below :

Table : 5.2 Climatic condition of Dhaka City

Parameters	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct.	Nov	Dec
Average rainfall (millimeter)	6.5	20.2	52.3	124.0	28.3	398.2	391.4	328.0	346.0	160.0	25.3	7.4
Rainy days permonth	1	2	4	8	14	19	22	22	16	9	2	1
Average temperature (°C)	18.8	21.5	26.1	28.7	28.9	28.0	28.7	28.7	28.7	27.4	23.6	19.8
Relative humidity (%)	70	66	63	71	79	86	87	86	86	81	75	74
Evaporation (millimeters)	104	79	81	77	78	86	87	130	118	106	75	105
Wind velocity	2	2	3	5	5	4	4	4	3	2	1	1

Source : JICA, 1991

5.3 Rainfall of Dhaka City

Annual average rainfall of Dhaka City is approximately 2000 mm. More than 80% of the annual rainfall occurs during May to September of which June , July and August are the months of heavy rainfall (table 5.2). Average number of rainy days per month during June to August are 19 to 22 as shown by table 5.2

5.4 Runoff in Dhaka City

Run of from urban areas as result of rainfall is generally higher than those from rural areas. This is because urban area has many impervious surfaces e. g. roof of house, paved roads and parking lots etc. Percent of impervious area and fraction of rainfall that is converted to runoff (run off ratio) for some area in the Dhaka West are given below based on measurements during monsoons of 1996 and 1997. It is seen that runoff ratios in commercial areas are higher than those in residential areas and can be as high as 80%.

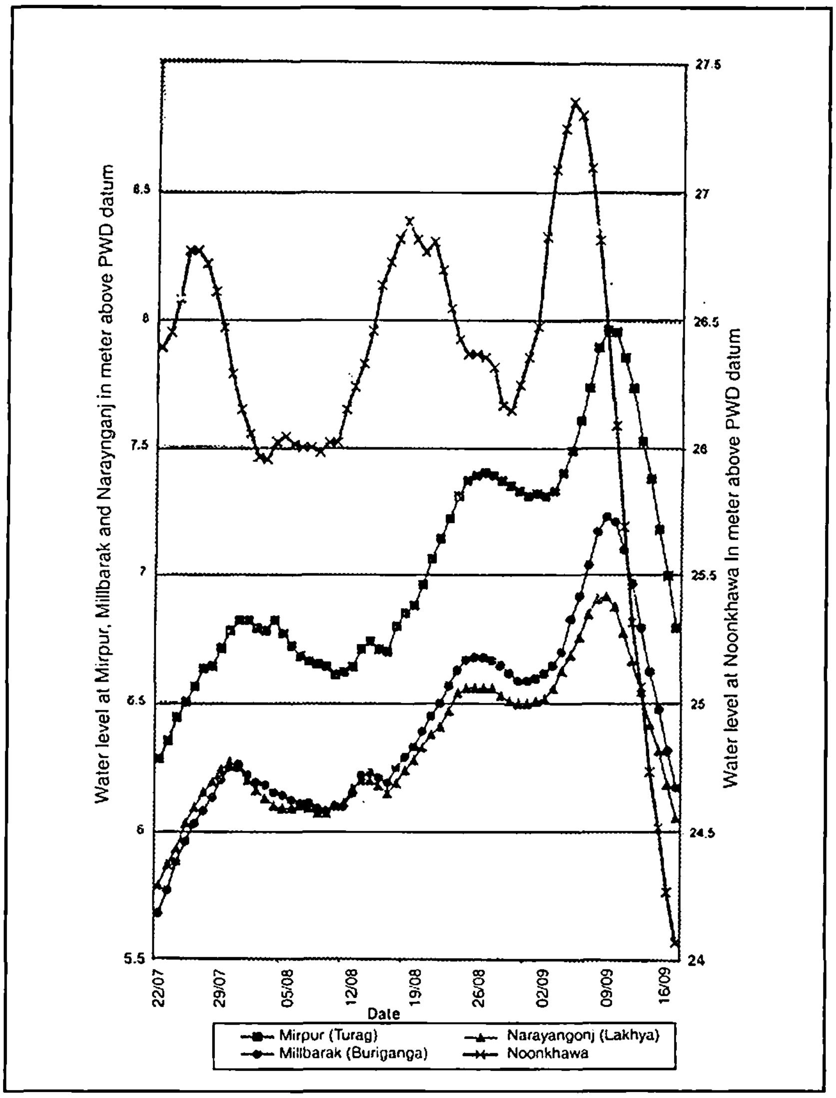
Table 5.3 : Imperviousness of land surface and runoff ratio for some areas (Dhaka-West)

Location	Land use	Sewer type	Impervious are in percent	Run off ratio
New Elephant Road and residential adjoining area	Commercial cum residential area	Under ground water	85	0.4-0.8
Dhanmondi and Satmosjid Road	High class residential area	Under ground water	65	0.4-0.7
Zigatala	Unplanned high density residential area	Under ground water	90	0.3-0.6
Azimpur	Planned and unplanned residential area	Surface drain	80	0.2-0.5
BUET	University campus	Surface & subsurface	55	0.1-0.3

Source : IFCDR, 1999

A rainfall hydrograph of the City of Dhaka and adjoining districts is given below (fig-5.3). It shows the rainfall scenerio of Mirpur, Narayangonj, Millbarak and Noonkhawa (in Burrigonga river) in meter above PWD datum in 1999.

Figure 5.3 : Rainfall Hydrograph of Dhaka City and Adjoining districts



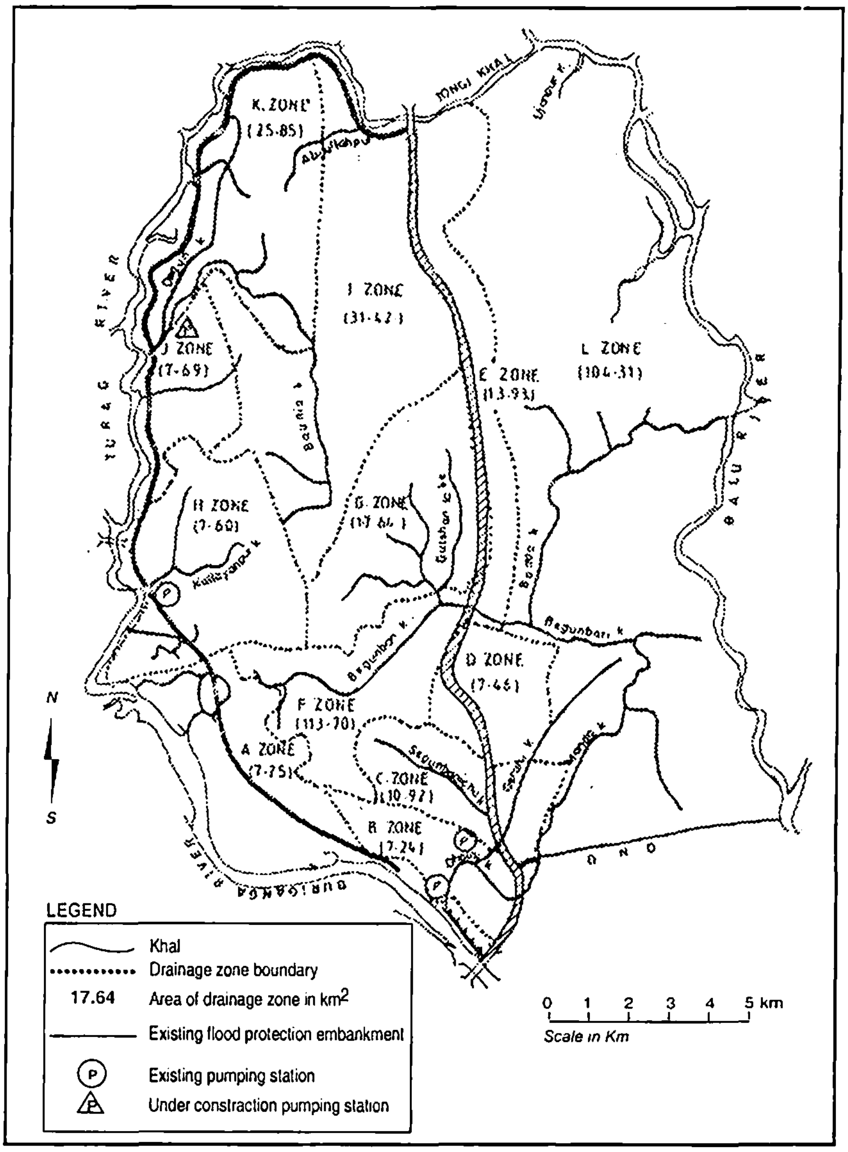
Source : IFCDR, 1999

5.5 Drainage, Relief and Hydrology of Dhaka City

Drainage by Khals and Lakes

The city rainfall-runoff is accumulated in low-lying areas and lakes, flows through Khals and ultimately is discharge to the rivers surrounding the city. The water level in surrounding rivers remains high during monsoon. As a result, the drainage system of Dhaka City in under the influence of back water effect from surrounding rivers. A hydrologic feature important for drainage is that maximum monthly rainfall usually occurs before the peak water level occurs in the surrounding rivers as illustrated.

Figure 5.4 : Major Khals and Lakes of Dhaka City.



Source : Modified after BCAS, 1999

The Dhaka West has 13 Khals having a total length of more than 31 km. While the Dhaka East has 27 Khals of total length of 60 km. Approximately 80% of the city area are drained through these channels to the surrounding rivers. The catchment area of the Khals in the Dhaka West are shown in table 5.4.

There are more than 40 Khals in Greater Dhaka City. There are three major Khals systems as follows :

1) Degun-Ibrahimpur-Kallyanpur Khal system drain to Turag river,

2) Dhanmondi-Paribag-Gulshan-Banani-Mahakhali-Begunbari Khal system drains to Balu river and

3) Segunbagicha-Gerani-Dhola Khal system drains to Balu and Buriganga rivers. Major Khals and Lakes are shown in fig 5.4.

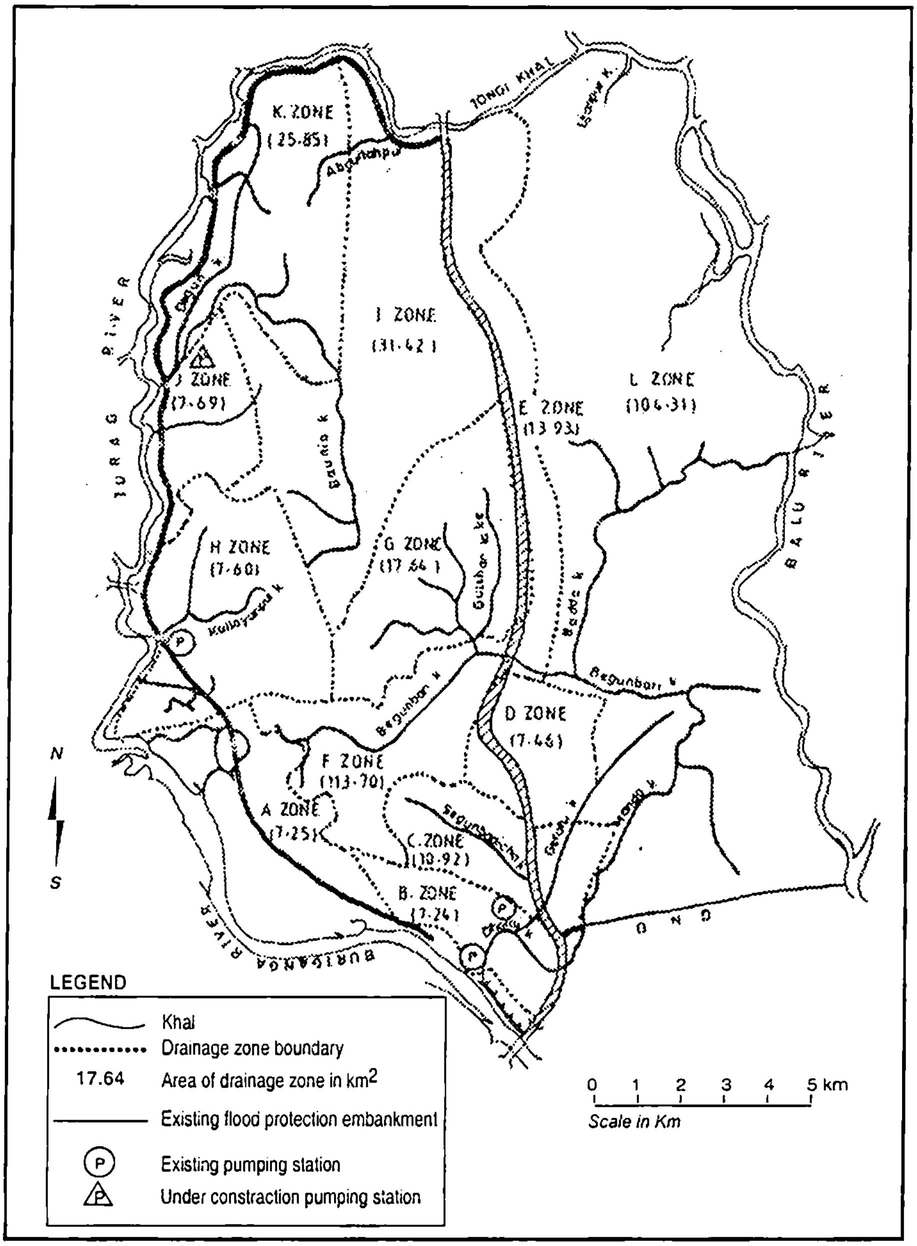
Table 5.4 : Some parameters of major Khals and Lakes in the Dhaka West

(1) Major Khals

Name	Length (km)	Catchment area (km)
Dholai Khal	4.0	16.8
Gerani Khal	3.4	6.7
Segunbagicha Khal	3.5	8.3
Begunbari Khal	6.5	37.7
Total	17.4	69.5

Source : BCAS, 1999

Fig 5.5 : The Drainage zones of Dhaka City



Source : Modified after BCAS, 1999

(2) Major Lakes

Table 5.5 : The area and depth of major lakes in the Dhaka West.

Name	Length (m)	Avg. Depth (m)	Area (sq. km)	Volume (10 m.)
Dhanmondi Lake	2400	2.5	0.176	44
Ramna Lake	400	4.5	0.02	09
Crescent Lake	650	2.5	0.16	04
Gulshan Lake	3800	2.5	0.480	120
Total	7250		0.692	177

Source : BCAS, 1999

The Greater Dhaka City area is divided into 12 drainage zones. The division is on the basis of topographic conditions, Khal system and outfall to the surrounding rivers. The drainage zones and their area are shown in Fig 5.5.

There are many water storage areas such as Lakes and low lying lands. Total area and depth of major Lakes in the Dhaka West are given in Table 5.5. The Dhaka East is in the floodplain of Balu River, is in fact low-lying area.

5.6 : Nature of flood in Dhaka City

Nature of flood in Dhaka City is briefly described below :

5.6.1 : Flooding by surrounding rivers

Several floods in Dhaka City are mainly caused by spill from surrounding rivers namely Turag river, Tongi Khal, Balu river and Buriganga.

5.6.2 : Travel time of flood in Dhaka City.

There were 3 flood waves in succession in 1998. It took approximately 6 days by the front of 1998 flood to reach Dhaka City from the India–Bangladesh border while the flood peak required approximately 4 days to travel to Dhaka. Because of hydraulic reasons, the flood peak moves faster than the flood trough.

Table 5.6 : Comparison of characteristics of 1987, 1988 and 1998 floods in surrounding rivers of Dhaka City

Parameter	River	Gauge Station	1998	1988	1987
Danger Level in meters above PWD datum	Buriganga	Millbarak	6	6.1	6.1
	Turag	Mirpur	5.94	5.94	5.94
	Tongi Khal	Tongi	6.08	6.08	6.08
	Balu	Demra	-	-	-
Date of crossing Danger Level at rising stage	Buriganga	Millbarak	26.07.1998	29.08.1988	15.08.1987
	Turag	Mirpur	18.07.1998	24.08.1988	03.08.1987
	Tongi Khal	Tongi	22.07.1998	28.08.1988	02.08.1987
	Balu	Demra	-	-	-
Number of days required by the flood front to arrive at Dhaka city from India-Bangladesh border.	Buriganga	Millbarak	7	7	10
	Turag	Mirpur	6	7	11
	Tongi Khal	Tongi	6	6	10
	Balu	Demra	-	10	10
Number of days required by the heist flood peak to travel from India-Bangladesh border to Dhaka city.	Buriganga	Millbarak	4	6	10
	Turag	Mirpur	4	6	10
	Tongi Khal	Tongi	5	6	10
	Balu	Demra	-	8	10
Height of peak flood level in metre above Danger Level	Buriganga	Millbarak	1.23	1.58	0.64
	Turag	Mirpur	2.03	2.41	1.32
	Tongi Khal	Tongi	1.46	1.76	0.82
	Balu	Demra	-	-	-
Duration of flood in days above Danger Level	Buriganga	Millbarak	56	22	16
	Turag	Mirpur	69	30	35
	Tongi Khal	Tongi	65	25	22
	Balu	Demra	-	-	-

Source : IFCDR, 1998

These result have been obtained by analyzing water level hydrograph at gauging station in surrounding rivers and at Noonkhawa on the Buriganga river. The hydrographs are based on daily water level and obtained for the BWDB. The gauge station at Noonkhawa is closest to the India-Bangladesh river. It is seen that 1987 and 1988 floods took longer time to reach Dhaka. The travel time in the above table suggests that it is possible to forecast the flood at Dhaka city 4 to 6 days ahead. This lead time can be increased considerably by using data from the catchment of Brahmaputra in India.

5.6.3 : Flood hight in surrounding rivers

It is seen that the third flood wave had the highest while the first one had the smallest height in 1998. The flood level at Mirpur was higher than those at other stations. This explains why flood water from the Turag river moved twards both Tongi Khal and Buriganga rivers.

The heights of maximum flood levels above DL (Danger Level) during 1987, 1988 and 1998 shows that the height of 1998 flood was smaller than that of 1988 while larger than that of 1987. But the rainfall during 1988 flood was much lesser than that of 1998.

5.6.4 : Duration of flood in surrounding rivers

Flood duration above DL in surrounding rivers during 1987, 1988 and 1998 floods are given in Table 5.6. A comparison of duration of these floods can also seen in table 5.6. It is seen that 1998 flood contained for more than 2 months which is unprecedented. The duration of 1987 and 1988 floods were much less and did not exceed 35 days.

The flood flows in surrounding rivers are affected by backwater effect from Dhaleswari, Sitalakkya and Meghna rivers. The back water effect is caused by tides in the Meghna river from the Bay of Bengal. The recession of flood water in the surrounding rivers was delayed considerably by the spring tides, which occur after new moon and full moon.

It is seen from the table that the duration of flood above DL at Mirpur is quite longer that those at other gauge stations. This is because the DL at Mirpur is longer than those at other locations. Since the DL is longer, it was crossed earlier during rise of flood and later during recession of flood.

5.7 River flood in Dhaka City

5.7.1 : Balu river flood in Dhaka-East

Dhaka East is the floodplain of the Balu river. Almost entire Dhaka East was flooded by spill from the Balu river during 1998 flood . The Balu river has its origin in upstream area of Pubail. It is joined by Tongi Khal links the Balu river with the Turag river. Later the Balu river meets the Lakhya river at Demra.

The flood of 1998 took place around 22nd July and continued for about sixty five days. It reached the peak on the 12th September. Residential areas like Basabo, Mugdapara, Uttar Badda, Joar Sahara etc. were the worst affected. Boats were seen to play in the submerged road during flood time. (picture 5.0). In some roads, the depth of flood was around 1.5 meter. Ground floor of the most of the building was inundat-

ed. The flood completely receded on around 23rd September.
Some residence of Joar Shahara and Basabo areas in the Dhaka East have mentioned that the 1998 flood level in their area has crossed the level of 1988 flood. Unfortunately, it can be verified since water level data from the Balu river for 1998 flood at Narayanganj on the Lakhya river has crossed the 1988 flood level substantially.

5.7.2 : Balu river flood in Dhaka-West

Dhaka West is expected to remain flood free since it was in the flood control project. Unfortunately, the areas adjunct to Mymensingh road Progati Sarani, DIT road and Biswa road were flooded during 1998 flood. Mohakhali, Gulshan, Banani, Badda, Baridhara etc. were the worst affected areas. Flood water stayed for about one month. Intrusion of flood water of Balu river from Dhaka East through some unblocked culverts and unclosed regulators was considered to be general cause for river flood in Dhaka West. Drainage network of Dhaka WASA was studied and field visits were made to find out the openings along the roads. There are 13 drainage structures marked as FS To FS 13 along the raised road.

5.8 Flood control measures for Dhaka City

A. Embankment

To observe the performance of flood control project in Dhaka-West, embankment and regulator were visited by IFCDR during September 10-12, 1998 when river flood level was highest. Measurements of river flood level were taken at some location along the embankment. There were erosion at the river side of the embankment at few locations. However, the erosion was not serious and protective measures were taken by BWDB. The site engineers of BWDB mentioned that the locations where concrete blocks with geo-textiles could not be placed were subject to erosion. The BWDB Engineers mentioned at that time (1998) that placement of geo-textile concrete blocked is expected to be completed soon.
Extensive slum habitation on the embankment was observed at location behind Rayer Bazar and Mohammadpur. Its is a threat to the safety of embankment. Maintenance has become difficult and condition of embankment has deteriorated at these locations.
It may be mentioned that a section of about 2.2 km long between Lalbag Kellermukh to Shasanghat along Buriganga river near the Friendship Bridge (Japan-Bangladesh Friendship Bridge) was not closed by flood protection embankment. The reason for not

completing the embankment at this location is not known. Flood water from Buriganga with active participation of local people saved the area from disaster.

The Mymensingh Road, DIT Road and Biswa Road were raised after the devastating flood of 1998 to prevent instruction of flood water from Balu river into the Dhaka West. Unfortunately the areas adjunct to these roads were inundated by flood water as discussed. This unexpected flooding was due to intrusion of flood water of Balu river through some unblocked culverts and unclosed regulator along the raised roads.

B. Regulator

There are 10-vent regulators on the Begunbari Khal at the downsteream side of Rampura Bridge on the DIT road. There are number of smaller size regulators on the embankment along Tongi, Turag and Buriganga rivers. The catchment area of Begunbari Khal at Rampura crossing is approximately 38 sq km. It drains huge area covering Dhanmondi, Green Road, part of Dhaka University, Paribag, Tejgaon industrial area, Mohakhali, Gulshan, Baridhara, Banani, Rampura etc. The regulators were constructed so that entry of flood water from the Balu river through the Begunbari Khal can be prevented by closing the gates of the regulator. It is reported that the gates were not closed at the right time and flood water entered inside. During field visit on September, 12 1998 it was observed that 12 out of 20 pumps of individual capacity of 5 cusec were pumping water from inside to outside (IFCDR, 1998)

Plot of water levels, at riverside and protected side as well as the difference between the two for the Rampura regulator on the data obtained from the recorded information at the site for August and September 1998. To compare the performance, similar information for the Goran Chandbari regulator on the embankment along Turag river are also plotted. It is seen that riverside water and protected side water levels were almost same at Rampura regulator while the river side water level was much higher than the river side water level for quite long time.

The analysis suggested that the Rampura regulator was not effective during 1998 flood due to operational fault. Of course, instruction of flood water through unblocked culverts also made the regulator ineffective. The Goran Chandbari regulators and on the embankment along Tongi, Turag and Buriganga rivers performed quite well during 1998 flood.

C. Pump Drainage of Rain water

Large Scale Pump Station

There are three permanent pumping stations. One is at out fall of Kallyanpur Khal to Turag river and its capacity is 10 cumec. Another one is the Dholai Khal at Naridada and its design capacity is 9.6 cumec. This is a very old pumping station and its efficiency has become very low. The third one is at the outfalll of Dholaikhal to Buriganga river and its capacity is 22 cumec. The darinage area of this pump station includes old Dhaka City as well as adjacent areas in the Dhaka Wast and also includes that of Narida pump station. The Narinda pump station would not be required when the complete flood control program associated with the third pumping station is implementd. All the three pumpiong stations were in operation during 1998 flood.

The Kallyanpur pump station was effective in draining rainwater during 1998 flood. It was observed that low lying areas such as kyllanpur, Shymoli etc were dry. These areas suffered fron severe flooding during 1988 flood. The water levels at river side and protected side as well as their differnce at pump station are plotted based on the data obtained from the recorded at pump station. The daily rainfall is also plotted based on the data obtained from the record at pump sation. The daily rainfall is also plotted. To illustrated the effetiveness of this pumped drainage, water level data from the regualtor at Goran Chandbari. Its gates were closed when river side water level becomes lower.

It is seen that the difference between riverside and protected side water levels at kallyanpur pump station is much larger than that of Goran Chandbari regulator. There was increase in protected side water level because of rainfall. However, in the case of kallyanpur pump station, the protected side water level was brought down and then it was nearly constant. This analysis also supported that the kallyanpur pump station performed effectively during 1998 flood.

As a result of operation of other two parmanent pump stations on Dholaikhal, larg pert of old Dhaka City was dry during 1998 flood. It is not clear why simultanious operation of these two pump stations of quite large capacity was necessary. One pump station is at Narinda and the other is a new at the out fall to Buriganga. Water Levels as well as difference at the new pump station is plotted. Along with the data at the crossing of Segunbagicha khal with Bishwa road. It is seen that the pumping station reduced the protected side water level after rainfalll quite substantially. Drop in water level is much larger compared to that in Segunbagicha khal.

It is seen that protected side water level at the new pump station increased suddenly on the 5th September 1998. As per opinion of local people, an earthen bund was constructed to stop the folw over the submerged sluice gate on the Zerani khal. The earthen bund suddenly colapsed resulting in on rush of water. This is the cause of sudden increase in the protected side water level at the pump station.

D. Small Scale Temporary Pumps

A number of small pumps in group were installed at different locations to drain out of the accumulated rainfall water. The capacity of each pump is 5 cusec. The internal water and accumulated rainfall, introduced flood water and domestic waste water, There were 20 pumps at Rampura regulator, 30 pumps at crossing of Segunbagicha khal with Biswa road, 1 pump at Goran Chandbari regulator and a total of 15 pumps along the embankment from Hazaribag to Kellarmukh as illustrated. IFCDR team observed during field visit on September 11 to 23 of 1998 that 12, 16 and 15 pumps were in operatin at Rampura regulator (IFCDR, 1998). Segunbagicha khal, Goran and Hazaribag to Kellermukh respectively.

The pumping at Rampura regulator was futile. The reasons have been explained with the help of observed data. The total pumping capacity was also insigniicant compared to the drainage area of Begunbari khal at Rampura regulator.

The pumping from Segunbagicha khal effective. The benefited areas are Mitijheel, Fakirapul, Shantinagar, Rajarbag and other areas. These areas are usually flooded during moderate to heavy rainfalls. The pumping was able to lower the protected side water level which had increased after rainfall.

The pumping at Goran Chandbari had negligible effective on the protected side water level. This was because the pumping capacity was very small compared to the vast volume of water accumulated in the retention area as observed. A large scale pump station is under construction near this location at the out fall of Degun Khal in the Turag river by the BWDB. The Pumping along the embankment from Hazaribag to Kellermukh was able to keep the protected side water level lower to considerable extent as observed from water marks.

5.9 Critical analysis of the flood control measures in Dhaka City

Whenever it rains, many of Dhaka's citizens know they are going to be flooded of waterlogged again an inconvenience that also brings sickness. Citizens, doctors and engineers all point accusing fingers at a new embankment around Dhaka built to protect them from floods. "Life becomes a prolonged nightmare when water logging occurs in our neighborhood. Says Mrs. Zakia Sultana, a resident of the Shantinagar area while talking to her. As one of the lowest lying areas of the city, Shantinagar collects run-off from higher parts. "The area suffers from acute drainage congestion from more than half of the mosnoon season." Mohammad Ibrahim Ali says " Ther was a time when the water used to drain away quickly, recede, causing untold misery to citizens. The residents of these area opined that the ring dam around Dhaka has something to do with it."

Construction of the "ring dam" officially called the Dhaka Intergrated Town Protection Embankment (DITPE) started after the flood of 1998, which spared in the capital, in the slums or diplomatic areas; 70% of Dhaka was inundated and damage was estimated at Tk. 9 billion. The idea was to built a wall around the city to keep out the monson floods, in a scheme that was later incorporated into the flood action plan. One half of the circular dam has been built; Construction of the second half is now in doubt. Here some opinino of some renowned critics obtained by Bangladesh Centre for Advanced Studies (BCAS) quoted below :

Critics such as private engineering consultant M. Aminur Rahaman said "building the dam was a political stunt by the then military ruler H.M. Ershad, who wanted to impress Dhaka citizens and who at the same time awarede the construction contract to party members". Prof Aniun Sishat of the Bangladesh University of Engineering and Technology said "the embankments design was based on inadequate survey and engineering data dating back to the 1960s. Development will inevitably have changd the drainage path inside the city since then. He also said "The final designs should have given special attention to this," Other leading engineers have joined the criticism, as has Engineering News, bulletin of 22,000 member Bangladesh Institute of Engineers. Critics said that "While the embankment keeps water out, no provision was made for flushing out sewerage or rain water originating, within the city wall. As a result, flood water polluted with sewage and industrial effluent builds up in the low-lying parts of the city. The water filling the streets and flooding the ground floors of homes and offices smells foul and is quite obsviously polluted, carrying every kind of waste from excreta to dead cats" (BCAS).

The dirty water causes sickness, and children are the most vulnerable. Dr., Sheikh Muhammad Ali, a private physician in Dhaka, said children suffer from increased rates of diarrhoea, measles and scabies when the flooding is its worst. The Dhaka Medical College, which usually admit 10-15 babies a day, admits a daily average of 50 at the height of the flooding. On the other hand the International Center for Diarrhoeal Diseases Research of Bangladesh (ICDDRB) has to put up tents outside its laboratories as there is no room inside for all the sick babies needing treatment.

Diarrhaoeal infection is especially likely when the ground and the drinking water is contaminated and in the slums, there is no sanitation, also latrines are constructed over ponds. ditches and rivers. This situation is likely to get worse as Bangladesh's urban growth rate is 5.8% and basic services such as water, sanitation and grabage disposal are already scanty to non-existent in many areas (BCAS).

Not only is this growth adding to the contamination of flood waters confined by the ring dam, it is also putting further obstacles in the path of flood and rain water attempting to escape from the city. Channels constructed in the old days of Moghul rule to help drain water away have been filled in and built over. The massive 40 meter wide Dholaikhal cannel is now a major highway.

Lakes and Marshes which absorbed extra run off have also been filled up by real estate developers, in some case reversing the drainage of water towards the city and smaller drains and ditches have become completely blocked with plastic bags, sanitary towels, cocount shells and all kind old drains and canals and to pump the water out over the new embankment. However, this will be an expensive drain on the public purse.

5.10 : Concluding Remarks : The City of Dhaka is surrounded by distributaries of the threee major rivers. The surrounding rivers are Burrigonga to the South, Turag to the West, Tongi Khal to the North and Balu river to the East. These distributaries carries huge quantity of water during rainy season and due to this fact bank of these distributaries become overflow and inundated the adjioning areas of the city. The structured drainage of the city are not sufficient to carry the runoff water because of huge quantity of water go to the reivers through runoff. Besides these, the climate of Dhaka City is classified as tropical monsoon. It is hot and humid during May to September while the monsoon rainy seasons is the same time. More than 80% of the total annual rainfall occurs during the said period and create flood occationally.

CHAPTER - VI

FLOODS IN BANGLADESH: REGIONAL OVERVIEW WITH CASE STUDY

CHAPTER-VI

FLOODS IN BANGLADESH : REGIONAL OVERVIEW WITH CASE STUDY

6.0 Introduction

Bangladesh has regularly been experiencing the curse of flooding including the devastating ones similar to those of the deluge of 1987, 1988, 1996, 1998, 2000 etc. The Government and the people of Bangladesh have embarked on some major initiatives to combat the flood threats and create an environment for secure social and economic growth. Following a Flood Policy Study financed by UNDP and joint flood studies by France, Japan, China and the USA, the Government asked the World Bank to assist them in developing and co-ordination a five year flood action plan, which drawing on these studies, would form the first stage of a long-term flood control program for the country.

The objective of the study is to assess the flood control and drainage options and to reduce flooding or manage flooding, establish the preferred solutions, to prepare a regional water development plan and to come out with a feasibility study of priority project.

6.1 : Regional overview

In the present study, in order to examine the nature, causes, vulnerability and probable control or adjustment of floods in Bangladesh, the whole country has been divided into five flood regions and indepth studies have been made in each of these regions. The regions are :

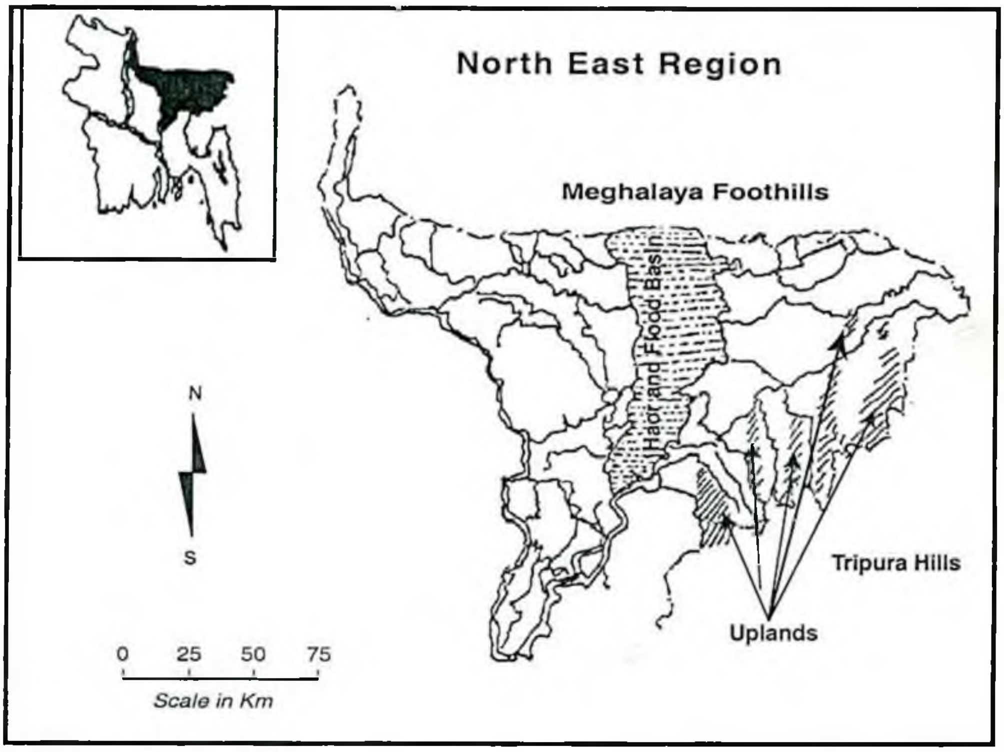
a) The North-East Region
b) The North-Central Region
c) The North-West Region
d) The South-East Region and
e) The South-West Region.

Elaborate flood situation of these five regions are discussed here. To get the actual scenario of these five regions, extensive questionnaire survey have been conducted. The result and findings of these survey are also narrated with the description below :

1. The North-East Region

6.2 Introduction : The North-East Region, with an area of 24,200 km is comprised mainly of six land forms : the Sylhet Depression, lowland floodplains, piedmont floodplains, alluvial fans, terraces, and uplands. Most of these landforms are of fluvial origin, although some have been modified by tectonic subsidence or uplift. Land use relates closely to topography, soil and flood depth, time, and duration. Approximately 50% of the region lies below 8 m elevation ; 25% lies below 5 m (PWD datum).

Fig- 6.1 : The North-East Region



Source : Modified after FAP

(i) The Sylhet Depression : The Sylhet Depression is a low-lying bowl-shaped basin covering about 25% of the region or 6,000 sq. km. Virtually all of this land is below 8 m and is flooded to depths of 5 m and more during the monsoon. Saucer-shaped, seasonally-flooded, inter fluvial areas called *haor* characterized this unit ; the small permanent lakes in the lowest pockets are called *beels*. The main rivers traversing the depression include the *Surma, Kalni, Kushiyara, Baulai*, and *Dhanu*. These rivers are characterized by highly sinuous, meandering sand-bed channels with cohesive banks. During the last two centuries, land use has been altered to meet the needs of an ever-expanding human population. The forest has been consumed and in its place, winter season rice is now being cultivated.

(ii) The Lowland Floodplains : The lowland floodplain were called as a result of deposition and erosion from the *Surman, Kushira, Meghna,* Old Brahmaputra, and Jamuna Rivers. This land form covers about 55% of the region or 13,260 sq, km. land elevations typically range from 16 m to 9 m on the *Surma/Kushira* floodplain, from 22 m to 9 m on the Old Brahmaputra floodplain, and are less than 7 m on the Meghna floodplain. The soil of the *Surma/Kushira* floodplain are mainly alluvial silts and clays while the Old Brahmaputra floodplain consists of poorly stratified fine sandy to clayey silt. The main crops of this region is rice which produce at least one and often twice annually.

(iii) The Piedmont Floodplain : The Piedmont Floodplain are found along tributary streams that join the larger mainstream rivers and cover about 4% of the region or 960 sq km land elevation range from 24 to 9m. Principal piedmont streams include the *Khowai, Monu Sutang, Dhalai* and *Juri* rivers which flow northwards from the Tripura Hills in India to join the *Kushiara.* These streams are characterized by meandering sand-bed channels.

(iv) The Alluvial Fans : The Alluvial Fans are found along the foot of the Meghalaya Plateau and cover about 6% of the region or 1490 sq km. The decrease in channel gradient and reduction in velocity as the stream leave their canyons causes deposition of sand and gravel sediments which take the form of a "fan-shape" conical delta.

(v) The Terrace Area : The Terrace Areas covers about 2% of the region or 500 sq km. It has been raised by uplifting and faulting so it si no longer subjected t inundation by normal flooding. Elevations range from 10 to 8 m and the soil are comprised of Madhupur clays.

(vi) Up Lands : Up Land occurs as out lines extending into the region from the Tripura Hill and cover about 8% of the region or 1970 sq. km. which generally called Hilly areas of this region. It has a cover of upland first thickets and grasses.

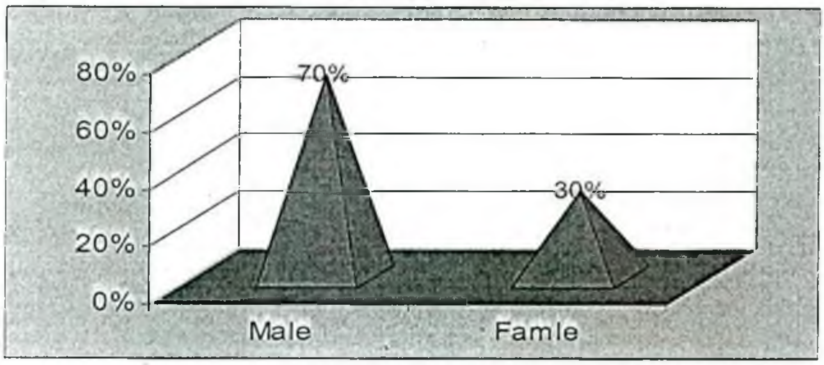
6.2.1 Questionnaire Survey : Most of the area of the Sylhet depression and the Lowland Floodplain become inundated almost every year due to overflow of river bank. In order to understand the intricate problems and mode of adjustment of the flood effected dwellers of the different flood-regions of the country extensive questionnaire surveys have been conducted using set-questions, the results and findings of which have been presented below:

Table- 6.1 : Sex ratio of the respondents

Sex	Total	Result	Percentage
Male	40	31	70%
Female	40	9	30%

Source : Questionnaire Survey, 2003

Fig- 6.2 : Sex ratio of the respondents



Source : Questionnaire Survey, 2003

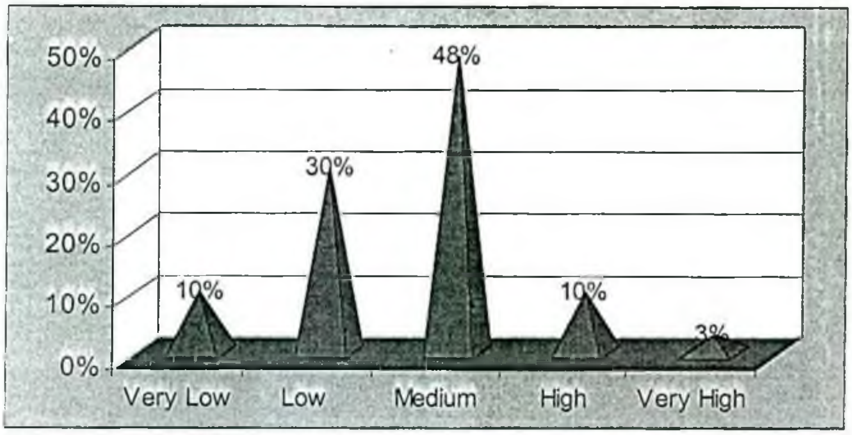
Sex ratio of the respondents are shown in figure No. 6.2. Most of the respondents (70%) are male. The rest (30%) was female. It is noticed at the survey period that some female respondents hesitate to answer the questionnaire on flood. This may be a causes of lesser number of the female respondents. However, people of the study area are very conscious with flood both male & female.

Table- 6. 2 : Levels of land in the study area

Levels of land	Total respondents	Result	Percentage
Very Low	40	04	10%
Low	40	12	30%
Medium	40	18	48%
High	40	04	10%
Very High	40	02	3%

Source : Questionnaire Survey, 2003

Fig- 6. 3 : Levels of land in the study area



Source : Questionnaire Survey, 2003

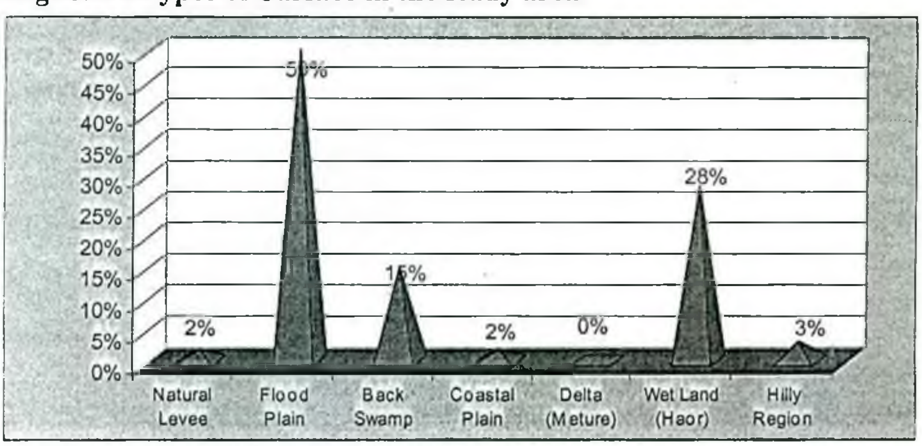
This region is formed with the combination of all categories of level of land. Low and medium land comparatively holding a large area. High and very high areas are respectively 9 and 3 percent considered as flood free zone in this area.

Table-6. 3 : Types of Surface in the Study Area

Types of Surface	Total respondents	Result	Percentage
Natural Levee	40	01	2%
Flood Plain	40	20	50%
Back Swamp	40	06	15%
Coastal Plain	40	01	2%
Delta (Mature)	40	00	0%
Wet Land (Haor)	40	11	28%
Hilly Region	40	02	3%

Source : Questionnaire Survey, 2003

Fig- 6. 4 : Types of Surface in the study area



Source : Questionnaire Survey, 2003

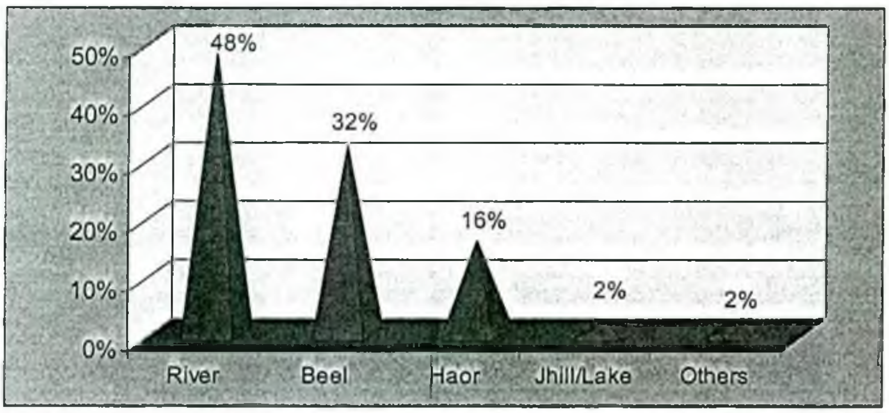
Analysing the type of surface of this area it is found that, half of this area (50%). are flood plain. The second highest type is wetland (Haor) and the third is Back Swamp. The district Sylhet, Sunamgonj, Habigonj, Kishoregonj are holding maximum wet-land areas.

Table- 6. 4 : Types of water body in the study area

Types of water body	Total respondents	Result	Percentage
River	40	19	48%
Beel	40	13	32%
Haor	40	06	16%
Jhill/Lake	40	01	2%
Others	40	01	2%

Source : Questionnaire Survey, 2003

Fig- 6. 5 : Type of water bodies in the study area



Source : Questionnaire Survey, 2003

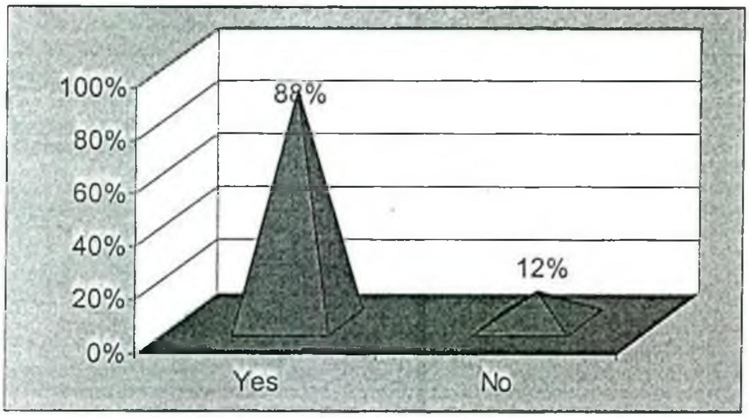
River and Beels are the common type of water bodies of the total study region of the country. The North-East region cover 48% and 32% of river and beels respectively. The other 16% of this region are wet-land (Haor). This area is totally different from other four regions of the country as divided.

Table- 6.5 : Flood occurence in the study area

Flood occurence	Total respondents	Result	Percentage
Yes	40	35	88%
No	40	05	12%

Source : Questionnaire Survey, 2003

Fig-6. 6 : Flood occurence in the study area



Source : Questionnaire Survey, 2003

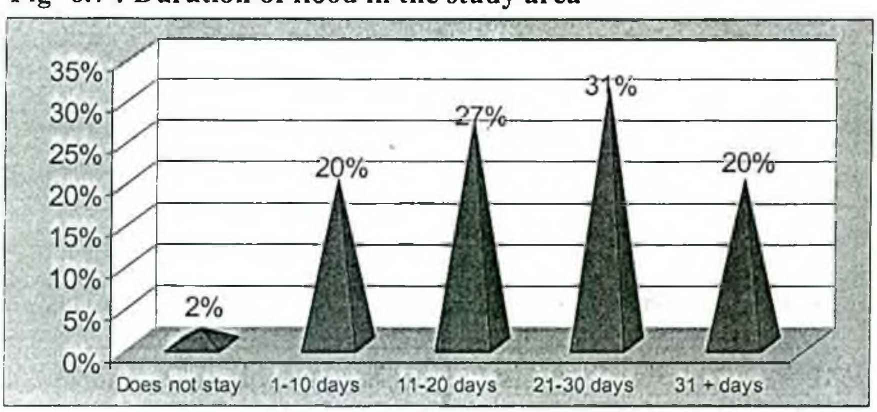
The total 88% of the respondents said that flood occurs in their region. The rest 12% said flood does not take part in their region regularly. While analyzing the level of land, it is found that high and hilly region of this areas are accordingly 9% and 3% of the total land.

Table- 6.6 : Duration of flood in the study area

Duration of flood	Total respondents	Result	Percentage
Does not stay	40	01	2%
1-10 days	40	08	20%
11-20 days	40	11	27%
21-30 Days	40	12	31%
31-+ Days	40	08	20%

Source : Questionnaire Survey, 2003

Fig- 6.7 : Duration of flood in the study area



Source : *Questionnaire Survey, 2003*

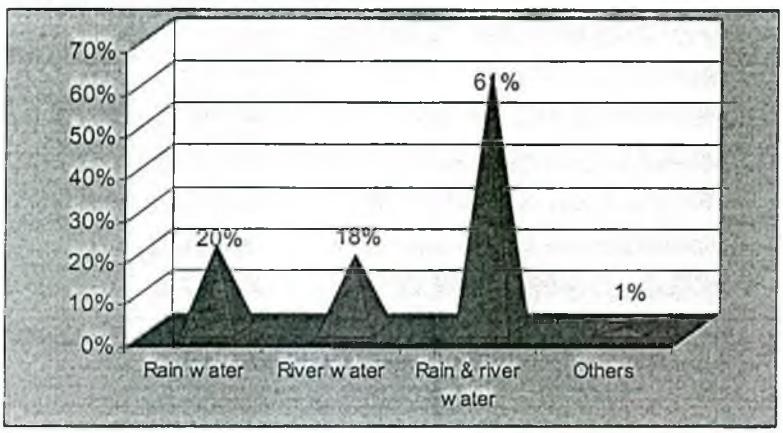
The duration of the flood in the study area are very significant. Only two percent of the respondents said flood doesn't stay in their area. On the other hand 20% respondents said that flood stays more the 31 days while occurs. At the same time the different statistics are found like 20%, 27% and 31% opined for accordingly 1-10 days, 11-20 days and 21-30 days.

Table- 6.7 : Sources of flood water

Sources of flood water	Total respondents	Result	Percentage
Rain water	40	08	20%
River water	40	07	18%
Rain & River water	40	24	61%
Others	40	01	1%

Source : Questionnaire Survey, 2003

Fig-6.8 : Sources of flood water



Source : Questionnaire Survey, 2003

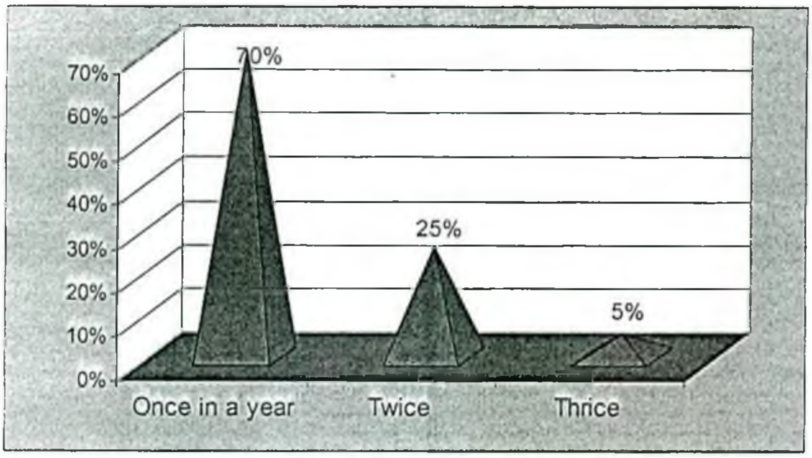
Almost every cases flood water comes from rain and river. In the rainy season rivers are fullfilled with water. Then the tide, surges and tsunamy become a vital causes of flood. 61% areas are flooded with rain and river water while 20% and 18% with rain and river water accoundingly. It is observed that flash flood occurred in this area. Very few people of this area are conscious about flash flood.

Table- 6.8 : Times of flood occurs in a year

How many times	Total respondents	Result	Percentage
Once	40	28	70%
Twice	40	10	25%
Thrice	40	02	05%

Source : Questionnaire Survey, 2003

Fig- 6.9 : Times of flood occurs in a year



Source : Questionnaire Survey, 2003

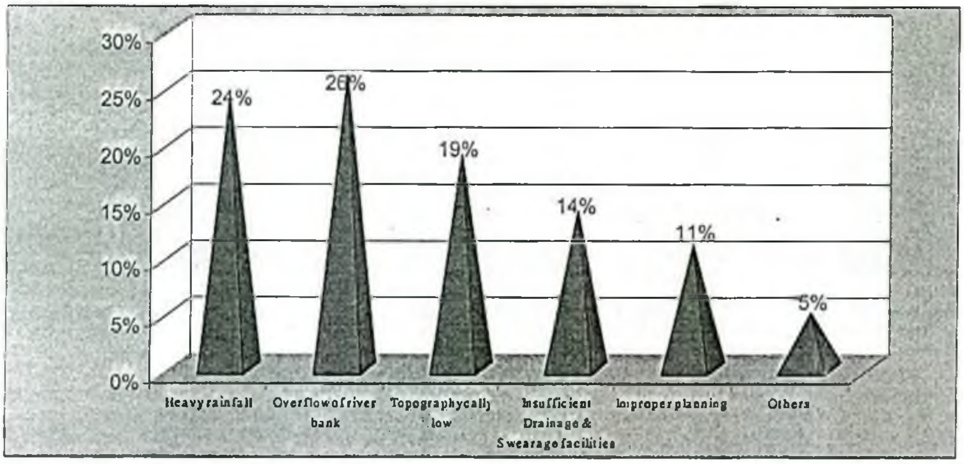
Flood does not take part more than once in a year. The toatal 70% of the respondents opined that flood takes part once in a year while 25% said twice and only 5% said thrice in a year. Haor area and river basin are inundated more than once in a year due to flash flood.

Table-6.9 : Causes of flood in the study area

Causes of flood	Total respondents	Result	Percentage
Heavy rainfall	40	09	24%
Overflow of river bank	40	11	26%
Topographycally low	40	07	19%
Insufficient Drainage & Swearage facilities	40	06	14%
Imporper planning	40	04	11%
Others	40	03	5%

Source : Questionnaire Survey, 2003

Fig- 6.10 : Causes of flood in the study area



Source : Questionnaire Survey, 2003

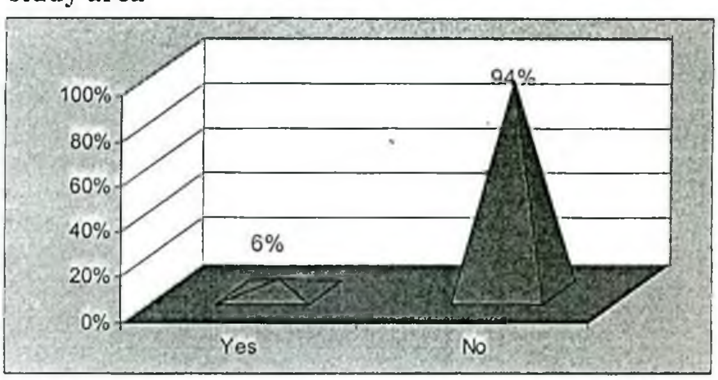
Various causes of flood are find outed in the study area while collecting information through questionnnaire survey. These are heay rainfalls, overflow of river bank, topogrphically low land, insufficient drainage & sewerage facilities, improper planning etc. A few No. of respondents expressed their opinion that flood water comes from India.

Table-6.10 : Present measures of flood controlling are appropriate or not in the study area

Appropriate/Not	Total respondents	Result	Percentage
Yes	40	03	6%
No	40	37	94%

Source : Questionnaire Survey, 2003

Fig-6.11 : Present measures of flood controlling are appropriate or not in the study area



Source : Questionnaire Survey, 2003

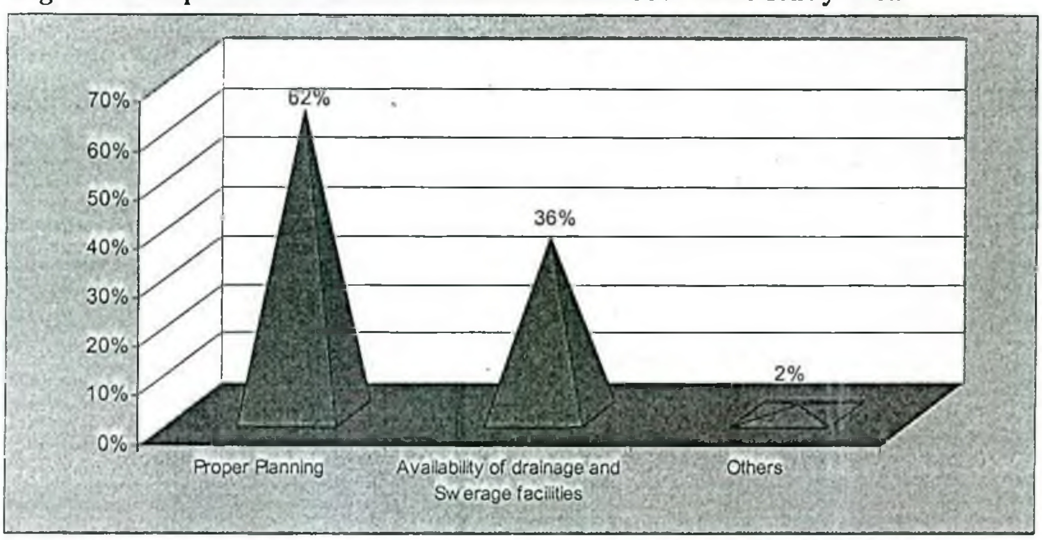
It is found in the hole study that the flood situation of the country is deteriorating simultaneously. But in the present study area maximum respondents (94%) opined that the present flood controlling methods are not appropriate. Only 6% expressed their opinion in favour of present flood controlling methods. While asking the question that why not appropriate? They answered that the situation is not improving for a long time. Basides these they do not get help sufficiently from the Government at the time of flood.

Table- 6.11 : Steps should be taken to control the flood in the study area

Suggestions	Total respondents	Result	Percentage
Proper Planning.	40	25	62%
Availability of drainage and Sewerage facilities	40	14	36%
Others	40	01	2%

Source : Questionnaire Survey, 2003

Fig-6.12 : Steps should be taken to control the flood in the study area



Source : Questionnaire Survey, 2003

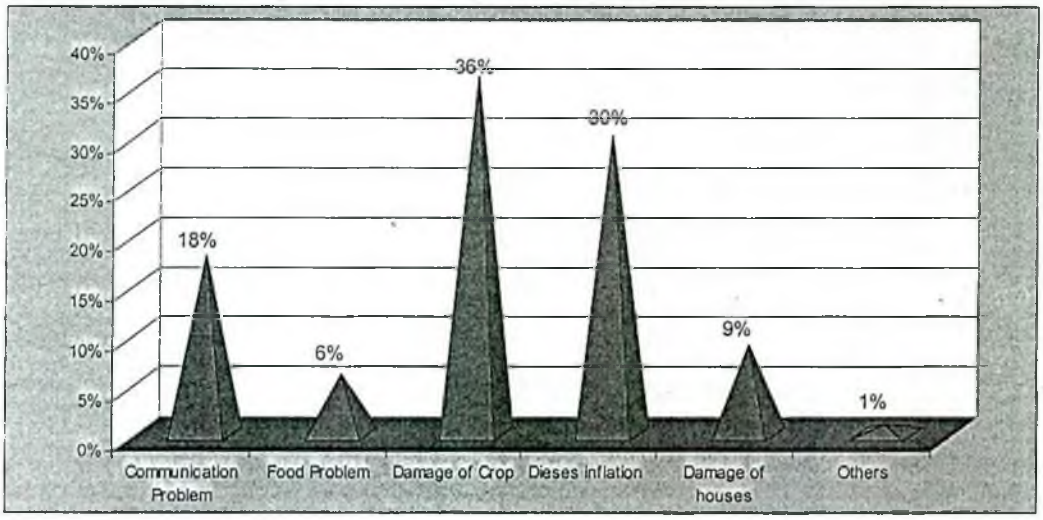
The respondents of the regon are seeking proper plannng fo the controlling measures of flood. Almost 62% of the respondents opined for proper planning. On the other hand 36% opined for insufficient drainage and sewerage facilities. Water logging due to drainage congestion is causing flood in this region.

Table -6.12 : Types of problem in the period of flooding

Type of Problems	Total respondents	Result	Percentage
Communication Problem	40	07	18%
Food Problem	40	02	6%
Damage of crop	40	14	36%
Disesas inflation	40	12	30%
Damage of houses	40	04	9%
Others	40	01	1%

Source : Questionnaire Survey, 2003

Fig -6. 13 : Types of problem in the period of flooding



Source : Questionnaire Survey, 2003

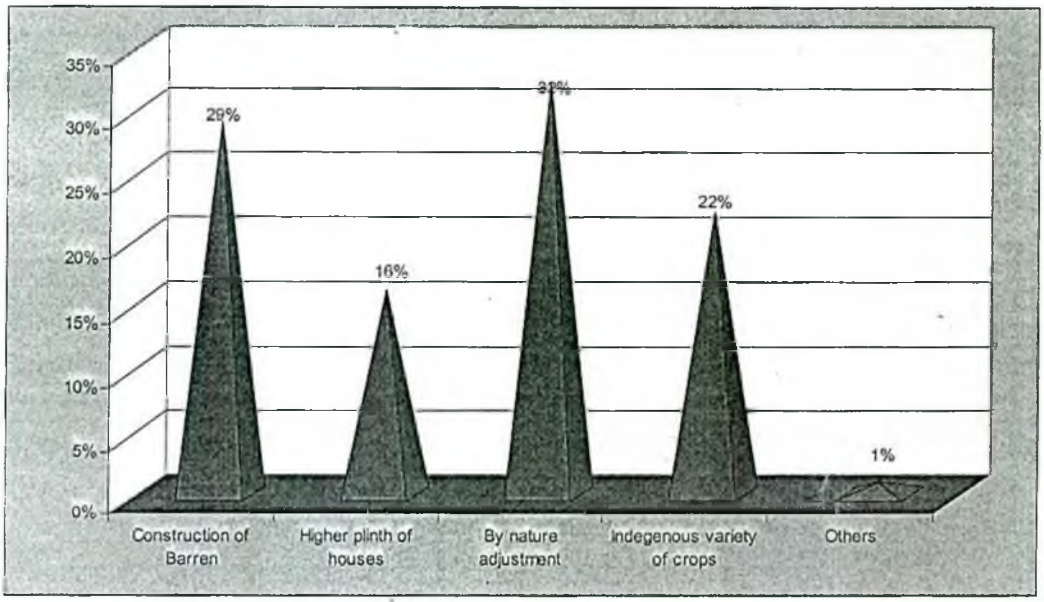
People in the inundated area face various types of problem at the timr flood. Among the respondents 36% said that flood damage their corps. This damge is an economic impact of flood to the people as well as the country. Diseases inflation and communication problem are also become serious at that time. Sometimes these may be causes of lost of lives. However, flood becomes a cause of different suffering directly and indirectly. Some common problems in the period of flooding are found to the local people like food problem, shelter problem, harvesting problem, cattle and domestice animals care taking problem etc.

Table- 6. 13 : How do the local people face problems at the period of flooding

Ways of problem facing	Total respondents	Result	Percentage
Construction of Barren	40	11	29%
Higher plinth of houses	40	06	16%
By nature adjustment	40	13	32%
Indigenous variety of crops	40	09	22%
Others	40	01	1%

Source : Questionnaire Survey, 2003

Figure 6.14 : How do the local people face problems at the period of flooding



Source : Questionnaire Survey, 2003

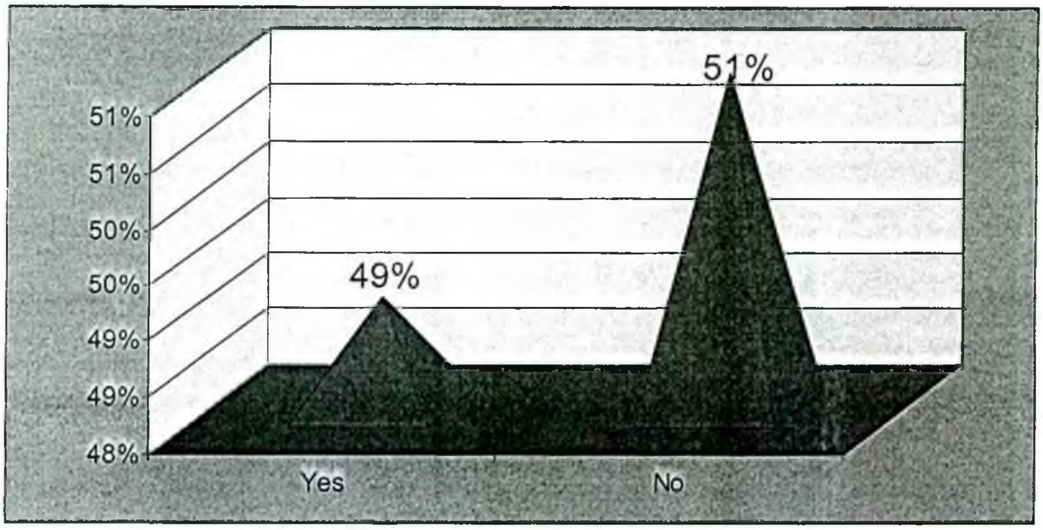
Local people faced the problems of flood in their own way. They can get help form various organization like Govt. NGO and other social.workers. Besides these local people take some necessary appropriate steps like Barren constructin, Higher plinth of houses, Indigenous variety of crops etc. Local people of the study area habituated to adjust with flood by nature. Some 20% of the responsents opined for construction of Barren is one of the vital steps to be taken to face the flood problem, while 16% for higher plinth of houses, 32% for by nature adjustment and 22% for indigenous variety of crops accordingly opined for in facing problems.

Table-6.14 : Flood becoming more serious or not in the study area

Yes/No	Total respondents	Result	Percentage
Yes	40	19	49%
No	40	21	51%

Source : Questionnaire Survey, 2003

Fig-6.15 : Flood becoming more serious or not in the study area



Source : Questionnaire Survey, 2003

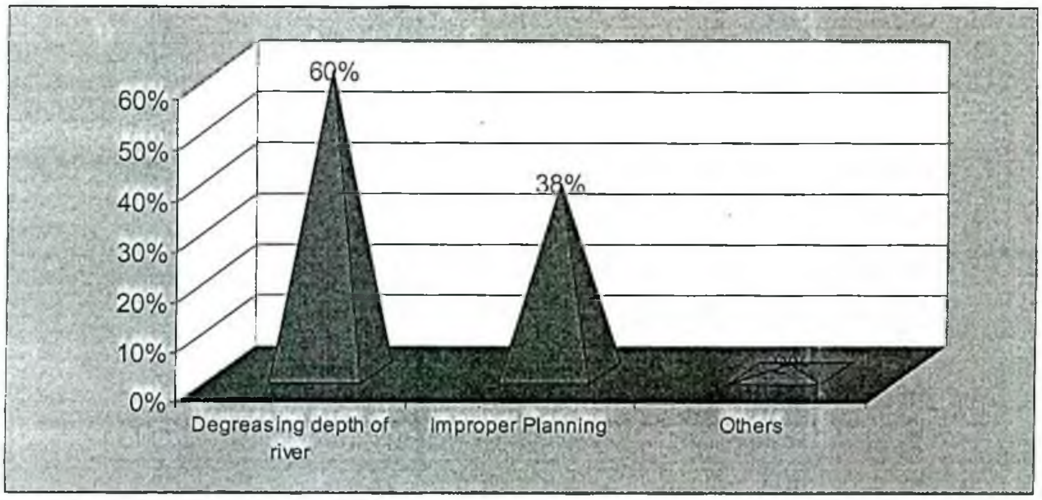
Among the respondents almost 49% local people of this area said that flood becoming more serious in their region. On the other hand 51% said that it is not becoming more serious. It is observerd that the above mentioned 49% respondents lives in the low and very low level land in the study area.

Table- 6. 15 : Causes of deterioration of flood in the study area

Causes of deterioration	Total respondents	Result	Percentage
Decreasing depth of rivers	40	24	60%
Improper planning	40	15	38%
Others	40	01	2%

Source : Questionnaire Survey, 2003

Fig-6. 16 : Causes of deterioration of flood in the study area



Source : Questionnaire Survey, 2003

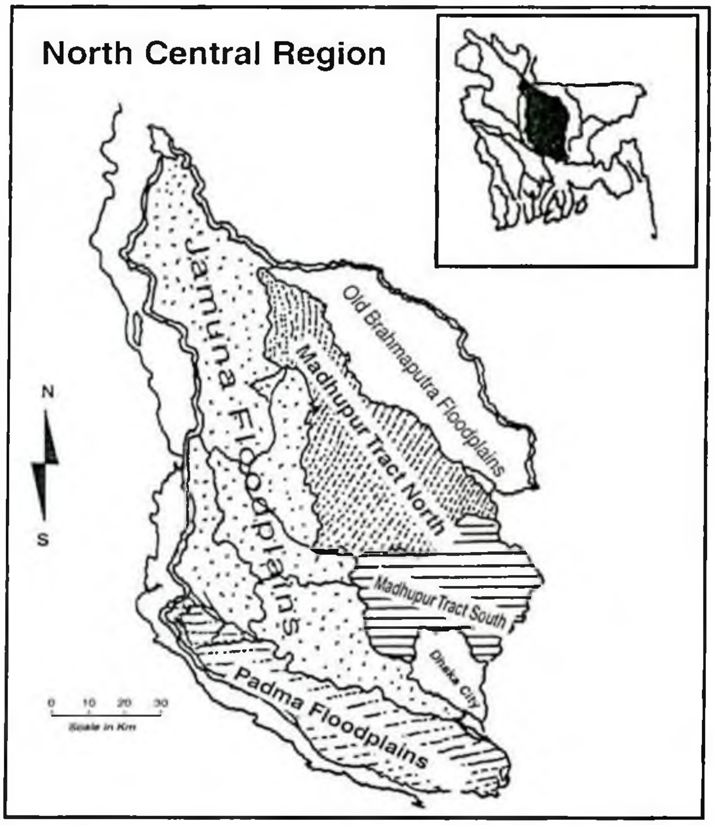
Most of the people of the study area identified that sedimentation of river and other water bodies is the main causes of flood occurance. Because, due to sedimentation depth of rivers decreasing and water logging capacity are lost. Some 38% respondents said that lack of improper planning is also responsible for deterioration of the flood situation.

2. The North-Central Region

6. 3 Introduction

The North-Central Region has an area of 12,000 sq/km covering the districts of Mymensingh, Jamalpur, Tangail, Gazipur, Manikganj, Munshiganj, Dhaka and Narayanganj. It is a very flat one with elevation between 18m (PWD) in the north to 4m (PWD) in the south. The area is bounded by the Jamuna river to the west, the Padma and Meghna rivers to the south and the old Brahmaputra and Lakhya rivers to the north and east. The population of the region except the industrial output of Dhaka and its neighboring area.

Fig.-6.17 : The North-Central Region



Source : Modified after FAP

6.3.1 : Flooding & Drainage in the North-Central Region

Flooding in the North Central Region originate from three sources :

1. Direct rainfall
2. Direct over bank spillage from the major boundary rivers and
3. Over bank spillage from the internal regional river.

It is possible for each phenomenon to occur separately or in combination with any other. The proportionate contributions of rainfall, Jamuna and local rivers varies between years and within flood seasons. The flooding and drainage system of the North Central Region is characterized and influenced by the three major rivers forming its boundary : the Jamuna, the Padma and the old Brahmaputra-Lakhya-Meghna system.

The old course of the Brahmaputra River forms the northern and part of the eastern boundary of the area. The mouth of this river has been steadily silting over the years since the river changed its course and the flows down this branch is a fraction of the original.

The Bangshi-Turag system provides the center spine drainage of the region. It is fed partly by spill from Jamuna through the Northern Dhaleswari intake via the Pungli River, partly the accumulated runoff from the north-west of the region and partly from the direct runoff in to the Bangshi from the western slopes of the Madhupur Tract. The regional rivers in the west of the North-Cenral Region are predominantly characterised by having river bank (Levees) which are elevated above the surrounding flood plain. This is a result of either man-made intervention, in the form of embankment, or a natural phenomenon of built-up levees, typically exhibited by rivers subject to regular flooding of sediment laden waters.

Average monsoon rainfall of the area varies from 1,400 mm to 2,200 mm. The south-west winds usually begin in June and last through to October bringing heavy, persistent rain.

6.3.1.0 Drainage of the North-Central Region takes place at 4 levels

1) The boundary river system (primary)
2) The regional river system (secondary)
3) The Khal system (tertiary), and
4) The beel system (quaternary)

The mechanism by which the region drains related directly to this hierarchical system and its interconnections. The key to the drainage of the North Central region lies in the prolonged influence of the high river levels in the boundary rivers over the regional river levels. Unless the levels of the lower Meghna can be reduced at times of high flow, the drainage outlet from the North-Central region will remain congested.

Limited improvement can be made to local drainage conditions within the region, but these will ultimately beat the expense of the downstream reaches, however restricting the inflow from the main rivers into the distributaries would decrease flooding by limiting water entering the regional drainage network.

6.3.2 : Regional Overview

The North-Central Region land resource broadly consist of five main characteristics sub-region on the basis of physiographic units :

- Young Brahmaputra and Jamuna Floodplain
- Old Brahmaputra Floodplain
- Padma Floodplain
- Madhupur Tract north
- Madhupur Tract south

6.3.3 : Timing of Flood

The patter of river levels generally experienced in the region shows a 2-peaked response, the first peak being generated by internal regional rainfall excess, normally in June/July and the second peak resulting from high cross –boundary flows in the major rivers normally in earlier September.

6.3.4 : Water development strategy

A water development strategy was proposed and the water resources characteristics, were considered along with socio-economic, environmental and national planning aspect :

(1) Identify economically viable developments

(2) Identify where high agricultural value can be added from controlled flooding interventions

(3) Priority to heavy distressed sub-regions

(4) Development first where socio-economic framework exist to sustain growth

(5) Involve local people in the planning and management of FCE/1 program

(6) Promote local economic initiatives induce by agricultural/livestock/fisheries improvements

(7) Allow for mitigatory measures wherever persons are adversely affected by a development

(8) Use embankments for several socio-economic purposes

(9) Economic promotion through improved institutional measures

(10) Sub –divide region into regional planning units to facilitate the planning process

(11) Develop environmental management program so as to sustain the region`s resources.

The region have been divided into 12 units as Planning Unit by FAP (FAP-3 study). The area is been investigated in detailed to the agricultural characteristics. The agricultural constraints are found out and necessary steps were taken by the Government. It is estimated that flood depth-duration-frequencies and groundwater utilization and availabilities through a parallel studies. FAP of Bangladesh had been divided the region into 13 units to facilitate the planning process in a certain project. At that time some development strategy had also been taken. The first component of the proposed strategy for development of the reegion`s water resources comprises improvements to land productivity, through the implementation of the cost effective flood control and drainage schemes.

The strategy must take into account that there are a number of factors which change the region whether of not a regional plan is developed and implemented. These factors` are for example:

(a) Increasing population with the consequent need for additional food production, additional housing areas and consequent increasing stress on land and water resources.

(b) The recent and continuing accretion of new land in the southern part of the region with its consequent effect on drainage of nearby areas.

(c) Development of other water resource schemes both in Bangladesh and in other regions and the resulting effects within the southeast region.

(d) The possible effect of a rise in sea level on the coastal polders.

6.3.5 Questionnaire Servey

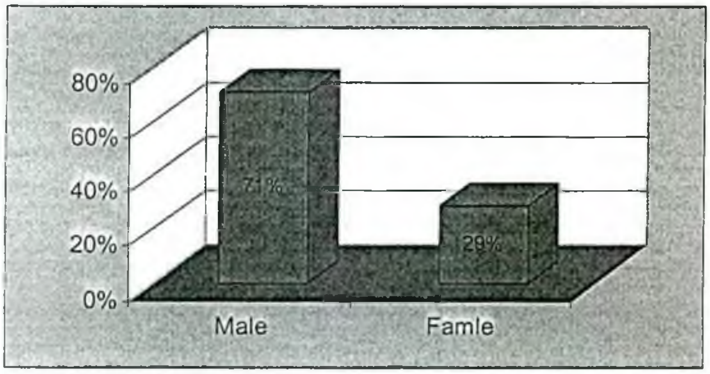
In order to understand the intricate problems and mode of adjustment of the flood effected dwellers of the different flood-regions of the country extensive questionnaire surveys have been conducted using set-questions, the results and findings of which have been presented below :

Table: 6.16 Sex ratio of the respondents

Sex	Total respondents	Result	Percentage
Male	40	28	71%
Female	40	12	29%

Source : Questionnaire Survey, 2003

Fig- 6.18 : Sex Ratio of the respondents



Source : Questionnaire Survey, 2003

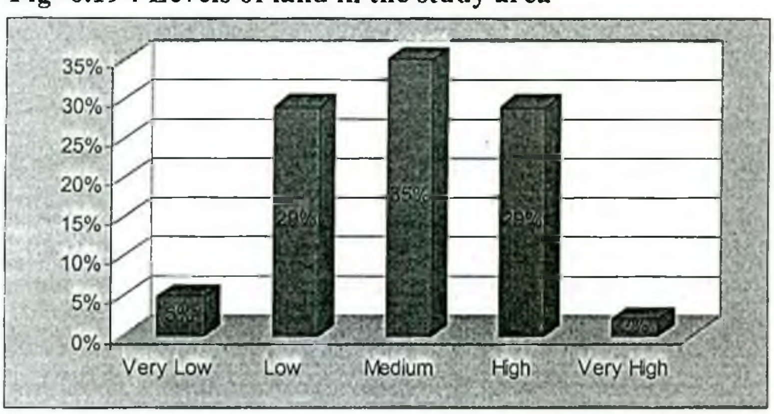
Respondents are selected randomly. Among the respondents selected in the North-Central region of the country, almost 71% of the respondents were male and the rest 29% were female. Male respondents were comparatively available while the survey was being conducted. So the ratio of the female are lesser than the male.

Table: 6.17 Levels of land in the study area

Level of land	Total respondents	Result	Percentage
Very low	40	02	6%
Low	40	11	29%
Medium	40	14	35%
High	40	11	29%
Very High	40	01	2%

Source : Questionnaire Survey, 2003

Fig- 6.19 : Levels of land in the study area



Source : Questionnaire Survey, 2003

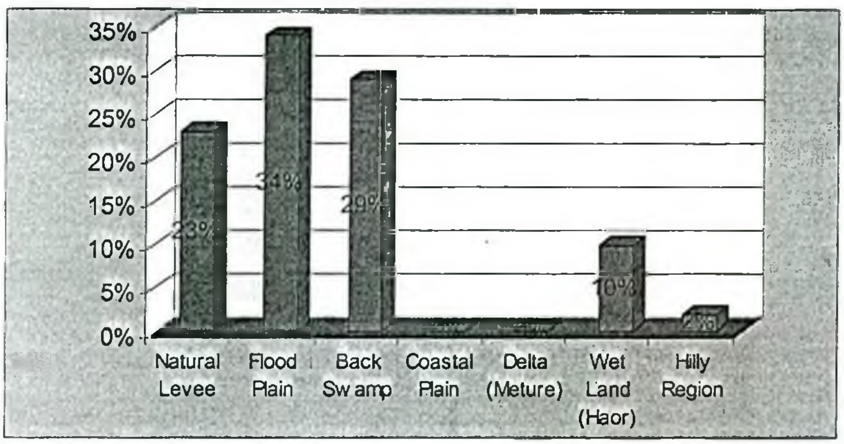
Most of the area covered with low, medium and high land. The quantity of these three types of level of land have an equilibrium. The survey data shows that 29% low land, 35% medium and 29% high land of the hole area. A few percent (6%) is very low land. Very low lands was identified in the haor area of the region . The study area has also a very few hilly region only 1 percent.

Table: 6.18 Types of surface in the study area

Types of Surface	Total respondents	Result	Percentage
Natural Levee	40	09	23%
Flood Plain	40	13	34%
Back Swamp	40	12	29%
Coastal Plain	40	00	0%
Delta (Meture)	40	00	0%
Wet Land (Haor)	40	04	10%
Hilly Region	40	01	2%

Source : Questionnaire Survey, 2003

Fig- 6.20 : Types of surface in the study area



Source : Questionnaire Survey, 2003

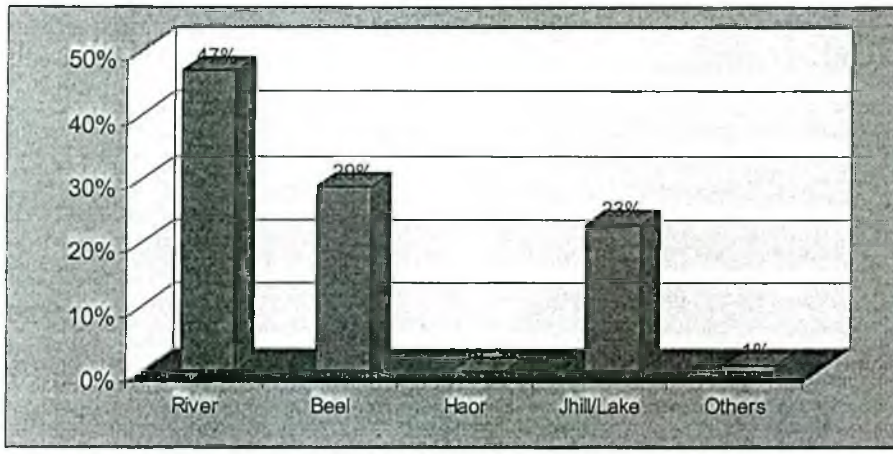
Generally Bangladesh comprises hill, terrace and flood plain areas. The terrace area occupy almost 8% of the country. Among these 8 percent Madhupur Terrace is located in the present study area. The survey data classified the surface and shows that 23% Natural levee, 34% Flood Plain, 29% Back Swamp, 10% Wet Land and only 3% Hilly region. No Coastal Plain and Delta region are found in this area.

Table : 6.19 Types of water body in the study area

Water bodies	Total respondents	Result	Percentage
River	40	18	47%
Beel	40	11	29%
Haor	40	00	0%
Jhill/Lake	40	09	23%
Others	40	02	1%

Source : Questionnaire Survey, 2003

Fig- 6.21 : Types of water body in the study area



Source : Questionnaire Survey, 2003

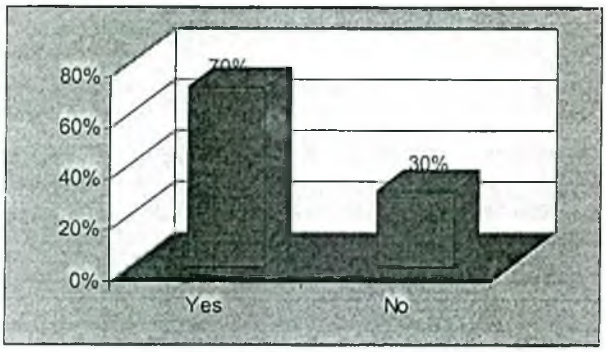
Bangladesh is basically a land of river. Most of the study area shows that river is the main water body of the region. Beel is an another water body which is common almost in all regions of the country. This is exception here that the survey data shows 23% Lake/Jill as water body of the study area. Parhaps the respondents opined including Haor area as Lake and Jhill for water bodies as because no one opined for Haor or Baor.

Table-6.20 : Flood occurance in the study area

Flood occurs	Total respondents	Result	Percentage
Yes	40	28	70%
No	40	12	30%

Source : Questionnaire Survey, 2003

Fig- 6.22 : Flood ocurance in the study area



Source : Questionnaire Survey, 2003

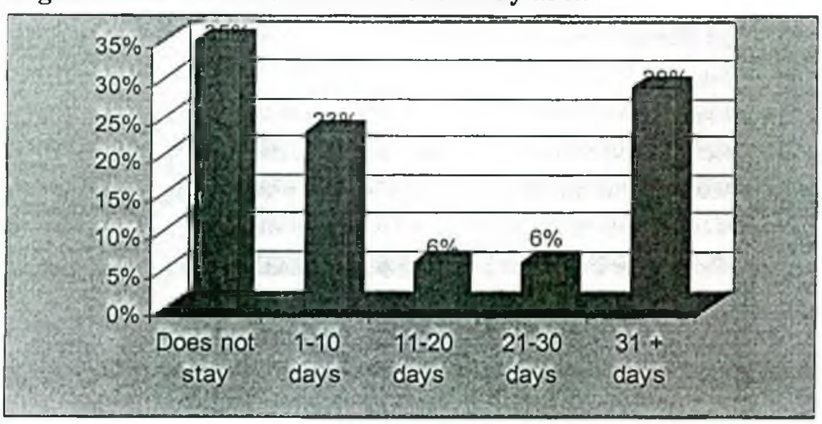
The survey data shows that one third of the area are free from flood. About 30% of the respondents said that flood does not occurs in their region. While 70% of the respondents said flood occurs in their region. Some high land and hilly region are considered as flood free zone.

Table-6.21 Duration of flood in the study area

Duration of flood	Total respondents	Result	Percentage
Does not stay	40	15	35%
1-10 days	40	09	23%
11-20 days	40	02	6%
21-30 days	40	02	6%
31+ days	40	12	29%

Source : Questionnaire Survey, 2003

Fig-6.23 : Duration of flood in the study area



Source : Questionnaire Survey, 2003

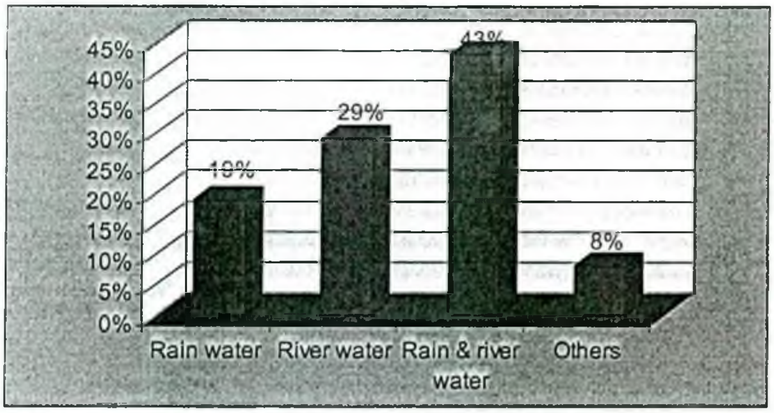
Duration of flood in the study area are not the same. A major portion of the respondents (35%) opined that flood occurs in their area, but does not stay long. While another 23% opined for 1-10 days, 6% opined for both 11-20 and 21-30 days respectively. But exception is that 29% of the respondents said that flood stays more than one month (30+days) in their area. On an average the area reflect a mixed feature of flood situation in the period of flooding.

Table-6.22 : Sources of flood water

Source of flood water	Total respondents	Result	Percentage
Rain water	40	08	19%
River water	40	12	29%
Rain & river water	40	17	43%
Others	40	03	8%

Source : Questionnaire Survey, 2003

Fig-6.24 : Sources of flood water



Source : Questionnaire Survey, 2003

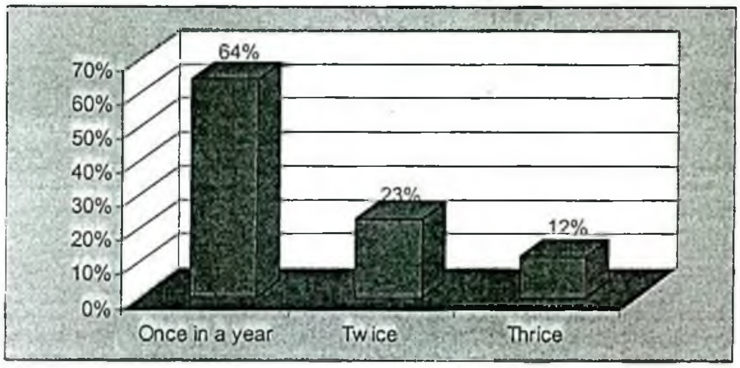
Almost every cases flood water comes from the surrounding rives. Rain water is also a main source of flood water. It is seen from the survey data, that 43% flood water comes from rain and river water, while 19% from the rain and 20% from the river water. Some other 8% flood water comes from others sources. Some of the respondents said that flood water comes from India. It happens specially due to Farakka Barraige as per the opinion of the respondents.

Table-6.23 : Times of flood occurs in a year (in the study area)

How many times	Total respondents	Result	Percentage
Once in a year	40	25	64%
Twice	40	10	23%
Thrice	40	05	12%

Source : Questionnaire Survey, 2003

Fig-6.25 : Times of flood occurs in a year (in the study area)



Source : Questionnaire Survey, 2003

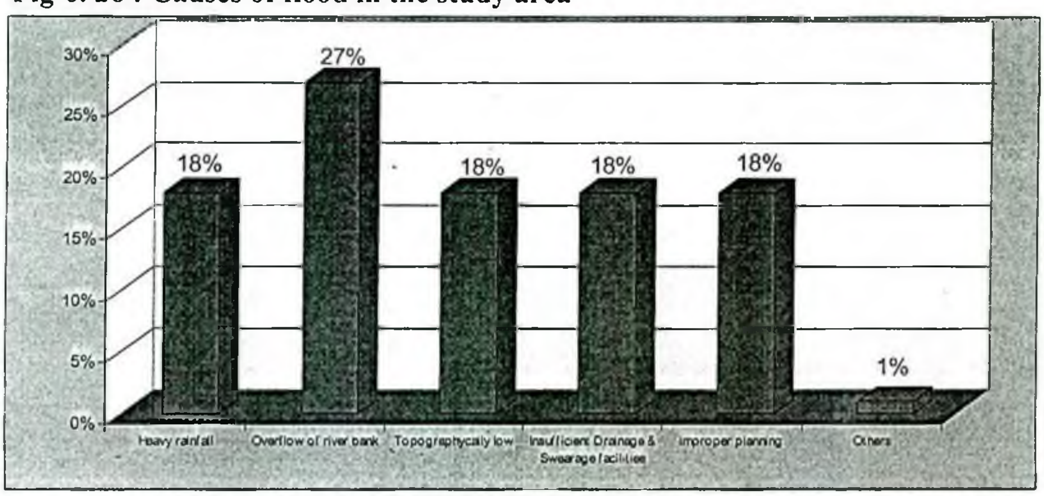
The survey data shows that 23% respondents said flood occurs twice in a year in their region. A large number (64%) of the respondents said that flood occurs only once in their region. Some other 12% said flood takes part thrice in a year. It is observed that wet land areas can receive flood more than once in a year.

Table-6.24 : Causes of flood in the study area

Causes of flood	Total respondents	Result	Percentage
Heavy rainfall	40	07	18%
Overflow of river bank	40	10	27%
Topographically low	40	07	18%
Insufficient drainage & sewerage facilities	40	07	18%
Improper planing	40	07	18%
Others	40	02	1%

Source : Questionnaire Survey, 2003

Fig-6. 26 : Causes of flood in the study area



Source : Questionnaire Survey, 2003

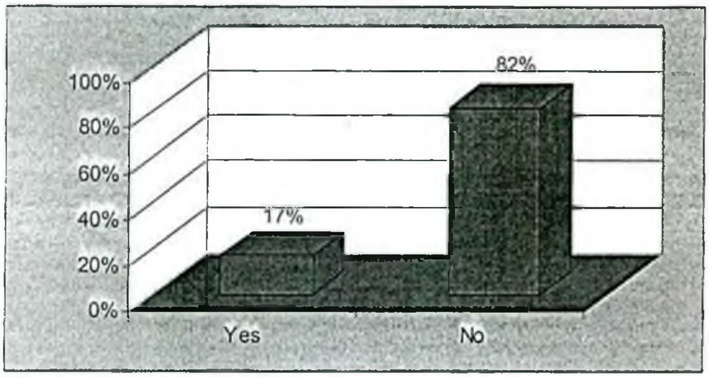
Several causes of flood are identified by the respondents. Some major portion of the respondents identified overflow of river bank is the main cause of flood. But 18% of the respondents opined for insufficient drainage and sewerage facilities and other 18% opined for improper planning.

Table-6.25 : Present Measures of flood controlling are appropriate or not

Yes/No	Total respondents	Result	Percentage
Yes	40	7	17%
No	40	33	82%

Source : Questionnaire Survey, 2003

Fig-6.27 : Present measures of flood controlling are appropriate or not



Source : Questionnaire Survey, 2003

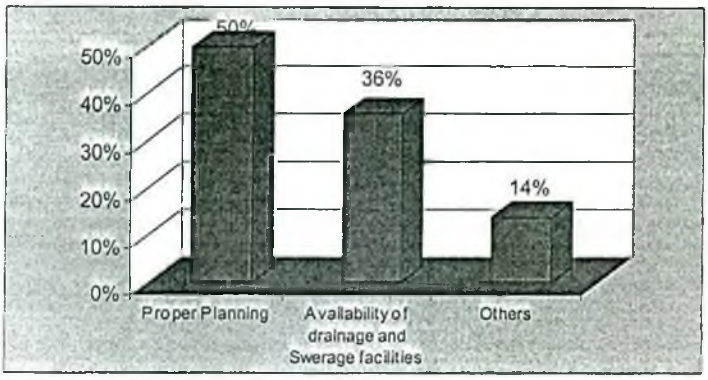
People of the study area opined that the existing flood control measures are not appropriate. Almost 82% people are not satisfied with the present measures while 17% are agreed with the existing measures. Most of the respondents said that the measures should be effective more in controlling flood.

Table-6.26 : Steps should be taken to control the flood in the study area

Steps should be taken	Total respondents	Result	Percentage
Proper planning	40	20	50%
Availability of drainage and sewage facilities	40	14	36%
Others	40	6	14%

Source : Questionnaire Survey, 2003

Fig-6.28 : Steps should be taken to control the flood in the study area



Source : Questionnaire Survey, 2003

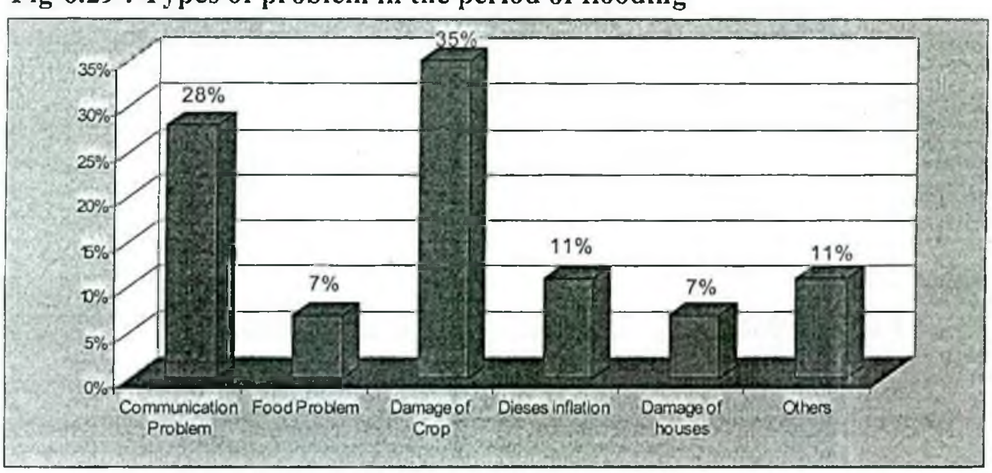
Local people who are not satisfied with the existing measures suggested as mentioned above. About 50% respondents said that existing plan are not appropriate and new proper plan should be introduced. Some 36% respondents said that the drainage and sewerage system have to be appropriate and available more. Some other 14% (6 out of 40) respondents opined that some other steps should be introduced, like dregging of River, Cannel, Khal etc.

Table-6.27 : Types of problem in the period of flooding

Types of Problem	Total respondents	Result	Percentage
Communication Problem	40	11	28%
Food Problem	40	03	7%
Damage of Corp	40	14	35%
Diseases inflation	40	04	11%
Damage of houses	40	03	7%
Others	40	04	11%

Source : Questionnaire Survey, 2003

Fig-6.29 : Types of problem in the period of flooding



Source : Questionnaire Survey, 2003

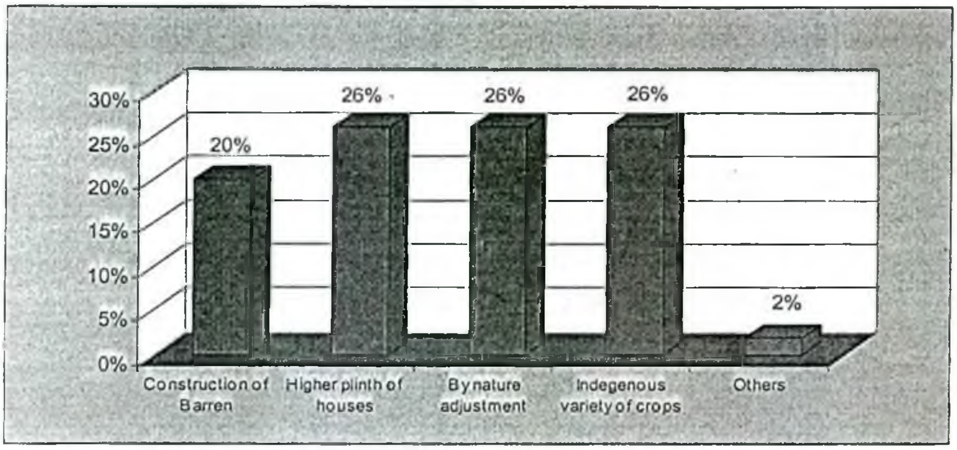
Sufferings of flood have identified through questionnaire survey in the study area. Some 35% respondents (14 out of 40) opined that damage of crops is the main problem in the period of flooding. Some other problems like communication problem food problem, diseases inflation etc. have also identified.

Table-6.28 : How do the local people face the problems

Ways of problem facing	Total respondents	Result	Percentage
Construction of Barren	40	08	20%
Higher plinth of houses	40	10	26%
By nature adjustment	40	10	26%
Indigenous variety of crops	40	10	26%
Others	40	02	2%

Source : Questionnaire Survey, 2003

Fig-6.30 : How do the local people face the problems



Source : Questionnaire Survey, 2003

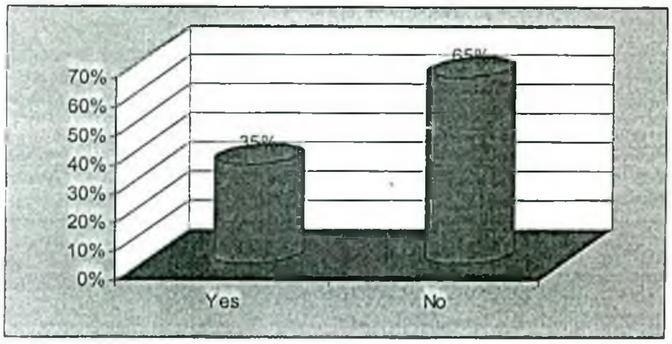
Local people face the problems of flood in their own way. Among those ways, construction of barren, higher plinth of houses, by nature adjustment and indigenous veriety of crops are mentioned here as principles way to face the problems. It is observed that local people of the study area are habituated with the cope of flood. Government and some other social organizations have constructed some Barren and Embankment besides the banks of the major rivers and their tributaries.

Table-6.29 : Flood becoming more serious or not in the study area

Yes/No	Total respondents	Result	Percentage
Yes	40	14	35%
No	40	26	65%

Source : Questionnaire Survey, 2003

Fig-6.31 : Flood becoming more serious or not in the study area



Source : Questionnaire Survey, 2003

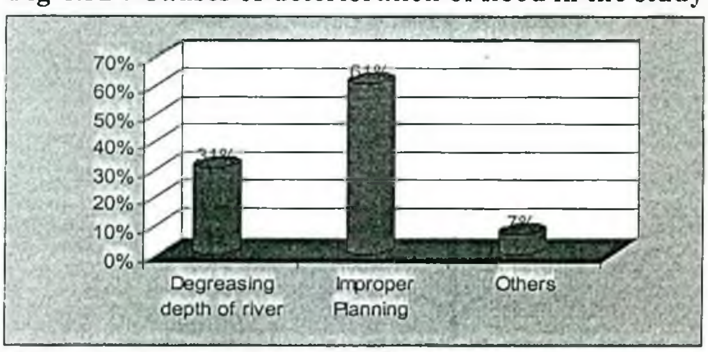
Among the respondents of the study area 35% said that flood becoming more serious in their region. People of the catchment area of the major rivers are very anxious with flood. On the other hand 65% respondents said that flood is not becoming more serious. In some areas the cope of flood is decreasing comparatively ever than before. It became possible due to some initiatives taken by the Government, NGO'S and the local peoples.

Table-6.30 : Causes of deterioration of flood in the study area

Causes of deterioration	Total respondents	Result	Percentage
Degreasing depth of river	40	12	31%
Improper planning	40	24	61%
Others	40	03	8%

Source : Questionnaire Survey, 2003

Fig-6.32 : Causes of deterioration of flood in the study area



Source : Questionnaire Survey, 2003

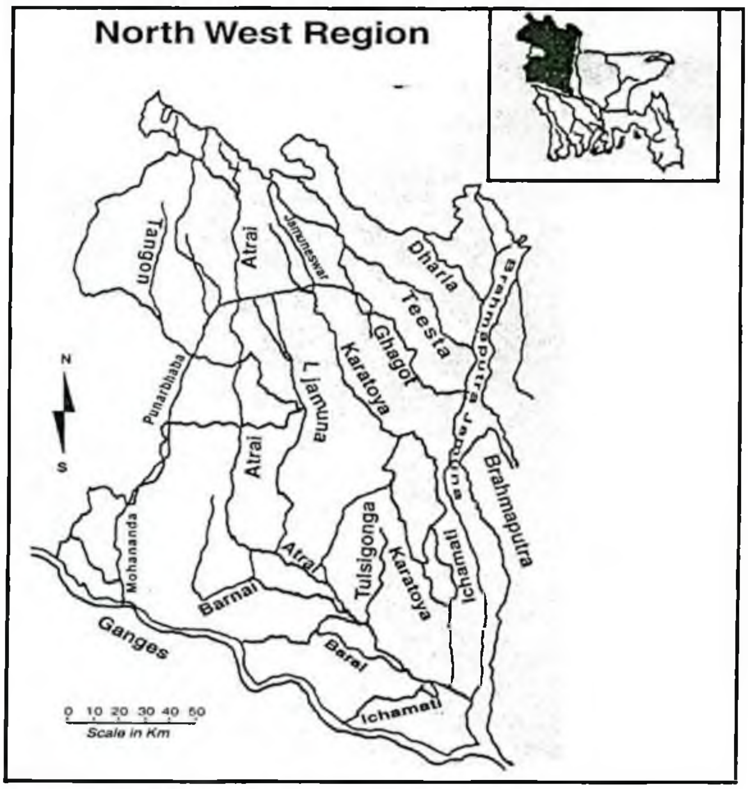
Some few respondents said that the flood situation deteriorating in their region due to decreasing depth of rivers and other water bodies. A large umber of the respondents (61%) said lack of proper planning is the main cause for deteriorating of flood, while 8% of the respondents said that there are some other reasonable factors for the deterioration of the flood like unconsciousness of the local people, absence of initiatives for conforlling measure of flood, deposition of the low land area etc.

3. The North-West Region

6.4 Introduction

The North-West Region covers about 34,600 sq. km. of land has a population of 25 million. The east and south of the region are bordered by the Brahmaputra and Ganges rivers. The region is sloped north to south-east with a maximum altitude range of 90-100 m. The average cropping intensity is about 158% of which rice forms about 119%. The varieties of rice planted as broadcasted aman, transplanted local and HYV aman and HYV boro (in irrigated areas). Other crops of the region include wheat, jute, oilseeds, sugarcane and pulses. The fisheries production of the region is dominated by 70% from the river floodplain and production has gradually decreased from 107,224 tons (1983/84) to 84,810 tons (1988/90). The reduction of fish resources is thought to be due to increased dry-season irrigation, over fishing by the expanding population and the impact of FCD intervention (FAP-2000).

Fig-6.33 : The North-West Region.



Source: Modified after FAP

6.4.1 : Flood and Drainage in the region

That part of the region bordered by the Brahmaputra river suffers from flooding caused by breaches in the main Brahmaputra Right Embankment (BRE). This type of flooding is very damaging in the disruption, it causes to peoples lives and in the losses to agriculture and infrastructure. Similar problems of a more limited scale occur along the *Teesta*, *Dharla* and *Dudhkumar* in the north-east on the region. In the south, branches from the Ganges are not a major source of flooding.

Within the region, flooding and drainage problems are mainly caused by the drainage patterns of the internal rivers. The majority of these drain to the south-east into the Lower Atrai/Lower Bengali system, and hence to the Brahmaputra through the *Hurasagar* outfall. Outfall conditions are often constrained during the monsoon by high levels in the Brahmaputra, and this in turn results in backing up and extensive flooding throughout the *Lower Atrai* and *Lower Bangali*. Flooding of over three meters regularly occurs in many parts of the *Lower Atrai*. However, while such flooding constrains agricultural production, it is not a problem in the same way as that caused by breaches from the major rivers since it develops more slowly and does not cause the same amount of social disruption. The upper reaches of the region are steeper than elsewhere and are susceptible mainly to flash flooding. In most cases the floods last only for a few days and do not cause a great deal of damage to crops, though they can do to infrastructure.

The region was divided into fifteen planning units in order to provide comprehensive coverage of these problem by FAP 2. Within each unit the flooding situation was assessed by a combination of field visits, primary data collection and analysis of secondary sources. The principle data used related to agricultural cropping, and infrastructure damage due to flooding, and water bodies and fisheries. This was supplemented by analysis of hydrological data and the development and use of a hydrodynamic model covering part of the region.

6.4.2 : Issues and Approaches in the Regional Development Plan (by FAP)

Planning for the region has been based on a number of broad principles. The main objective has been create a stable flooding regime which gives local people the ability to plan their lives with some degree of confidence and which allows them control of the local natural resources. A second aim has been to create a sustainable pattern of development, which balances the requirements of agriculture, fisheries, navigation, ground water and the environment. The third aim has been to safeguard lives property to the extent possible at the time of major floods.

Within these objectives a number of other principles have been applied. The most significant feature of food protection measures is the impact that they have on adjacent and downstream areas. Generally flood control in one area will lead to increased water depths or discharges and consequent disbenefits elsewhere. In extreme cases this leads to the cutting of flood control embankments by people, in as attempt to reduce level differences between protected and unprotected areas. Such "public cutting" is widespread through the region. It causes significant loss and damage and is an important source of social conflict and tensions. For this reason a major policy adopted has been to avoid, as far as possible, any plans which would result in significant disbenefits downstream or elsewhere. While it is not possible to apply this principle always, it has meant, for example, that structural measures have generally not been recommended in the upstream reaches, since this would have the effect of increasing discharge and flooding in the downstream reaches, where serious problems already exits.

Experience with previous development indicates that small-scale schemes often perform better than larger ones, because they can be implemented more quickly and local people can more easily be involved in their management. Thus emphasis was put on small-scale schemes however, these must take place within a regional or sub-regional context which tries to ensure, as far as possible, that disbenefits do not occur elsewhere.

Flood Control and Drainage Schemes (FCDS) are extensive throughout most of the region, and there are many existing and on-going projects. Considerable efforts have been applied to integrating the planning with these existing developments where appropriate, and to making the best possible use of existing infrastructure.

There are a considerable number of non-structural measures which can also be applied to reduce on mitigate flooding problems. These are grouped under the general term "flood proofing" and include such measures as raising important infrastructure on platforms above the expected flood level, instituting flood warning systems, and providing secure stores for emergency relief and grain. Such measures are relevant everywhere but particularly important for unprotected areas. Generally they should be seen as complementary measures to the structural measures discussed above.

6.4.3 : Multidisciplinary approach

FAP has taken a multi-disciplinary view in the planning approach. Impact on fisheries, navigation and environment for flood control intervention has been assessed, based on the present condition and future condition. The social impact has also been assessed, based on response to the flooding problem, mitigation plan and response from conflicting interest groups. In the planning of flood control plans the following aspects were taken into account :

- removing the adverse environment effects of previous water resources management and flood control projects,
- adopting and extending environmentally and ecologically sound biodiversity and conserving and developing the national wetlands and migratory bird sanctuaries, and
- protecting, covering and developing fish habitat

6.4.4 : Development Options and Scenarios

Development scenarios were formulated all the major parts of the region. Some of these are narrated below:

6.4.4.1 : The Brahmaputra Right Embankment (BRE) – Analysis shows that the most serious flooding problems along the Brahmaputra are due to breaches in the BRE. It also shows that these flooding problems can be eliminated, if the BRE is effectively sealed. Sealing of the BRE is therefore a priority measure for the region. The development scenario for the area includes proposals by other FAP studies. Flood Action Plan has taken different projects for developing different aspects like Master Plan preparation for long term protection, Developing Bank, Water management, Drainage improvement etc.

6.4.4.2 : Upper Korotoya/Middle Bengali System – Upper Korotoya basin is subject to extensive flooding at its downstream end where it joins the Bengali system. In keeping with the principle that upstream works should not lead to increased disbenifits in downstream reaches, these developments are associated with a major drain, the "Bangali Floodway", which connects the Upper Korotoya to the Brahmaputra main river and residential flow to the lower Bangali. The most important measure in the Middle Bangali System is sealing of the BRE and if this cab be successfully accomplished major projects to reduce flooding are not needed. In this area due consideration was given to a second line of defense against breach flooding through the BRE.

6.4.4.3 : Lower Atrai/Lower Bangali System - Extensive development of FCD works have taken place in the Lower Atrai. On the whole these have not performed as well as expected due to problem of increased water levels, public cutting and consequent damage. Full protection along the *Lower Atrai* is now considered an infeasible solution. An alternative engineering solution suggested was a large regulator at the *Hurasagar* outfall, however, the problem at the outfall is the constraint set by the outfall level in the Brahmaputra, rather than backflow from the Brahmaputra to the *Atrai* and such a structure would not be effective.

6.4.4.4 : Teesta Basin Development– Breaches from the *Teesta* river cause similar problems to those along the Brahmaputra, but on a similar scale. The main development scenario involve repairing and sealing the *Teesta* embankments which already exit along both sides of the river and more most of its length. Drainage lines are from the north to south, so that the impacts of breaches on the left bank are relatively limited in extent. The first element of Teesta Basin Development is sealing of the Teesta Right Embankment as part of the Gaibandha Improvement Project, the priority project investigated under the North-West Regional Study.

6.4.5 : Questionnaire Survey

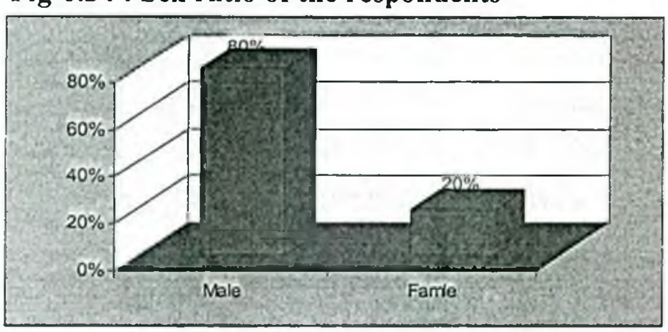
In order to understand the intricate problems and mode of adjustment of the flood effected dwellers of the different flood-regions of the country extensive questionnaire surveys have been conducted using set-questions. The North-West region is also brought out under the survey. The results and findings of which have been presented below :

Talble-6.31 : Sex ratio of the respondents

Sex	Total	Result	Percentage
Male	40	32	80%
Female	40	08	20%

Source : Questionnaire Survey, 2003

Fig-6.34 : Sex ratio of the respondents



Source : Questionnaire Survey, 2003

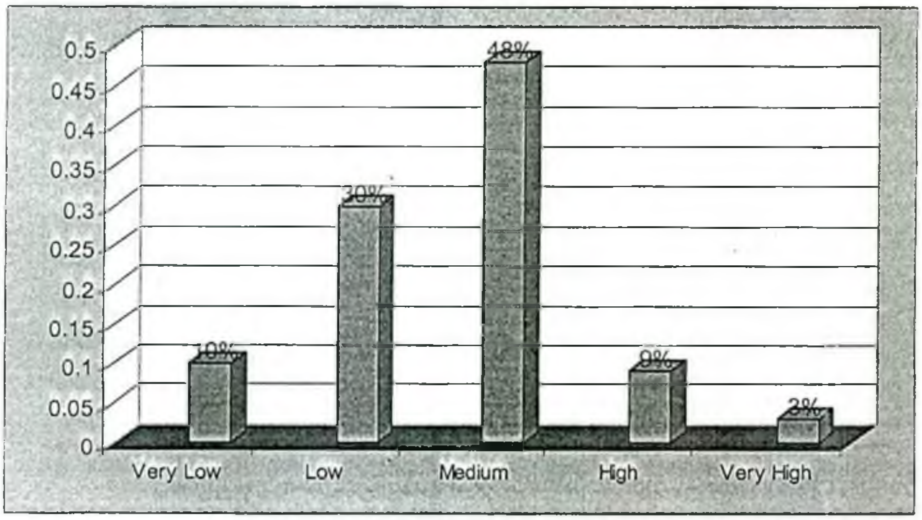
A limited member of people 40% were asked about flood in the North-West region. Among the respondents 20% were female and 80% were male. Most of the female respondents were service holder and student. They were selected as they might be able to provide true information on the related field.

Talble-6.32 : Level of land in the study area

Level	Total	Result	Percentage
Very low	40	04	10%
Low	40	12	30%
Medium	40	19	48%
High	40	03	09%
Very High	40	02	03%

Source : Questionnaire Survey, 2003

Fig-6.35 : Level of land in the study area



Source : Questionnaire Survey, 2003

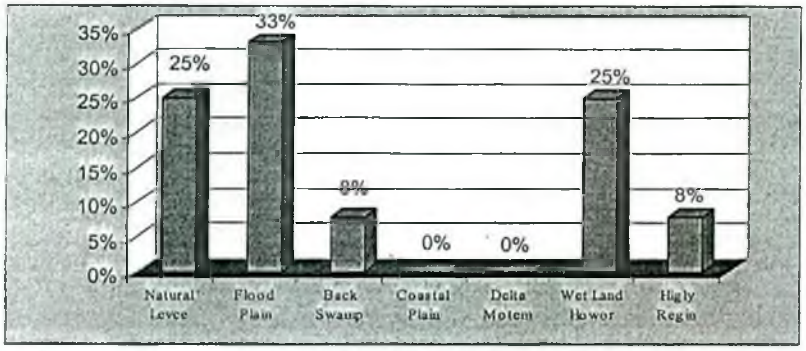
Medium and low level land comparatively more than other levels of land in this area. Survey statistics shows 10% very low land 9% high land. Flood takes part in the low and medium level areas. Some few districts like Pabna Shirajgonj, Natore, Rajshahi, Bogra, are comparatively more harzardous than other district in this region.

Table-6.33 : Types of surface in the study area

Types of Surface	Total respondents	Result	Percentage
Natural Leeve	40	10	25%
Flood Plain	40	13	33%
Back Swamp	40	03	8%
Coastal Plain	40	00	0%
Delta Mature	40	00	0%
Wet Land (Haor)	40	10	25%
Hilly Regin	40	03	8%

Source : Questionnaire Survey, 2003

Fig-6.36 : Types of surface in the study area



Source : Questionnaire Survey, 2003

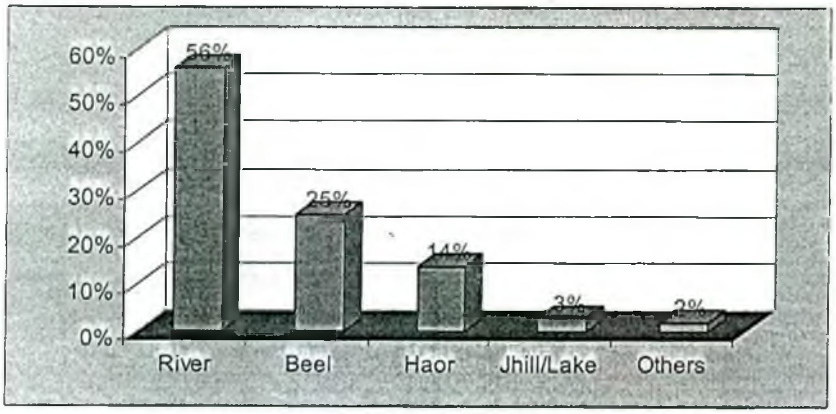
Maximum area in the North-West Region is Flood Plain, Wet Land and Natural Leeve. No coastal plain and Delta regions are found from the survey statistics. Some few hilly region (8%) is found. About 33% respondents said that they live in flood plain area, while 25% in the Wet land and 25% in the Natural Leeve. This region is not similar to the other regions as divided in the present study.

Table-6.34 : Types of water body in the study area

Type of Surface	Total respondents	Result	Percentage
River	40	22	56%
Beel	40	10	25%
Haor	40	05	14%
Jhill/Lake	40	02	3%
Others	40	01	2%

Source : Questionnaire Survey, 2003

Fig-6.37 : Types of water body in the study area



Source : Questionnaire Survey, 2003

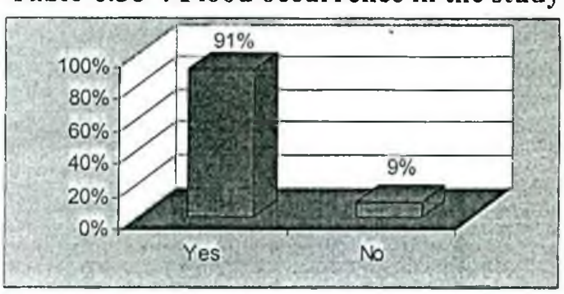
River, Beel and Haor are main water bodies in the study area. Some few regions has Jhill/Lake. Among the respondents 57%, said that river is the main water body in their region, while 25% opined for Beel and 14% for Haor. Padma, Jamuna, Teesta, Atrai are main revers in this area. Chalan Beel is the most fmilier Beel all over Bangladesh located in this area. The east and the south of the region is bordered by the major rivers the Brahmaputra and the Ganges.

Table-6.35 : Flood occurrence in the study area

Flood occurrence	Total respondents	Result	Percentage
Yes	40	32	91%
No	40	03	9%

Source : Questionnaire Survey, 2003

Table-6.38 : Flood occurrence in the study area



Source : Questionnaire Survey, 2003

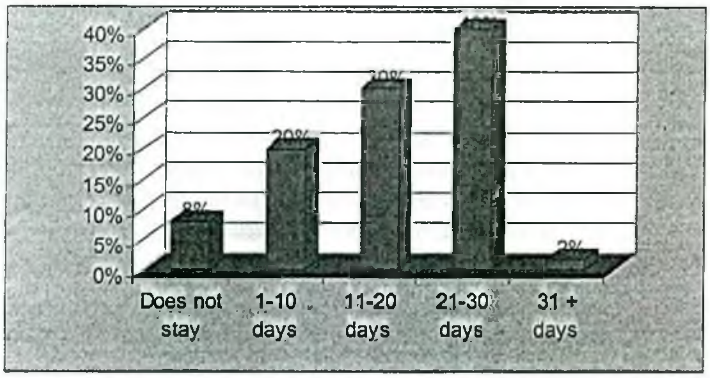
Flood is the common phenomenon of this area. It is found that almost every year flood occurs in this region. Some few high lands are free from the cope of flood. About 91% respondents said flood occurs in their region. On the other hand only 9% said flood does not take part in their region.

Table-6.36 : Duration of flood in the study area

Duration	Total respondents	Result	Percentage
Does no stay	40	03	8%
1-10 days	40	08	20%
11-20 days	40	12	30%
21-30 Days	40	16	40%
31-+ Days	40	01	2%

Source : Questionnaire Survey, 2003

Fig-6.39 : Duration of flood in the study area



Source : Questionnaire Survey, 2003

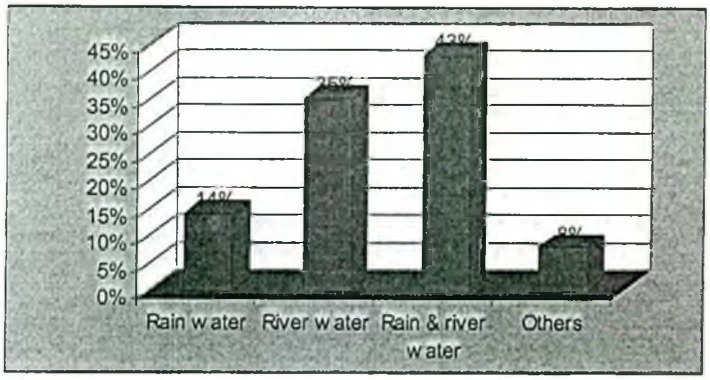
Duration of flood in this area shows different feature. Some few area shows that flood stays more than 30 days. Some few area shows (8%) that flood does not stay there. High level of land and hilly regions are flood free zone. But most of the area become inundated. The respondents shows that flood stays in their area long time. Some 20% respondents said that the flood stay 1-10 days in their region while 30% said for 11-20 days and 40% for 21-30 days.

Table-6.37 : Sources of flood water

Sources	Total respondents	Result	Percentage
Rain water	40	06	14%
River water	40	14	35%
Rain & River water	40	16	43%
Others	40	04	8%

Source : Questionnaire Survey, 2003

Fig-6.40 : Source of flood water



Source : Questionnaire Survey, 2003

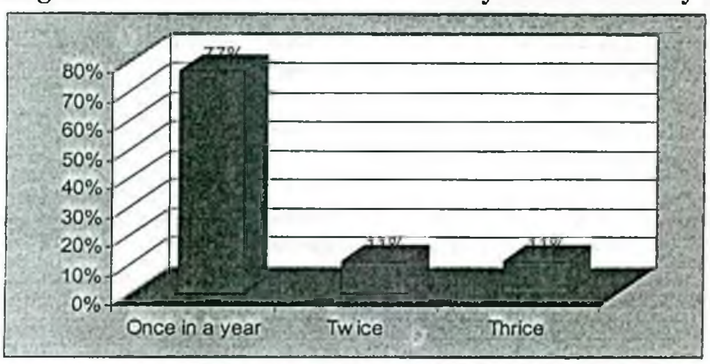
River and Rain water together occurs flood in the study area. It is observed that rivers brings a lot of water from India which sometime becomes a main causes of server flood. Local peoples are habituated with flood. Only 14% respondents said that flood occurs due to rain, while 35% opined for river only and 43% for rain and river combindly. Some few respondents (7%) said flood water comes from India.

Table-6.38 : Times of flood occurs in a year in the study area

How many times	Total respondents	Result	Percentage
Once in a year	40	32	77%
Twice	40	04	11%
Thrice	40	04	11%

Source : Questionnaire Survey, 2003

Fig-6.41 : Times of flood occurs in a year in the study area



Source : Questionnaire Survey, 2003

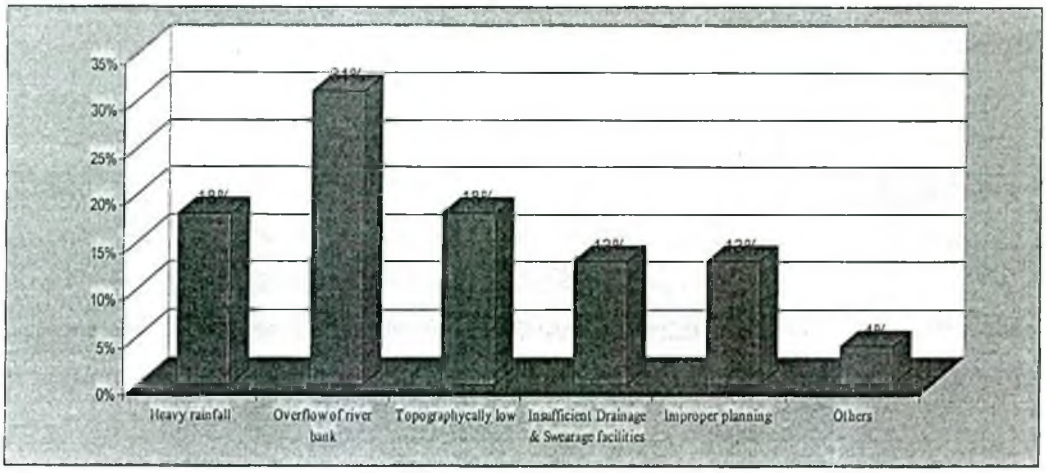
Maximum time flood occurs once in a year. Some respondents (11%) said that flood occurs more than once (twice) in their region while the same figure has got for thrice. Almost 77% respondents said flood take part only once in a year in their region. Maximum part of the study area flooded once in a year and the flood stays more than one month.

Table-6.39 : Causes of flood in the study area

Causes of flood	Total respondents	Result	Percentage
Heavy rainfall	40	07	18%
Overflow of river bank	40	12	31%
Topographycally low	40	07	18%
Insufficient Drainage & Sewearage facilities	40	05	13%
Imporper Plaing	40	05	13%
Others	40	03	4%

Source : Questionnaire Survey, 2003

Fig-6.42 : Causes of flood in the study area



Source : Questionnaire Survey, 2003

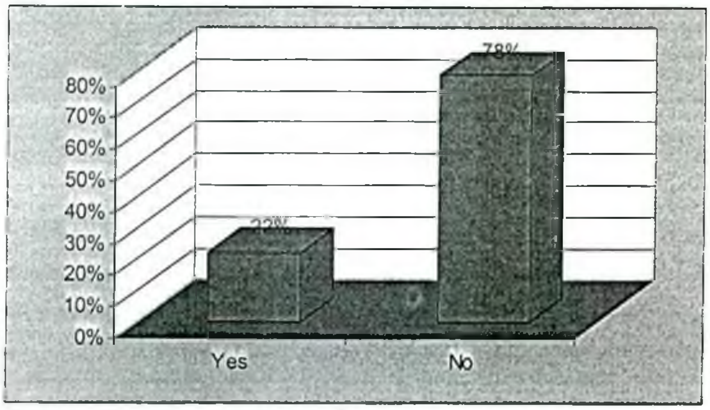
The survey data shows considerable variation of flood causes, in relation to such respects as climate, topography and water resources. These variations are reflected in the range of flooding problems existing within the region. Local people of the study area identified some few reasons, like heavy rainfall, overflow of river bank, topographically low land, insufficient drainage & sewerage facilities etc. Some few peoples (13%) also opined for lack of proper planning which is one of the vital causes of flooding.

Table-6.40 : Present measures of flood controlling are appropriate or not

Yes/No	Total respondents	Result	Percentage
Yes	40	09	22%
No	40	30	78%

Source : Questionnaire Survey, 2003

Table-6.43 : Present measures of flood controlling are appropriate or not



Source : Questionnaire Survey, 2003

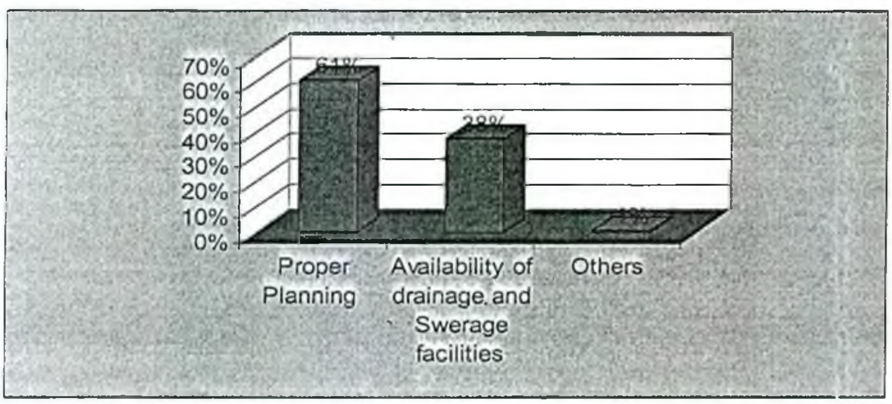
People of the inundated area are not satisfied with the present measures of flood controlling in their region. Some 78% respondents said that the present measures are not appropriate. Some other 22% respondents also said that present measures are appropriate. Most of these people who are safisfied with the present measure live in the high level of land in the area.

Table-6.41 : Steps should be taken to control the flood in the study area

Steps should be taken	Total respondents	Result	Percentage
Proper Planning.	40	24	61%
Availability of Drainage and Sewerage facilities	40	15	38%
Others	40	01	1%

Source : Questionnaire Survey, 2003

Fig-6.44 : Steps should be taken to control the flood in the study area



Source : Questionnaire Survey, 2003

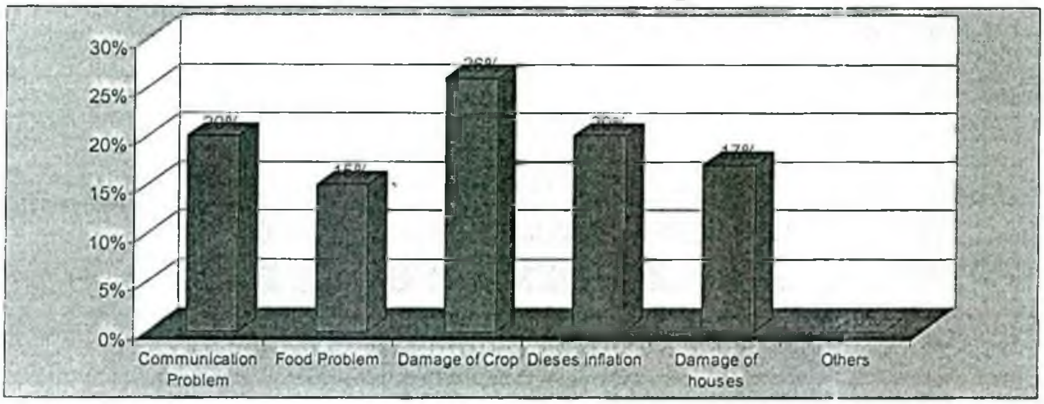
Within the region, flooding and drainage problems are mainly due to the drainage patterns and proper planning. So that, the respondents opined for proper planning and drainage and sewerage facilities.. As per their suggestion drainage and sewerage facilities could be made more appropriate and available to control the flood.

Table-6.42 : Types of problem in the period of flooding

Type of Problems	Total respondents	Result	Percentage
Communication Problem	40	08	20%
Food Problem	40	06	15%
Damage of Crop	40	11	26%
Dieses inflation	40	08	20%
Damage of houses	40	07	17%
Others	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.45 : Types of problem in the period of flooding



Source : Questionnaire Survey, 2003

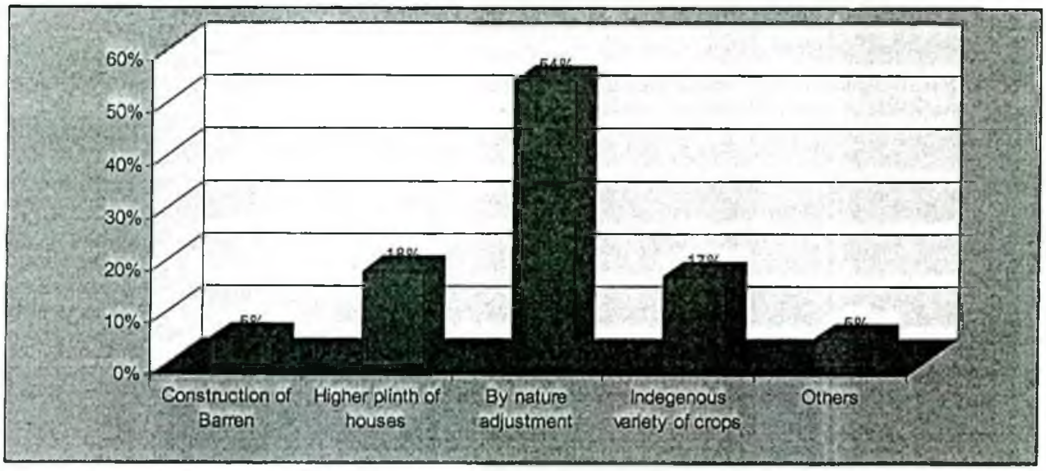
A various types of problems could be identified in the period of flooding in a certain area. They study area identified some problems equally important. These are like communication problem (20%), food problem (15%), crops damage (25%) diseases inflation (20%), damage of houses (17%) etc. In addition, some indirect losses occurs due to flood, like economic and physical loss of the local people.

Table-6.43 : How do the local people face problems

	Total respondents	Result	Percentage
Construction of Barren	40	02	5%
Higher plinth of houses	40	07	18%
By nature adjustment	40	22	54%
Indigenous variety of crops	40	07	17%
Others	40	02	5%

Source : Questionnaire Survey, 2003

Fig-6.46 : How do the local people face problems



Source : Questionnaire Survey, 2003

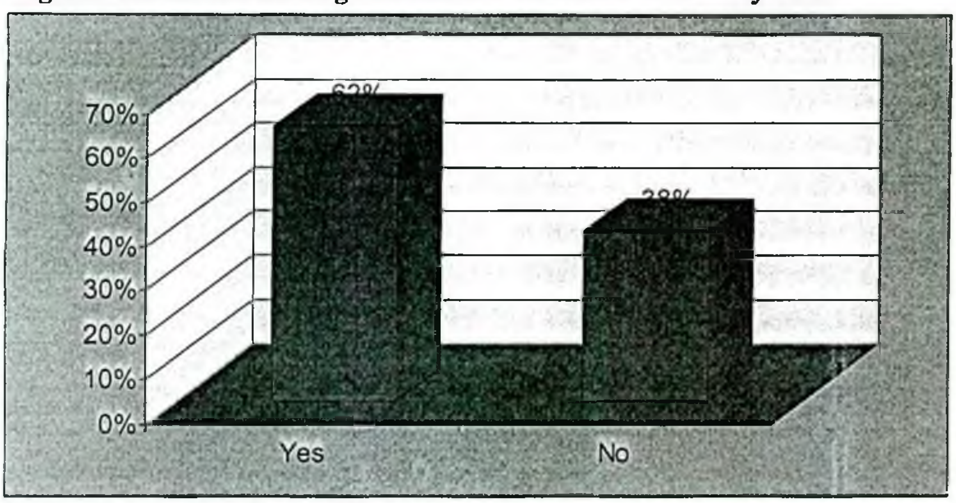
A critical consequence of flood is physical destruction of land and other. Properties. People of the inundated area try their best to protect themselves and their property in different way. Some local way have been find outed through the study. These are construction of Barren, Higher Plinth of houses, By nature adjustment, Indigenous variety of crops etc. Some 54% respondent said that they faced flood problem by nature.

Table-6.44 : Flood becoming more serious or not in the study area

Yes/No	Total respondents	Result	Percentage
Yes	40	25	62%
No	40	15	38%

Source : Questionnaire Survey, 2003

Fig-6.47 : Flood becoming more serious or not in the study area



Source : Questionnaire Survey, 2003

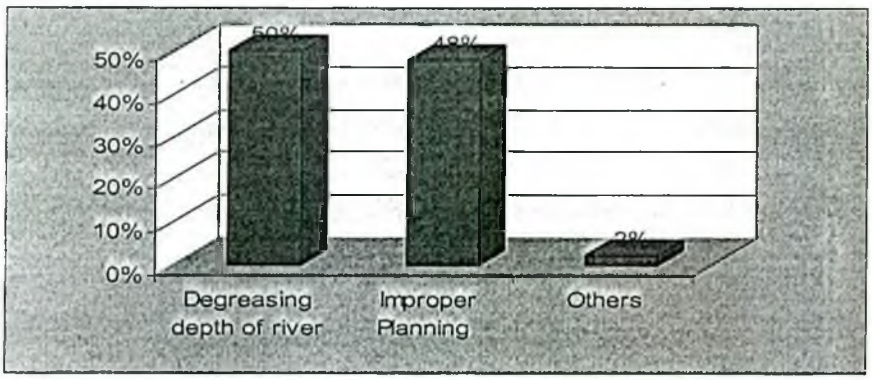
About two-third of the respondents (62%) of the study area said that flood situation are becoming more serious. Particularly this may be applicable for the low land area. Some 38% respondents said that flood are not becoming more serious in their region.

Table- 6.45 : Causes of deterioration of flood in the study area

Causes	Total respondents	Result	Percentage
Decreasing depth of rivers	40	20	50%
Improper planning	40	19	48%
Others	40	01	2%

Source : Questionnaire Survey, 2003

Fig 6.48 : Causes of deterioration of flood in the study area



Source : Questionnaire Survey, 2003

FAP and other organization related to flood study find outed different causes of deterioration of flood in Bangladesh, particularly for some regions. Decreasing depths of river and other water bodies is the most significant causes. Similarly improper planning is also one of the other causes. The survey data shows that 50% people opined for sedimentation of the water bodies and 48% for improper planning.

4. The South-East Region

6.5 Introduction

The area comprises the greater districts of Chittagong, Comilla and Noakhali being bounded approximately by the rivers Feni to the south-east, Meghna and Lower Meghna to the west, the Titas to the north and the Bay of Bengal to the south. The area of greater Chittagong and the Chittagong Hill Tracts is also extent the region which is not addressed at all by the flood.

The nature of flooding in this region could be comparable to the flash floods in the greater Sylhet and Mymensingh districts noted before. Heavy rains in these hilly areas, as well as in the adjacent ranges of the Arakan in India and Buram were reported to have been the major causal factors.

The area like much of Bangladesh is intensively cultivated. However further agricultural development is to a certain extent constrained by the water resources of the area. The major determinant factors are problems of flooding, scarce fresh surface water resources in the dry season, groundwater limitations and impaired drainage. The dominant constraints vary from area to area as indicated in the centerfold.

Fig-6.49 : The South-East Region

Source : Prepared form the FAP data.

6.5.1 : Major Sources of flooding

The river Karnaphully, Sangu, Matamuhuri, Halda and Feni spilled over to inundate their banks. Apart from damage to standing crops, shrimp-culture in vast tracts of barckish water was disrupted by the inflow of fresh water. Major roads including that between Chittagong and Cox's Bazar, went under on several occasions. Bank erosion by certain rivers took place, irrespective of whether their water levels were rising or falling. These was reported for the Matamuhuri, the Sangu in Chandanaish and Satkania, the Dhalu in Satkania, the Srimati canal in Patiya, the Bankkhali in Ramu etc.

6.5.2 : Flood Situation

The flood situation in the greater Chittagong region express a mixed senario of flood. Some portion o the region were worsely inundated in 1998 flood. However, as noted earlier the intensity of bank erosion increased as flood water began to recedes. Heavy rainfall is also another cause of rising water level and inundated the coastal areas of this region. Moreover, flooding in this region resulted in the breaching of embankments and damages to sluice-gates in the coastal area as well as in off-store islands like Maheshkhali and Kutubdia. A large area of this region is flood free zone known as Hilly and Tracet area.

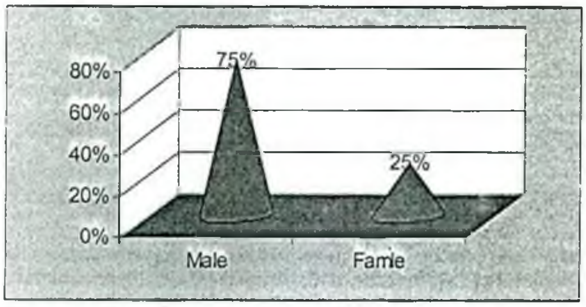
6.5.3 Questionnaire Survey : In order to understand the problems and mode of adjustment of the flood effected dwellers of the different flood-regions of the country extensive questionnaire surveys have been conducted using set-questions. The North-West region is also brought out under the survey. The results and findings of which have been presented below :

Table-6.46 : Sex ratio of the respondents

Sex	Total respondents	Result	Percentage
Male	40	30	75%
Female	40	10	25%

Source : Questionnaire Survey, 2003

Fig-6.50 : Sex ratio of the respondents



Source : Questionnaire Survey, 2003

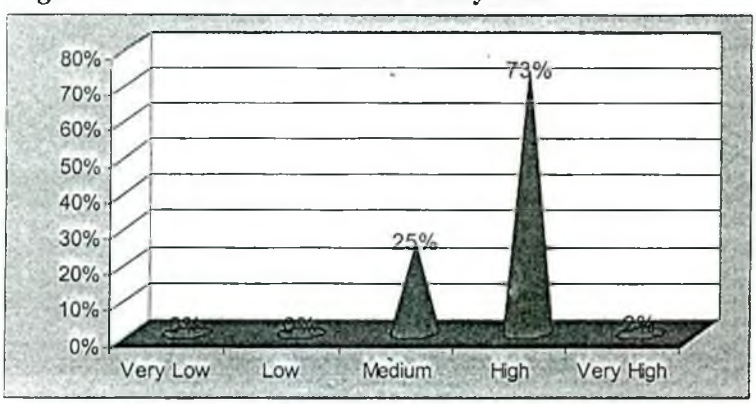
Total forty (40) respondents were asked for flood in the study area. About 75% of them (30 out to 40) were male and the rest 25% (10 out of 40) were female. Some of the female respondents were completely housewife and some of them were student and service holder. Both male and female respondents found aware about flooding in the region.

Table-6.47 : Levels of land in the study area

Level of land	Total respondents	Result	Percentage
Very low	40	00	0%
Low	40	00	20%
Medium	40	10	25%
High	40	29	73%
Very High	40	01	2%

Source : Questionnaire Survey, 2003

Fig-6.51. : Levels of land in the study area



Source : Questionnaire Survey, 2003

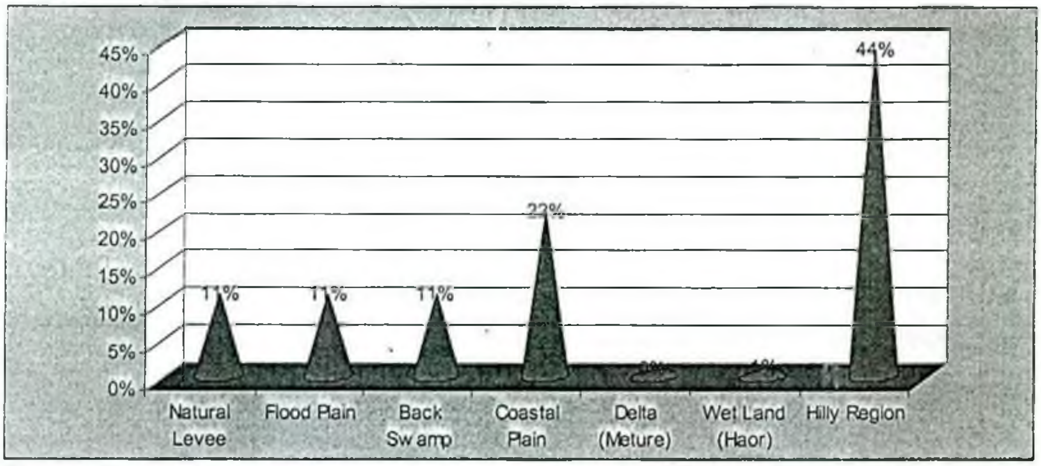
The South-East region includes the main hilly region of the southern part of the country, like Rangamati, Khagrachari, Bandarban, Chittagong Hilly areas. In the survey period it is found that 73% of the respondents said that their level of land is high, where about 25% said their level of land is medium, No respondents among the 40 persons said that their level of land is low and very low.

Table-6.48 : Types of Surface in the study area

Surface Type	Total respondents	Result	Percentage
Natural Levee	40	04	11%
Flood Plain	40	04	11%
Back Swam	40	04	11%
Coastal plaid	40	08	22%
Delta (Mature)	40	00	0%
Wet Land (Haor)	40	02	1%
Hilly region	40	18	44%

Source : Questionnaire Survey, 2003

Fig-6.52 : Types of Surface in the study area



Source : Questionnaire Survey, 2003

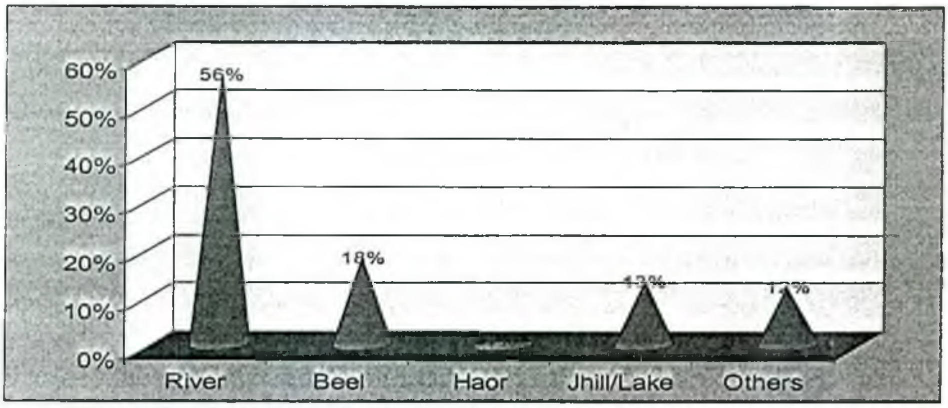
Surface types of the study area shows a various features. Some 44% of the respondents live in hilly region, 22% of them lives in coastal region. But it is found that the people of coastal area are not saying that they live in flood free area. Other statistics from the survey shows that 11% of the respondents said that surface type of their region is Natural levee, 11% for flood plain and the same percentage for Back Swamp. No delta region is found in the survey data though there are delta in Chittagong region.

Table-6.49 : Type of water bodies in the study area

Water body	Total respondents	Result	Percentage
River	40	22	56%
Beel	40	07	18%
Haor	40	01	1%
Jhill/Lake	40	05	13%
Others	40	05	12%

Source : Questionnaire Survey, 2003

Fig-6.53 : Type of water bodies in the study area



Source : Questionnaire Survey, 2003

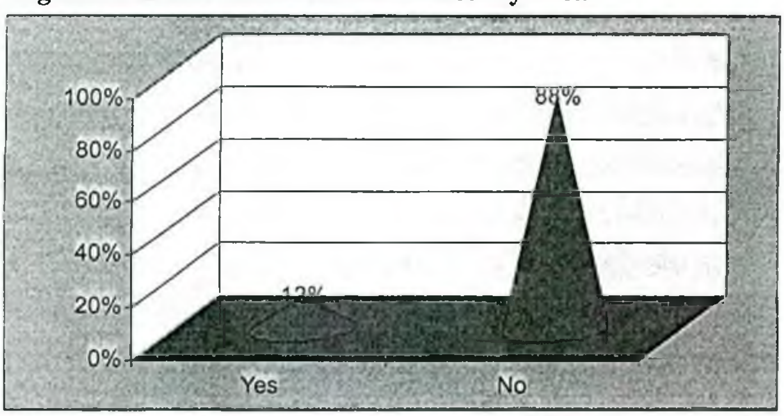
It is said that Bangladesh is a land river. The respondents of the study area also opined that rivers are the main water bodies of their region. Haor area is only one percent. Other main water bodies are Beel, Jhill, Lake etc.

Table-6.50 : Flood occurrence in the study area

Yes/No	Total respondents	Result	Percentage
Yes	40	05	12%
No	40	35	88%

Source : Questionnaire Survey, 2003

Fig-6.54 : Flood occurrence in the study area



Source : Questionnaire Survey, 2003

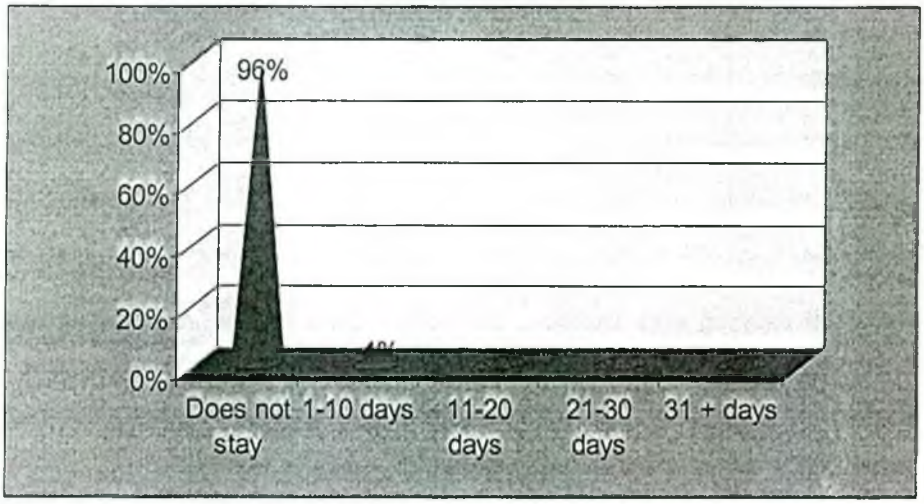
Only twelve percents respondents said that flood occurs in their region. On the other hand 88% said that flood does not take part in their region. The pervious data of land level shows that 73% people live in high level area and 25% in medium level. High level lands generally consedered as flood free zone.

Table-6.51 : Duration of flood in the study area

Duration of flood	Total respondents	Result	Percentage
Does not stay	40	37	96%
1-10 days	40	02	4%
11-20 days	40	00	0%
21-30 days	40	00	0%
31 + days	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.55 : Duration of flood in the study area



Source : Questionnaire Survey, 2003

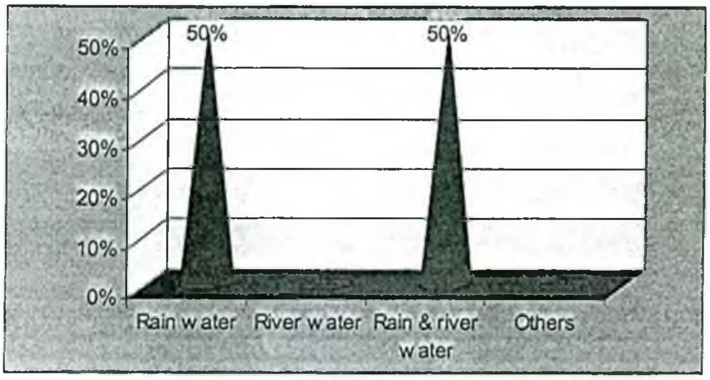
Duration of flood in this area is the minimum. Flash flood which occurs in the foot hills does not stay long. It may mentioned that some 88% of the respondents said that flood doesn't take part in their area. Longibity data reflects that flood occurs but does not stay long in the study area.

Table-6.52 : Sources of flood water

Source of flood water	Total respondents	Result	Percentage
Rain water	40	20	50%
River water	40	00	0%
Rain & river water	40	20	50%
Others	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.56 : Source of flood water



Source : Questionnaire Survey, 2003

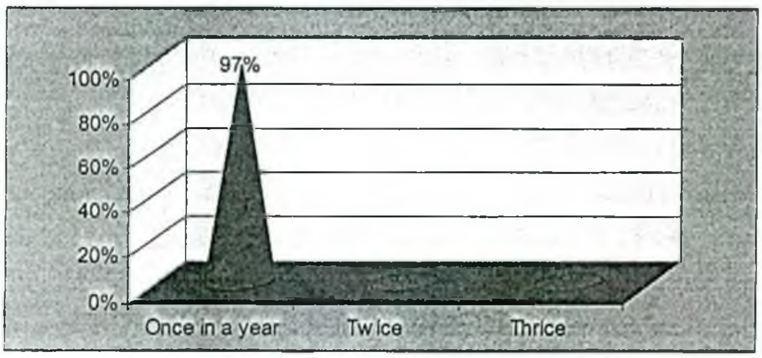
Flood water comes specially from rain and over flow of river bank. Rain water brings flood occasionally in the study area. Rain and River water caused flood when the duration of flood found a little long. The survey data shows 50% flood water comes from rain and the other 50% is from rain and river combindly.

Table-6.53 : Times of flood occurs in a year in the study area

How many times flood occurs	Total respondents	Result	Percentage
Once in a year	40	32	97%
Twice	40	07	3%
Thrice	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.57 : Times of flood occurs in a year in the study area



Source : Questionnaire Survey, 2003

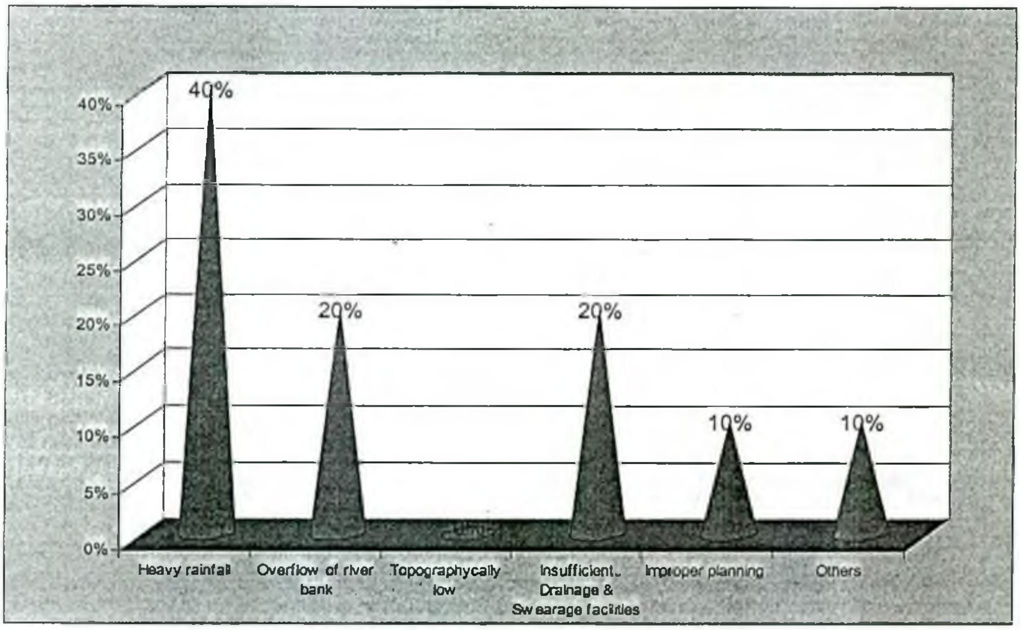
Generally it can be said that flood occurs only once in a year. But in some region, it occurs more than once in a year as per survey data. The percent study area is especially flood free zone of the country. About 97% respondents said flood occurs once in a year. But it is not regular. It does not occurs every year. Some coastal areas of this region may have flood problems more than once in a year.

Table-6.54 : Causes of flood in the study area

Causes of flood	Total respondents	Result	Percentage
Heavy rainfall	40	16	40%
Overflow of river bank	40	08	20%
Topographically low	40	00	0%
Insufficient drainage & sewerage facilities	40	08	20%
Improper planning	40	04	10%
Others	40	04	10%

Source : Questionnaire Survey, 2003

Fig-6.58 : Causes of flood in the study area



Source : Questionnaire Survey, 2003

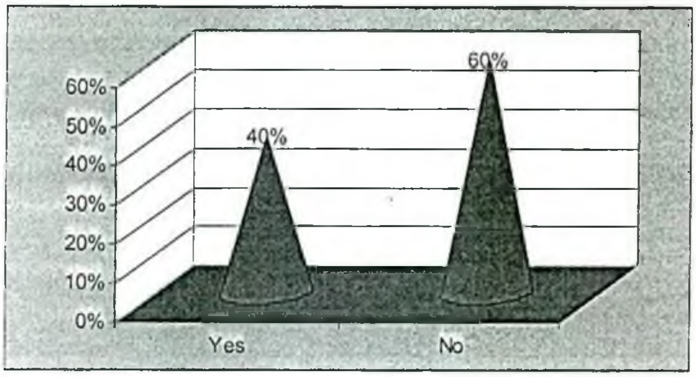
Precipitation is the main factor governing the flood cycle of a region. Some other reasous are the indirect result of precipitation. Overflow of river bank rise toward the flood peak while huge precipitation occurs with the exception of flash flood. Topographically low, improper planning, drainage congestion etc. are also vital causes of flood of the study area. Major portion of the respondents (40%) supports precipitation as the main cause of flood.

Table-6.55 : Present measures of flood controlling are appropriate or not

Yes/No	Total respondents	Result	Percentage
Yes	40	16	40%
No	40	24	60%

Source : Questionnaire Survey, 2003

Fig-6.59 : Present measures of flood controlling are appropriate or not



Source : Questionnaire Survey, 2003

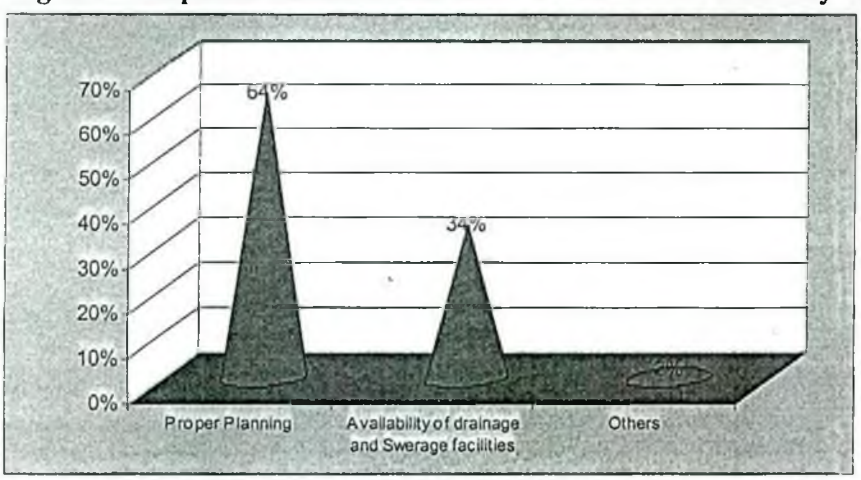
Since 1972 when Bangladesh enraged as an independent state, there has been a growing clammier for the immediate implementation of measures to eliminate floods from them Government has taken some measures to control flood. Local people of the study are not satisfied with the existing measures in their region. Almost 60% are not satisfied at the some time 40% respondents are satisfied with the present measures.

Table-6.56 : Steps should be taken to control the flood in the study area

Steps should be taken	Total respondents	Result	Percentage
Proper planning	40	26	64%
Availability of drainage and sewage facilities	40	13	34%
Others	40	01	2%

Source : Questionnaire Survey, 2003

Fig-6.60 : Steps should be taken to control the flood in the study area



Source : Questionnaire Survey, 2003

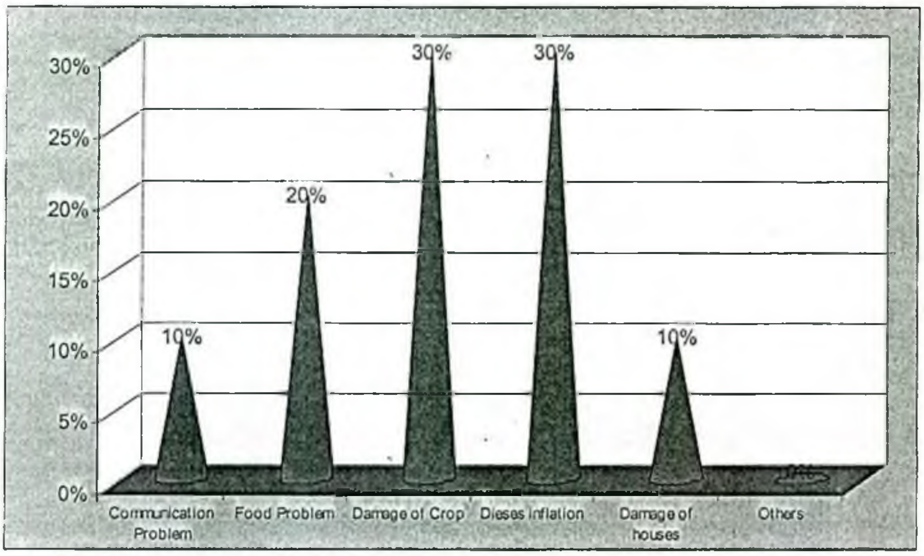
Local people gave some suggestions to controll the flood in their region. They felt the need of proper planning in controlling flood in their region. Some of them suggested that drainage and sewerage facilities should be effective and available more. Some other suggestions have also came out from them like higher plinth of houses, weather forcasting etc. However, local people strongly feel the need of proper planning and available drainage and sewerage facilities to control the flood.

Table-6.57 : Type of problems in the period of flooding

Problems	Total respondents	Result	Percentage
Communication problem	40	04	10%
Food problem	40	08	20%
Damage of corp	40	12	30%
Disease inflation	40	12	30%
Damage of houses	40	04	10%
Others	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.61 : Type of problems in the period of flooding



Source : Questionnaire Survey, 2003

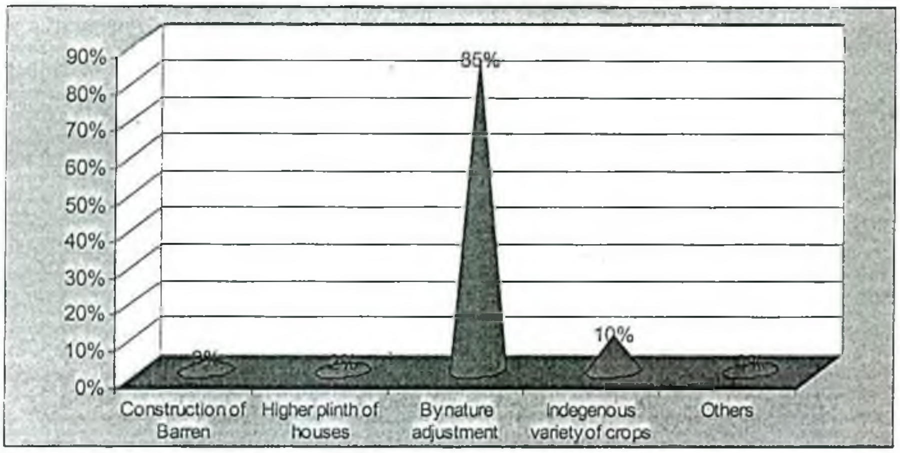
Sufferings of flood might not be described properly through this study. But local people of the study area mentioned some problems at the time of flooding. Those are communication problem, food problem, crop damage, diseases inflation, damage of houses, roads, bridge, etc. These are common problems in the region while flood occurs.

Table-6.58 : How do the local people face the problems

	Total respondents	Result	Percentage
Construction of Barren	40	01	3%
Higher plinth of houses	40	01	2%
By nature adjustment	40	44	85%
Indigenous variety of crops	40	04	10%
Others	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.62 : How do the local people face the problems



Source : Questionnaire Survey, 2003

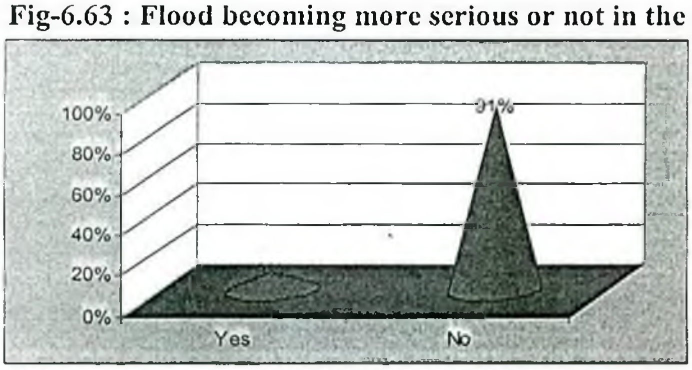
Local people are habituated with the flood problems. Due to the activities of human beings floods have intensified in Bangladesh. Construction of culvert and drainage are the local people's initiatives in controlling flood. They do it by nature. The survey data shows that 85% of the respondents opined for by nature adjustment of flood in this study area.

Table-6.59 : Flood becoming more serious or not in the study area

Yes/No	Total respondents	Result	Percentage
Yes	40	03	9%
No	40	37	91%

Source : Questionnaire Survey, 2003

Fig-6.63 : Flood becoming more serious or not in the study area



Source : Questionnaire Survey, 2003

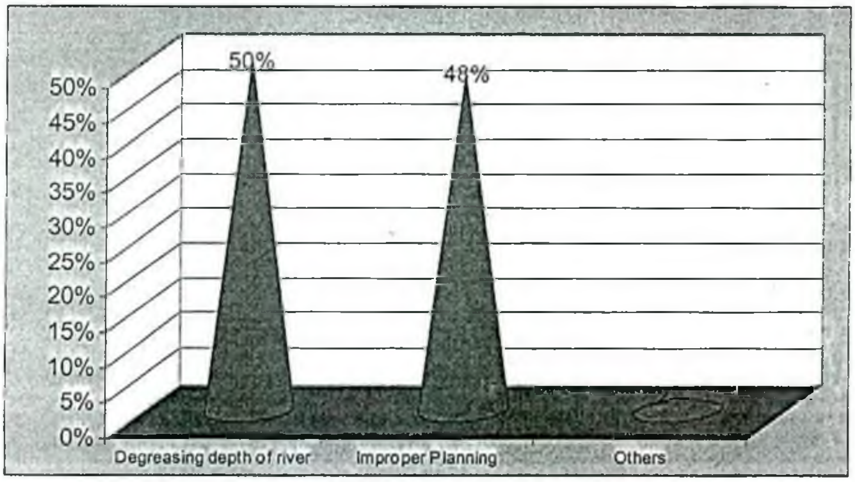
From the previous discussion it is found that the present study area is almost flood free zone of the country. About 91% of that respondents said the flood are not becoming more serious in their region. Only 9% said flood becoming more serious. Some few coastal regions of the area may have the deteriorating situation of flood.

Table-6.60 : Causes of deterioration of flood in the study area

Causes of deterioration	Total respondents	Result	Percentage
Degreasing depth of river	40	20	50%
Improper planning	40	19	48%
Others	40	01	2%

Source : Questionnaire Survey, 2003

Fig-6.64 : Causes of deterioration of flood in the study area



Source : Questionnaire Survey, 2003

The immediate before data shows that flood situation are not deteriorating all most all the area. On the other hand while asking the causes of deterioration the respondents they mentioned some reasons like decreasing depth of river, improper planning etc. Sedimentation of rivers and water bodies are more responsible in flooding in the subsequent region. At the some time people do not agree with the present plan of controlling flood.

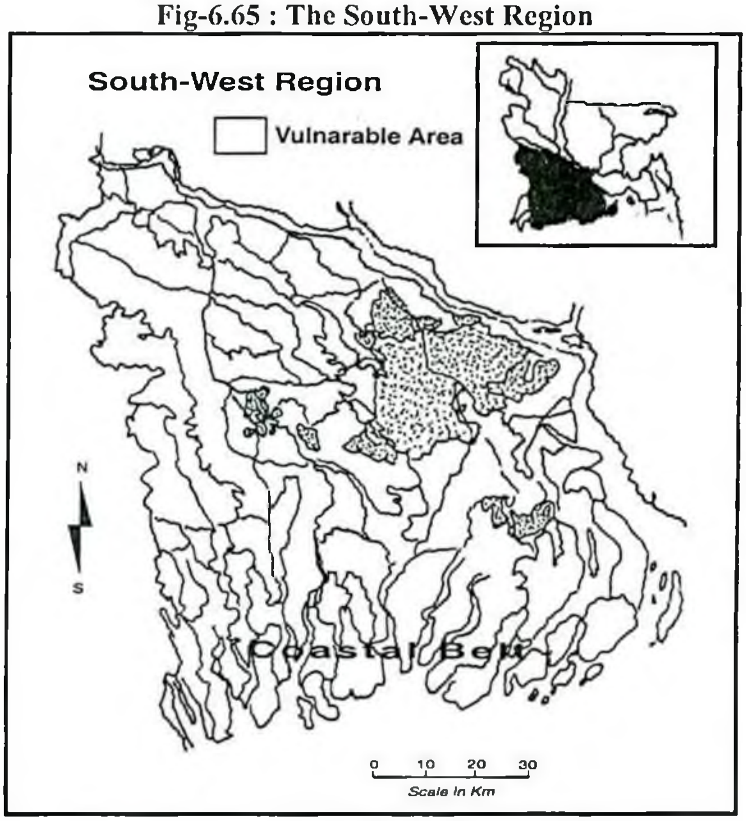
5. The South-West Region

6.6 Introduction

The South-West area comprises the south-west and south-central region which together have a gross area of about 40,450 sq km. The South-West Area is bounded by the three major rivers (Ganges, Padma and Lower Meghna) to the north and east, the Indian border to the west and the Bay of Bengal to the south. About 10 percent or about 4000 sq km is covered with coastal mangrove rivers and natural land depressions known as 'beels'.

The population of the area is just over 26 million which growing rapidly. Agriculture is the most important economic activity of the area and currently a total of 2.5m. hector net are cultivated of which 1.1m. hector area provided with some measure of flood control and drainage and about 0.64m. hector are irrigated. On average nearly 12% of land is subjected to flooding each year. Aquaculture and fisheries are important in the South-West region.

Fig-6.65 : The South-West Region



Source : Modified after FAP

6.6.1 : Water Management Issues

Three major water management issues in the South-West Region have been taken are as follows :

(1) acute shortage in the South-West Region of surface water resources in the dry season

(2) widespread flooding, primarily from the Ganges/Padma and Lower Meghna

(3) drainage congestion, mainly in the coastal polder areas but also in inland where natural drainage is inadequate.

To these may be added concerns over the availability and management of the ground water resources, concerns about salinity instruction and grave concerns of the sustainability of number of important rivers.

The problems of drainage in the coastal polder area are mainly as a consequence of the polders themselves, which have vastly reduced tidal cubature have prevented the natural process of land building. The reduced cubature, exacerbatea by lower regional inflows since constuction of Farakka Barrage, is causing many rivers to silt up which in turn reduces the possibility of gravity drainage from within the polders.

6.6.2 : Regional Water Resource Management Plan

In line with the emerging strategy the Regional Water Resource Management (RWMP) Plan has been prepared. In preparing the plan, the policies of the GOB as embodied in the FFYP (1990-95) and the Natural Water Plan have been taken into account. Due attention has also been to the Eleven Guiding Principles as provided in the FAP.

The plan contains several development options and is structured into several phase linked to progressive increase in demands and to the necessity for major investments to create additional surface water resources in the South-West Region.

The augmentation of the dry season flows to the area being of regional importance and a key to alleviating the present problems and in achieving food grain sufficiency in the area is programmed to be developed in the short term/medium term.

6.6.3 : Summery

The South-West region suffers from serious shortage of water in the dry season, salinity intrusion in the south, drainage congestion in the polder areas and elsewhere and flooding in the east of the region from over bank spill of rivers. Capture fisheries have declined in the recent years and the Sundarbans is gradually deteroraring. There is already food deficit in the area which will increase as the population and demand increases unless large scale increase in agricultural production is attained. This can only be achieved by augmentation of dry season flows as ground water has limited potential. Various options has been examined to achieve this. Augmentation of dry season flows is also needed for salinity control in Khulna Satkhura and Bangerhat and surrounding areas also may be required for environmental control considering in particular Sundarbans.

The second consideration was for the development of Drainage Congestion of this area. Various options were considered. Dredging coupled with amalgamating certain polders offers the best choice in the Bagerhat, Shatkhira and Dumuria areas while internal improvement in water management will improve the south central polder areas.

Increase in security from flooding cannot be attained by capital projects alone. Non-structural measures like flood proofing, flooding warning, better internal water management etc. are also equally essential. Institutions to manage these capital investment need strengthening if they are not to deteriorate.

6.6.4 Questionnaire Survey

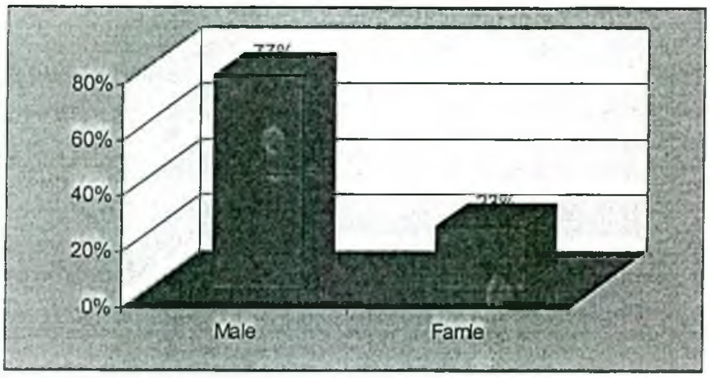
In order to understand the intricate problems and mode of adjustment of the flood effected dwellers of the different flood-regions of the country extensive questionnaire surveys have been conducted using set-questions, the results and findings of which have been presented in the following pages :

Table-6.61 : Sex ratio of the respondents

Sex	Total respondents	Result	Percentage
Male	40	31	77%
Female	40	09	23%

Source : Questionnaire Survey, 2003

Fig-6.66 : Sex ratio of the respondents



Source : Questionnaire Survey, 2003

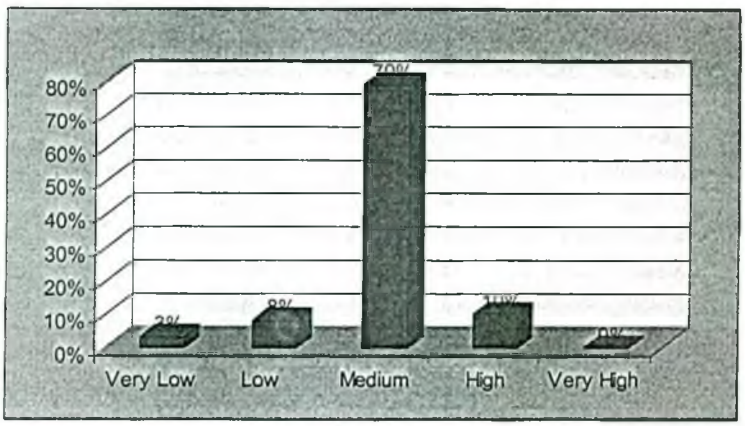
Sex ratio of the respondents mentioned above. It is found that most of the respondents (77%) are male and the rest (23%) are female. Male respondents were available at the period of survey so that the number of male is the maximum.

Table-6.62 : Levels of land in the study area

Levels of land	Total respondents	Result	Percentage
Very Low	40	01	3%
Low	40	03	8%
Medium	40	28	79%
High	40	08	10%
Very High	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.67 : Levels of land in the study area



Source : Questionnaire Survey, 2003

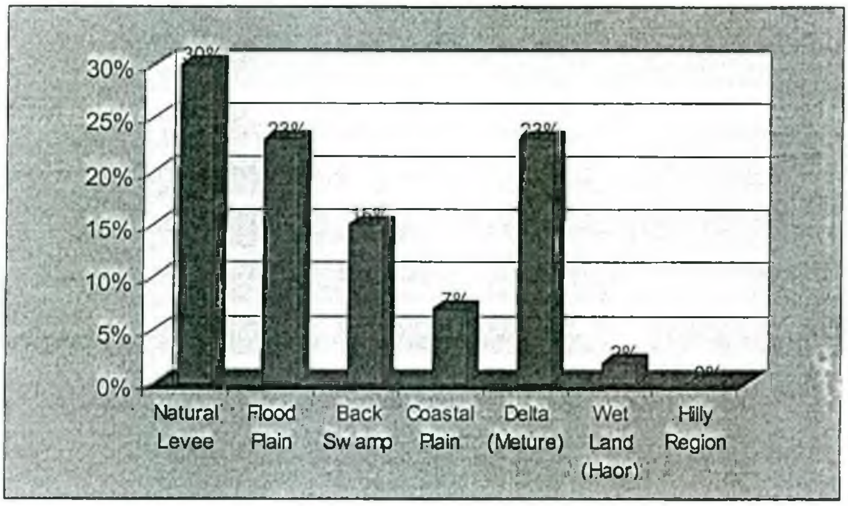
Bangladesh is a land of flood plain. Topography of Bangladesh consisting Flood Plain, Terrace, Hilly area and Detach region. In light of these the levels of land found various types. The study area is actually combination of deltaic formation and coastal region. The survey data shows that 79% land level is medium, 10% is high and 8% is low. Only 3% is very low.Very high area (Hilly area) is not found in the subsequent study area.

Table-6.63 : Types of Surface in the study area

Types of surface	Total respondents	Result	Percentage
Natural Levee	40	12	30%
Flood Plain	40	09	23%
Back Swamp	40	06	15%
Coastal Plain	40	03	7%
Delta (Mature)	40	09	23%
Wet Land (Haor)	40	01	2%
Hilly area	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.68 : Types of Surface in the study area



Source : Questionnaire Survey, 2003

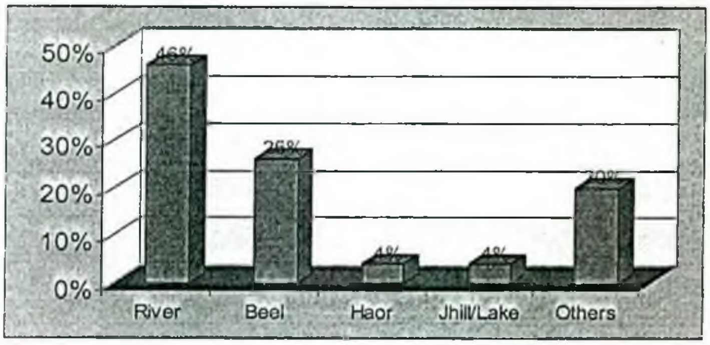
The South-West region mainly consisting the greater Khulna, Barisal and Jessore districts. Greater Jessore and Khulna region are the region of deltaid formations. The survey data reflect all categories of surface except hilly area. Natural levee, Flood Plain, Back swamp and delta are comparatively more than other surface types.

Table-6.64 : Type of water bodies in the study area

Water bodies	Total respondents	Result	Percentage
River	40	18	46%
Beel	40	10	26%
Haor	40	02	4%
Jhill/Lake	40	02	4%
Others	40	08	20%

Source : Questionnaire Survey, 2003

Fig-6.69 : Type of water bodies in the study area



Source : Questionnaire Survey, 2003

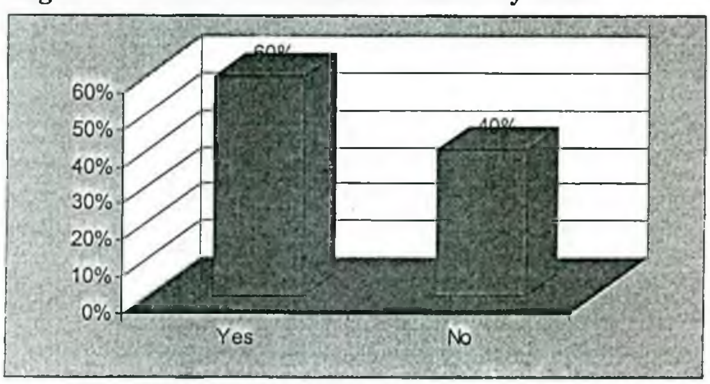
River and Beel are common water bodies in the subsequent region. It is found that these two type of water bodies are common for all other regions of the country. This region is known as delta region of the country. Among these various type of water bodies river is 46% and Beel is 26%. Almost 20% respondents opined for others type of water bodies those are Khal, Pond, Dighi and Fish Project. These water bodies generally have no any kind of contribution in flooding.

Table-6.65 : Flood occurrence in the study area

Yes/No	Total respondents	Result	Percentage
Yes	40	24	60%
No	40	16	40%

Source : Questionnaire Survey, 2003

Fig-6.70 : Flood occurrence in the study area



Source : Questionnaire Survey, 2003

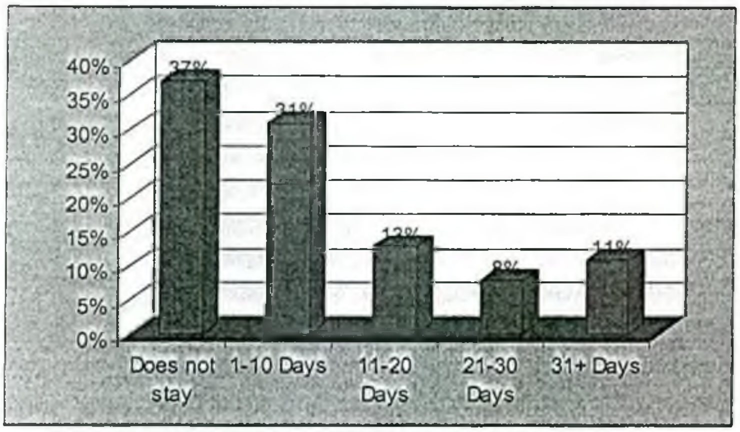
Flood takes part in the study area as an yearly phenomenon. Some few area are not flooded regularly as those areas are comparatively high. About 24 among 40 (60%) respondents said that flood occurs in their area and 40% said flood does not take part in their region.

Table-6.66 : Duration of flood in the study area

Duration	Total respondents	Result	Percentage
Does not stay	40	15	37%
1-10 days	40	13	31%
11-20 days	40	05	13%
21-30 days	40	03	8%
31 + days	40	04	11%

Source : Questionnaire Survey, 2003

Fig-6.71 : Duration of flood in the study area



Source : Questionnaire Survey, 2003

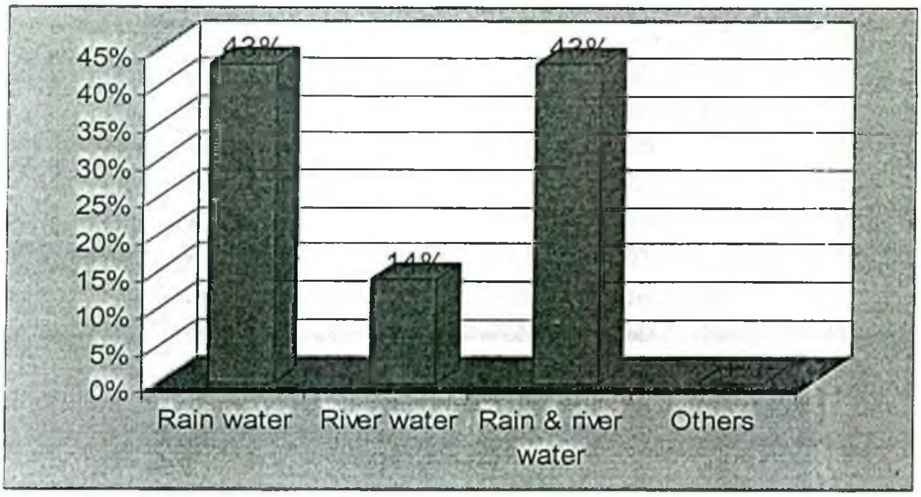
Flood occurs in the area but doesn't stay long with some few exceptions. Only 11% respondents said flood stays more that 30 days or one month in their area. The survey statistics (37%) also represent that flood doesn't stay in the region. Among the respondents 31% said flood stays 1-10 days and 13% opined for 11-20 days. Overall data shows the feature that flood occurs in the region but doesn't stay long.

Table-6.67 : Sources of flood water

Surface of flood water	Total respondents	Result	Percentage
Rain water	40	17	43%
River water	40	06	14%
Rain & river water	40	17	43%
Others	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.72 : Sources of flood water



Source : Questionnaire Survey, 2003

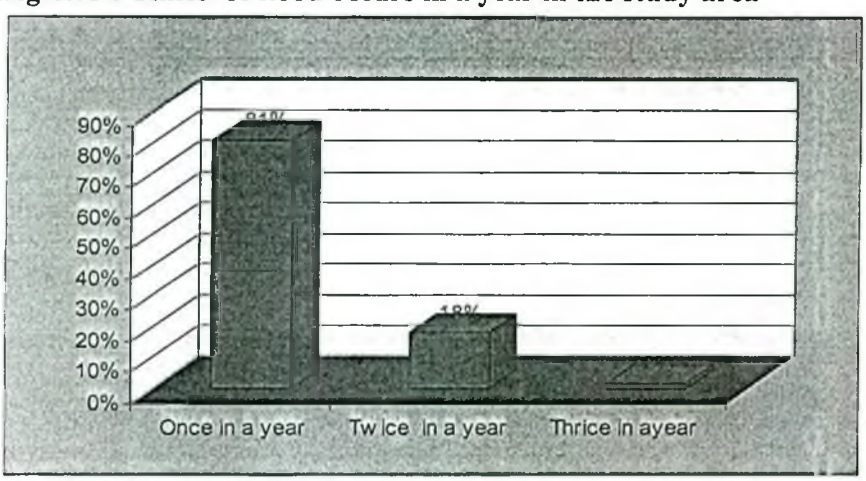
River is the main source of flood water in the present study area. Combindly rain and river water occurs flood in the rainy season while large volume of rainfall occurs over the area. The same data found from the survey (43%) that, rain and river water combindly comes in the period of flooding.

Table-6.68 : Times of flood occurs in a year in the study area

How many times	Total respondents	Result	Percentage
Once in a year	40	32	81%
Twice	40	07	18%
Thrice	40	01	2%

Source : Questionnaire Survey, 2003

Fig-6.73 : Times of flood occurs in a year in the study area



Source : Questionnaire Survey, 2003

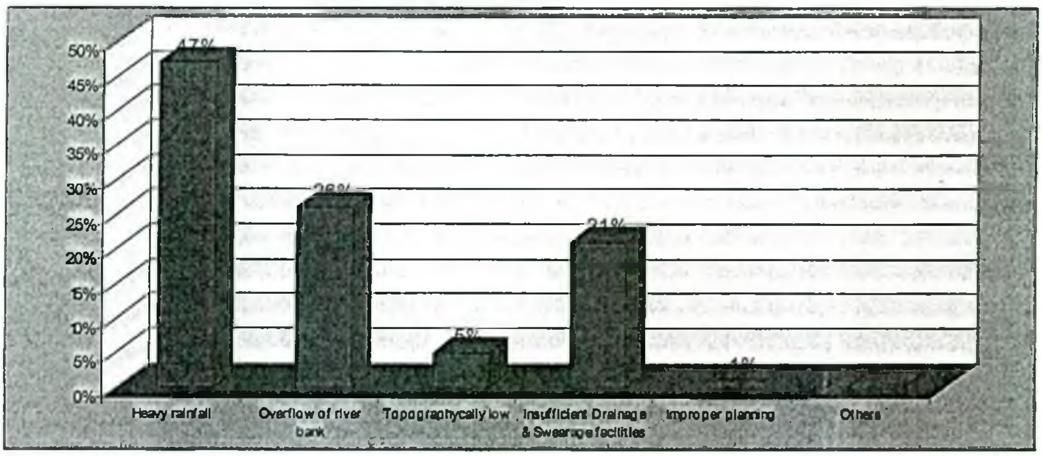
The region are partly flood free. Some part of the study area inundated regularly once in a year specially in the rainy season. Most of the area inundated once in a year. Some few region inundated twice in a year. It is very rare in the area. Coastal regions of the area might be integrated where flood takes part more than once in a year.

Table-6.69 : Causes of flood in the study area

Causes of flood	Total respondents	Result	Percentage
Heavy rainfall	40	17	47%
Overflow of river bank	40	10	26%
Topographically low	40	02	5%
Insufficient drainage & sewerage facilities	40	08	21%
Improper planing	40	01	1%
Others	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.74 : Causes of flood in the study area



Source : Questionnaire Survey, 2003

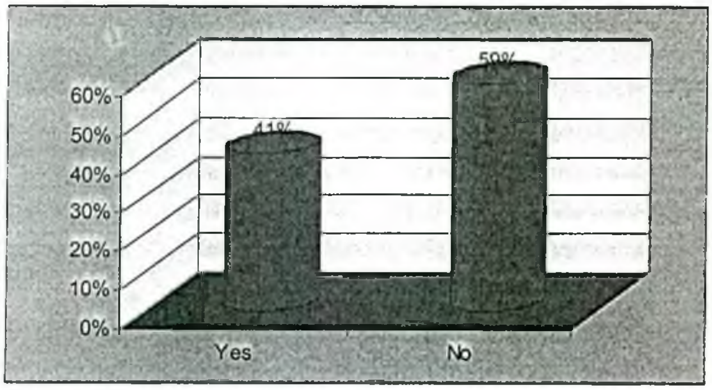
Rainfall is the main cause of flood in the study area. It is normally associated with the yearly monsoon rains that pour into the local rivers. River bank overflows and inundated the subsequent area while heavy rainfall occurs. The rain water could not pass into the river due to drainage congestion in the local area. Some very few respondents opioned that improper planning is a vital cause of flooding in the area.

Table-6.70 : Present measures of flood controlling are appropriate or not

Yes/No	Total respondents	Result	Percentage
Yes	40	16	41%
No	40	24	59%

Source : Questionnaire Survey, 2003

Fig-6.75 : Present Measures of flood controlling are appropriate or not



Source : Questionnaire Survey, 2003

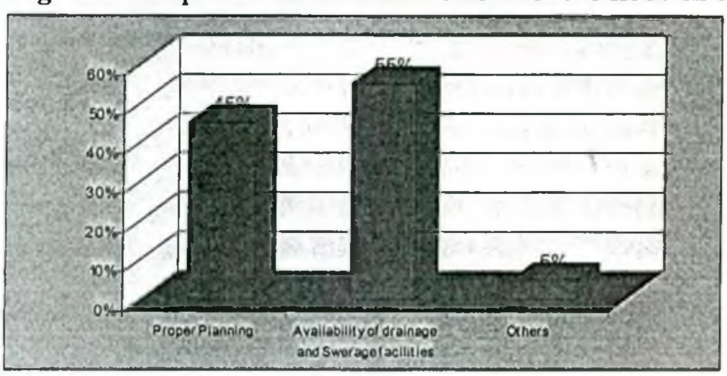
Local people of the study area are not satisfied with the present measures of flood controlling. Of course some 41% respondents said that present methods are appropriate for their region. The study area is not inundated zone of the country. While flood occurs, it create some problems occasionally. Thus the people of the study area evaluated the measures of flood controlling in their area.

Table-6.71 : Steps should be taken to control the flood in the study area

Steps should be taken	Total respondents	Result	Percentage
Proper planning	40	18	45%
Availability of Drainage and Sewage facilities	40	22	55%
Others	40	08	5%

Source : Questionnaire Survey, 2003

Fig-6.76 : Steps should be taken to control the flood in the study area



Source : Questionnaire Survey, 2003

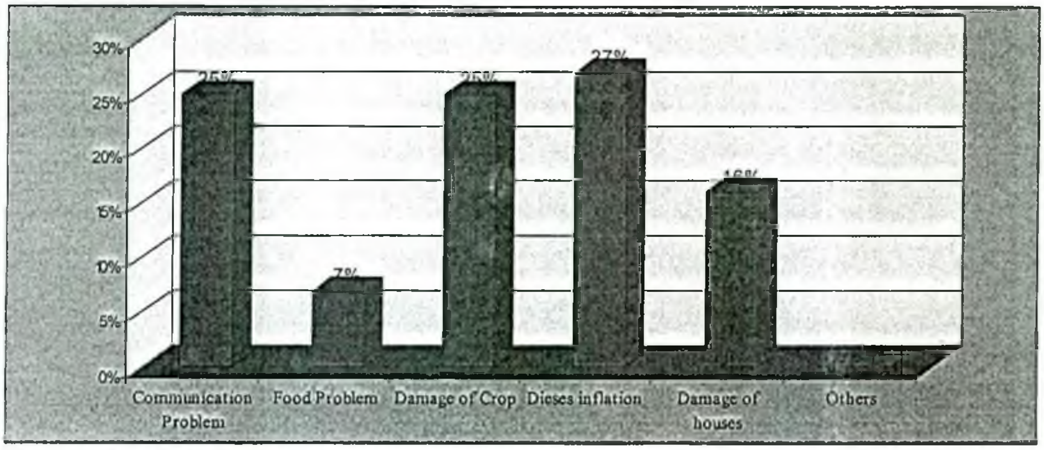
To control the flood problems effectively more what necessary steps should be taken in the study area are came out through the survey. The local people feel to avail the drainage and sewerage facilities more than present. Proper planning should be introduced immediately and new methods should be applied. A few (5%) of the respondents suggested in their own way that, locally some initiatives could be taken.

Table-6.72 : Type of problems in the period of flooding

Type of Problems	Total respondents	Result	Percentage
Communication Problem	40	10	25%
Food problem	40	13	7%
Damage of corp	40	10	25%
Disease inflation	40	11	27%
Damage of houses	40	06	16%
Others	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.77 : Type of problems in the period of flooding



Source : Questionnaire Survey, 2003

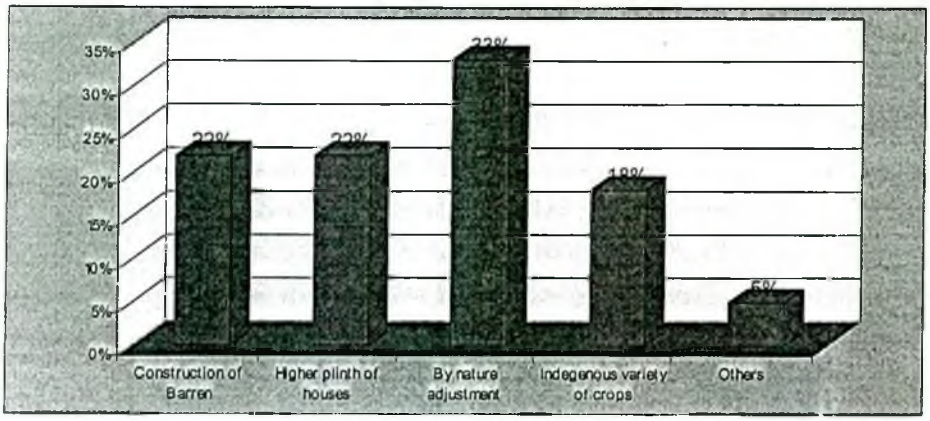
The impact of flood is ultimately creating problems to the human beings and livestock's. Some problems are also find outed through the survey as mentioned in the data. These are communication problem, food problem, crop damage, diseases inflation etc. These problems are not equally found all the area of this region.

Table-6.73 : How do the local people face the problems

	Total respondents	Result	Percentage
Construction of Barren	40	09	22%
Higher plinth of houses	40	09	22%
By nature adjustment	40	13	33%
Indigenous variety of crops	40	07	18%
Others	40	02	5%

Source : Questionnaire Survey, 2003

Fig-6.78 : How do the local people face the problems



Source : Questionnaire Survey, 2003

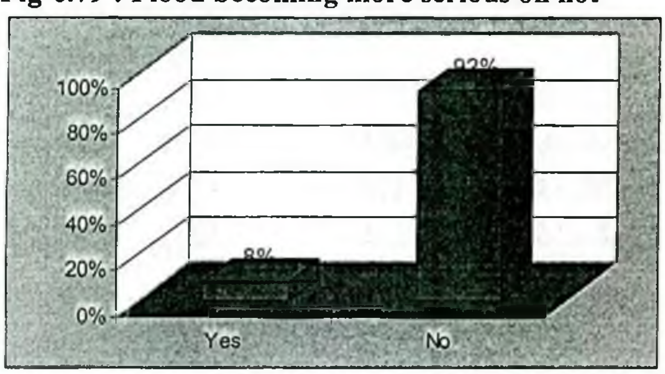
Local people of the concerned study area are habituated with yearly normal flood which occurs in between May to July. Some proper steps have also been taken locally to save themselves from the cope of the flood in their own way like, construction of Barren, higher plinth of houses, indigenous variety of crops etc. A major portion of the respondents said that they are habituate to adjust with flood by nature. It is also observed in the area that flood doesn't stay for a long. No sever flood has also takes part regularly in the area with some very few exceptions.

Table-6.74 : Flood becoming more serious on not

Yes/No	Total respondents	Result	Percentage
Yes	40	04	8%
No	40	36	92%

Source : Questionnaire Survey, 2003

Fig-6.79 : Flood becoming more serious on not



Source : Questionnaire Survey, 2003

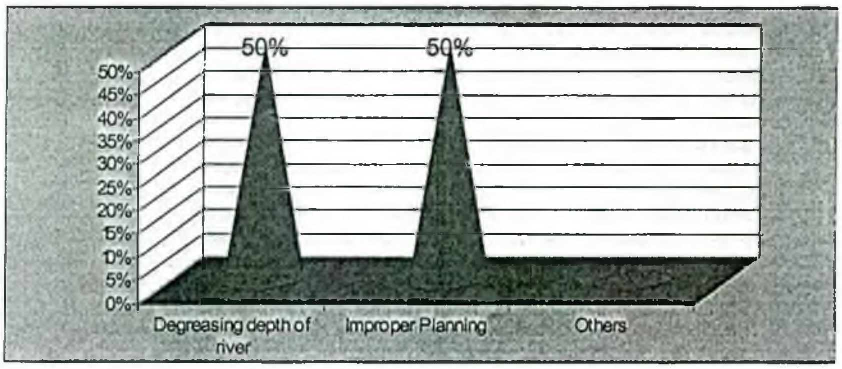
Generally we can find that the region we are talking about is almost flood free zone of the country. Due to heavy rain in the summer or rainy season, normal flood takes part here. No sever flood occurs regularly with some very few exceptions. The survey data shows that 92% respondents said floods are not becoming more serious. Percentage of the data represent that only coastal area and some few low land may have some problems of flooding due to heavy rain or overflow of river bank only in the rainy season.

Table-6.75 : Causes of deterioration of flood in the study area

Causes of deterioration	Total respondents	Result	Percentage
Decreasing depth of rivers	40	20	50%
Improper planning	40	20	50%
Others	40	00	0%

Source : Questionnaire Survey, 2003

Fig-6.80 : Causes of deterioration of flood in the study area



Source : Questionnaire Survey, 2003

The previous data shows that flood situation are not deteriorating in the area. Only 8% respondents said flood situation are not improving. That might be only in the coastal area or topographically low area. Though the people of the concerned study area confess that the flood situation is under control now, but they are not satisfied with the flood control activities introduced by the concerned authority. Some few respondents opined that no activities found from the government in their area for long year past. They also find outed a cause of flood occurring in the rainy season, that is sedimentation of rivers and decreasing depth of river and other water bodies.

6.7 Concluding Remarks

The study through questionnaire survey all over the Bangladesh reflect the hydrological and morphological characterestics of the country. It is observed that about four-fifths of the country is flood plain and due to flat tropography of the floodplain almost one-third to one-fifths of the country becomes inundated almost every year. The study also represent various types of flood occurs in different parts of the country. These types are flash flood, normal mousoom rain flood, high intensity rainfall flood, tidal flood, storm surges etc. The coastal belt of the country is vulnerable to tidal bores and storm surges.

Causes of flood in different regions of the country is findouted through the questionnaire survey. The local people identified some major causes of flood in their regions. Among these causes heavy rainfall, overflow of river bank, decreasing depth of rivers and other water bodies, drainage cougestion, lack of sewerage and drainage facilities, improper planning etc. are some major causes. Some other causes of flood should mention here like construction of roads and highways with improper planning, decreasing depth of cannels, Beels, Haors, Baors etc. Local people also gave some suggestions to protect the flood in their own ways.

The maximum people of the study area are found desatisfied with the present methods of controlling flood. They are also not satisfied with the initiatives taken by the Government in their regions. But some areas of Bangladesh specially hilly and tract area are found flood free zone of the country. People of these area opined that flood situation are not deteriorating in their area. On the other hand coastal people said that floods are occurring in their region with more severe than before.

In case of adjustment with flood, most of the areas found that local people are not afraid with flooding as this is a common and regular phenomenon almost every year in their regions. Moreover, some of the respondent s said that, occurrence of flood is useful for their regions as flood water wash away the waste and increase the fertility of crop field through siltation. However, the overall scenario of flooding in Bangladesh is reflected through the questionnaire survey which will fulfill the objectives of the present study successfully.

CHAPTER - VII

CONCLUSION

CHAPTER – VIII
CONCLUSION

7.0 General Conclusions

Flood is a common natural phenomenon in Bangladesh. Inhabitants of this country are very much familiar and accustomed with the flood. They know well how to cope with the adverse effects of flood. A series of disastrous floods occurred in this country in different years in the near past. Among those floods of 1954, 1987, 1988, 1996, 1998, 2000 and lastly of 2004 were most devastating. Floods have been a part of history of Bangladesh for quite sometimes. In normal years about 10,000 square kilometers, or 20% of the country is submerged in monsoon waters and Bangladeshis are prepared to cope with the situation. This regular level of flooding is a fact of life in Bangladesh. Generally the Bangladeshi people welcome and enjoy the normal monsoon floods. Such seasonal benign floods appears to be beneficial to the country. More than 90% of all the water that flows through Bangladesh originates else where mostly in the Himalayan slopes of India, Nepal and China. The devastating huge floods occur after several years and cause colossal loss to life and property in Bangladesh. These floods carry a huge quantity of silts to the plains of Bengal and coastal shelf and thus help the formation of deltaic land of the country. However, the disastrous huge floods brings enormous grief and misery to the people.

People of Bangladesh and the policy makers of this country are concerned with floods. Policy makers of the country have taken some multi disciplinary action and policy to protect vulnerable areas from the devastation's of floods. Effective actions have taken place in different parts of Bangladesh like establishing forecasting centers, constructing embankments and flood protection dams, and chalked out appropriate water development strategies etc.

From the analysis and study of the flood and the climato-hydrological situation of Bangladesh and its neighbouring countries, it is evident that flood has become a recurring hazard for the country. Bangladesh has to face the loss and damage of this obvious natural clamity. It is observed that the overall flood situation of the country is deteriorating gradually. It's intensity and frequency of occurrences are increasing year to year. In order to reduce the loss and damage of flood and to bring an effective control over the flooding situation of the country both the long-term and short-term control measures should be taken. The Government of Bangladesh should have a precise national flood control policy for permanent solution of the devastating flood. In that case international and regional importance for co-operation should be ignored. Bilateral or multilateral exchange of opinion and data or information regarding hydro-climatological condition of the channels and basins of the catchment areas should not be established among the countries of the region in Government level. In addition, The huge human resources of Bangladesh can be utilized effectively to implement various structural flood control measures.

However, the flood problem of Bangladesh is not a simple locally created hazard. This problem has both the local and international dimensions. The hazards of floods of Bangladesh are related to the climatological, tectonic and ecological situation of the himalayan Sub-Continent and the solution or control of the flood problems of the country obviously incorporated a joint multilateral and integrated initiative by the countries sharing the catchment basin of the rivers of Bangladesh.

7.1 Major Findings

The analysis of the present study provides us with some clear cut facts about the flood behaviour of Bangladesh. It is found from the foregoing studies and discussion that flood is a very common and familiar phenomenon to the people of Bangladesh. Since 1972 when Bangladesh emerged as an independent state there has been a growing clamour for the immediate implementation of measures to eliminate floods. The hydrologists, the water resource engineers, the water development board argued the Government to make flood control the Number one Priority of the country. Unfortunately, the flood becoming one of the most serious natural hazard in Bangladesh till now. It is also found that social scientists of the country have not attracted their serious attention to flood as they considered that it is a physical phenomenon to be dealt with mainly by hydrologists and engineers. The Government naturally has to pay attention to floods because they have a great bearing on the lives of the people and affect output levels, particularly crops. Opposition politicians are also interested in floods because they provide an opportunity to show the oppositions concern for people and also prove the inefficiency and callousness of the Government.

Generally, the peak flood period of the country occurs in between June to September. Peak flows of the three major rivers, Padma, Meghna and Jamuna of the country show different data in the same period. People of the country are habituate with flood problems. They are conscious with flood and also prepared to save themselves from the cope of flood with some few exceptions. The policy of flood adjustment measures instead of the control of floods have become popular among general people.

Some major causes of the flood are identified in this study. These might be mentioned here:

i) The territorial downpour started in the country early June and continued upto September with very little intermission. All waterways, low lands, rivers, canals and beels are on the verge of overflow.

ii) During the peak flow period, Enormous quantity of water came down to Bangladesh from the Himalayan region including India, Nepal and Bhutan and occurs flood.

iii) In Bangladesh we have more than 230 rivers and waterways. Out of those 54 including 3 main rivers (Padma, Meghna & Brahmaputra) originated in the upper Himalayan region. Theses 54 rivers carry water and in turn pushes to other rivers. These river currents carries about 240 core tons of alluvial soil each year. 25% gathers in the bed of the rivers. As a result, the rivers are primarily filled in with inland rain-water which finds no alternative but overflow their embankment as upper water comes down.

iv) Ecological erosion such as deforestation in the Himalayan region caused floods across the Nepalese frontiers sweeping over the north-eastern region of the Indian subcontinent. It this perennial Brahmaputra affliction the lower part of the Ganges basin in the west and south-west is a pery to about the same rate of damage and destruction.

v) As many as 54 common rivers including the main 3, most of them originated in the Indian territory, account for about 80% of the flood run-off in Bangladesh. These flowing water naturally inundates almost the whole of Bangladesh.

vi) The demolition of forestry in the Himalayan region to combat the crying need for wood as population grows, causes the on-rush of water from the mountains flowing into the rivers without any impediment and the silting of river beds.

vii) Bad drainage system is also responsible for flood. the water of heavy rainpour in the high places cannot flow quickly into there ocean owing to bad drainage system and lack of sufficient number of outlets and sluices. The construction of highways, railways and embankments without sufficient water gates increases the chance of flood and make them dangerous.

The above mentioned 7 points could be indicated as responsible factor; for flood occurrence. Considering the factors mentioned above, some measures could be find outed to counter against continuos threat of devastating flood:

Firstly, A bold political decision, Sincerity of the Government to the purpose is primarily required to solve the flood problems.

Secondly, The Geophysical polities is required because of the fact that 54 rivers including the 3 major rivers (Padma, Meghna & Jamuna) and their large part basin originate and locate outside Bangladesh, mainly in India and Nepal. Therefore geophysical politics among these neighbouring countries are essential. Without neighboring co-operation one cannot expect the right type of permanent solution of this flood problem.

Thirdly, Immediate construction of big reservoir where water can be stored for 20 to 30 days during peak flood period. It would reduce the fury of flood and will help improve flood position in Bangladesh.

pass longer times in boats and shifted elevated spots, i.e. road, embankments etc.

Finding shelter for domestic animals is even more difficult than for people. People first try to put their livestock on some high ground in or around their living quarters. If that fail they drive them to the nearest high land or embankment where the animals may be unprotected and exposed to sun and rain sometimes for days on end. As a result the incidence of death among domestic animals in the flood-affected regions is found to be quite high.

The majority of the people in the flood affected regions do not seem to lack confidence in meeting the challenge of floods. As a mater of fact, more than 70 percent of the people interviewed by the researcher spoke of their ability to overcome the crisis. This does not mean that they can become better off or remain as well off as before.

7.3 Need for further research: The word 'flood' is very familiar to all categories of people of Bangladesh as it occurs almost every year (in the country Bangladesh). When comes, it become harmful for the people for the society and for the Environment directly or indirectly. Every year people and various organization including GO & NGO takes necessary steps to save the people of the inundated area. Huge quantity of money, time and manpower are spent, but sufferings of the people and other concerned (animals, livestocks etc) increasing. Devastating floods becoming more serious day after day. For on example it might be indicated that flood, 2004 crossed all previous record in respect of inundation, damages and sufferings. Although flood protection activities are continuing in the country but fruitful progress in this sector is still wanted to the ordinary people of Bangladesh.

Sector wise individual research should be done for the achievement up to the expectation. Some important sectors are mentioned below.

i) To protect the major portion of the areas from annual floods Bangladesh has to improve the present data processing and information system for flood froceasting and warning in the river basins and the other rivers flowing from outside the national boundaries.In some cases it has been observed that because actual information concerning heavy rainfall in the headwaters available, Bangladesh has not been able to undertake appropriate measures for protecting lives and property of the flood affected areas.

ii) Form the field study and questionmaire survey it is found that the present strategy of flood control and drainage system are not appropriate. Further research and critical analysis in this sector could idenfified the failure of the present strategy and drainage system and also can recommand some new appropriate methods.

iii) Another vital point that should be noted is that, a very high percentage of the flow of the rivers in Bangladesh comes from outside the country. From a technical point of view, flood control and low-flow regulation could most rationally be achieved by a combination of the technical measures outside and inside the nations borders. In that case international cooperation of the neighboring countries would be of a great benefit to Bangladesh in respect of flood. But some political strategy might be considered here. It is strongly recommended that critical analysis and research is urgently need in this sector of flood protection measures.

iv) The significance of hydrological data and hydrological studies for water resourcesces development planning has gained international recognition during 10 to 20 years and in many countries there exists a network of regular hydrological stations. This is also the case in Bangladesh. Only further research and analysis with recent data and information can find out the appropriate suggestion in this measures of countrolling flood.

v) Indentification of actual economic losses of flood and environmental degradation could be measured through more critical research. However, flood is a common natural hazards in Bangladesh. Form the very beginning of country, flood taking part almost every year, sometime it cause as sever flood, No appropriate measures yet not be adopted to protect the damages and suffering of the country. In that case it is strongly recommended here that the need for further research is now to be seriously attended.

7.4 Concluding Remarks : Since 1972 when Bangladesh emeraged as an independent state there has been agrowing clamour for the immediate implementation of measures to eliminate floods, It is strongly recommended at that time bey the hydrologists and water resorece engineers that flood problem should be given number one problem in Bangladesh. After 33 years of Independent of the country Bangladesh it is still now number one natural hazards.

Research and Analysis had been made, Flood protection Projects have been implemented, Economic losses had been identified after each flood, Environmental effect had beed studied, Some more steps related to flood have also been taken, but still now flood problem is out of control to the country. It may mentioned here that, some very few improvements have also been achived in this sector through past 33 years.

Impacts of flood to the lives of the country are immeasureable. Impact on livelyhood, impacts on environment, economic impacts, social impacts are directly and indirectly involved to the daily life of the country Bangladesh. Losses and benefits of these sectors mentioned above are identified. Particular and elaborately analysis now could be seriously attended.

Causes and effects of flood are analyzed in various way. Recommendations have also made from different organization and research centre. Some necessary steps have also been taken but expected achievements are still wanted. Although flood is a natural hazard and it comes in severe way in Bangladesh after some few years, the permanent solution is now urgently needed.

Every year flood inundates land and causes damage in Bangladesh. The area affected and the losses and suffering, however, do not remain the some. Even though it is not easy to obtain an accurate account of damage, We can get a comprehensive view on the basis of rough estimates prepared by the appropriate agencies of the government. Flood cause damage to crops, culverts, Bridges, Homesteads, roads, railways and embankments, Human lives and livestock assets are also lost in floods. However, damages of flood are known to the people of Bangladesh. They need to get rid of the curse of flood.

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END

APPENDICES

APPENDIX-I

Table -2.14 : Situation in August

Basin : Brahmaputra **Rainfall in Millimeters**

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Kurigram	722.5	291.0	492.6	201.6	157.0	304.2
Dalia	1247.5	570.0	519.5	-50.5	63.0	236.0
Kaunia	729.9	345.0	661.0	316.0	169.5	274.0
Rangpur	610.1	318.0	420.1	102.0	105.5	157.0
Chilmari	834.4	299.0	616.0	317.0	250.0	372.0
Dewanganj	618.7	337.0	617.0	280.0	72.0	302.5
Gaibandha	272.8	288.0	500.0	212.0	168.0	282.5
Bogra	733.8	297.0	504.2	207.2	98.5	201.1
Jamalpur	702.2	361.0	516.8	155.8	82.4	297.2
Mymensing	800.1	362.0	767.0	405.0	211.6	365.5
Dhaka	704.8	337.0	563.0	226.0	122.0	395.0

Source : BWDB, 1998

Basin : Ganges **Table : 2.15** **Rainfall in Millimeters**

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Panchagarh	1604.2	572.0	908.0	336.0	131.5	339.0
Dinajpur	892.7	336.0	554.9	218.9	170.4	256.6
Pabna	639.0	264.0	274.5	10.5	52.0	138.8
Naogaon	858.9	289.0	247.6	-41.4	65.0	150.1
Rajshahi	537.8	251.0	160.5	-90.5	43.0	77.5
Kushtia	774.8	268.0	241.3	-26.7	47.2	122.9
Jessore	751.1	314.0	178.7	-135.3	34.0	95.8
Khulna	666.2	347.0	309.0	-38.0	48.0	153.0
Satkhira	548.8	332.0	174.3	-157.7	32.0	67.3
Faridpur	650.0	289.0	350.6	61.6	110.6	246.1
Barisal	994.2	398.0	524.5	126.5	54.6	297.8
Patuakhali	1049.8	551.0	646.7	95.7	143.0	426.9

Source : BWDB, 1998

Basin : Meghna **Table : 2. 16** **Rainfall in Millimeters**

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Kanaighat	1227.0	763.0	780.0	17.0	97.0	426.0
Sylhet	1152.2	637.0	779.0	142.0	119.0	410.0
Sunamganj	2514.7	1089.0	1841.5	752.5	325.0	692.0
Sheola	850.6	561.0	780.0	219.0	93.0	416.0
Moulvi Bazar	666.9	393.0	236.0	-157.0	55.0	117.0
Manu Rly Br	520.6	406.0	304.0	-102.0	87.0	174.0
Habiganj	955.5	398.0	452.6	54.6	109.0	253.2
Durgapur	1093.7	617.0	751.4	134.4	135.0	292.6
Bhairab Bazar	256.3	337.0	292.0	-45.0	54.0	109.0
Comilla	692.2	566.0	327.9	-238.1	95.6	162.5
Chandpur	588.6	334.0	538.0	204.0	124.8	277.5

Source : BWDB, 1998

Basin : South Eastern Hill **Table : 2. 17** **Rainfall in Millimeters**

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Parshuram	671.1	410.0	576.7	166.7	102.5	242.1
Noakhali	994.4	161.0	977.8	361.8	138.6	444.1
Narayanhat	928.1	584.0	953.8	369.8	185.0	478.5
Panchpukuria	860.3	478.0	1045.7	567.7	123.2	459.7
Bandarban	911.1	464.0	689.5	225.5	97.5	278.7
Rangamati	1377.9	507.0	503.5	-3.5	57.5	219.0
Lama	1048.7	571.0	1239.5	668.5	195.0	552.5
Chittagang	1086.9	548.0	1306.0	758.0	237.0	518.0
Ramgrah	1075.7	467.0	496.0	29.0	71.0	259.5

Source : BWDB, 1998

Situation in September

Basin : Brahmaputra **Table : 2.18** **Rainfall in Millimeters**

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Kurigram	678.1	348.0	355.1	7.1	99.0	239.0
Dalia	634.2	470.0	563.0	93.0	205.0	416.0
Kaunia	1046.0	366.0	417.7	51.7	217.7	227.7
Rangpur	696.5	347.0	260.4	-86.6	85.0	191.8
Chilmari	728.8	270.0	480.2	210.2	200.0	375.2
Dewanganj	742.1	306.0	372.5	66.5	80.0	238.5
Gaibandha	762.6	231.0	174.6	-56.4	56.0	142.5
Bogra	762.6	262.0	271.5	9.5	119.2	178.6
Jamalpur	509.3	312.0	270.7	-41.3	128.5	183.8
Mymensing	714.3	336.0	234.0	-102.0	76.5	122.7
Dhaka	607.4	232.0	224.0	-8.0	44.0	117.0

Source : BWDB, 1998

Basin : Ganges **Table : 2.19** **Rainfall in Millimeters**

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Panchagarh	535.9	398.0	745.0	347.0	206.5	560.5
Dinajpur	604.0	295.0	362.3	67.3	125.8	211.4
Pabna	541.7	222.0	483.3	261.3	92.0	373.3
Naogaon	616.3	237.0	283.0	46.0	83.0	153.0
Rajshahi	650.7	253.0	194.2	-58.8	35.0	137.2
Kushtia	381.0	197.0	333.1	136.1	91.3	231.7
Jessore	560.9	253.0	188.8	-64.2	86.3	150.3
Khulna	692.1	236.0	341.0	105.0	73.0	227.0
Satkhira	940.3	326.0	252.2	-73.8	62.5	202.8
Faridpur	524.8	269.0	226.0	-43.0	53.0	109.0
Barisal	719.1	313.0	238.6	-74.4	45.5	187.3
Patuakhali	886.3	395.0	351.6	-43.4	59.8	316.0

Source : BWDB, 1998

Basin : Meghna **Table : 2. 20** **Rainfall in Millimeters**

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Kanaighat	998.3	769.0	394.0	-375.0	87.0	254.0
Sylhet	1218.2	537.0	388.8	-148.2	125.0	236.0
Sunamganj	1130.3	733.0	378.0	-355.0	72.0	199.0
Sheola	853.3	470.0	617.0	147.0	168.0	401.0
Moulvi Bazar	486.6	289.0	70.0	-219.0	17.0	51.0
Manu Rly Br	640.0	462.0	211.0	-251.0	63.0	161.0
Habiganj	497.8	263.0	158.5	-104.5	44.0	118.4
Durgapur	1525.2	533.0	363.6	-169.4	64.0	242.5
Bhairab Bazar	534.7	276.0	239.0	-37.0	71.0	114.0
Comilla	570.5	257.0	214.3	-42.7	80.5	116.7
Chandpur	602.0	235.0	108.9	-126.1	25.0	65.5

Source : BWDB, 1998

Basin : South Eastern Hill **Table : 2. 21** **Rainfall in Millimeters**

Station	Recorded Maximum Rainfall	Normal Rainfall	Actual Rainfall	Deviation from Normal	1-day Maximum Rainfall	10-day Maximum Rainfall
Parshuram	378.5	236.0	246.1	10.1	55.0	124.6
Noakhali	733.4	438.0	232.2	-205.8	56.8	145.2
Narayanhat	497.9	267.0	217.4	-49.6	39.0	104.2
Panchpukuria	493.5	236.0	233.9	-2.1	54.7	125.1
Bandarban	574.2	247.0	189.3	-57.7	63.0	130.3
Rangamati	436.8	289.0	358.9	69.9	62.5	172.9
Lama	662.2	319.0	328.0	9.0	90.0	146.0
Chittagang	638.8	275.0	139.6	-135.4	32.0	75.0
Ramgrah	472.3	260.0	109.7	-150.3	32.5	68.5

Source : BWDB, 1998

APPENDIX – II

Table -2.3 : Monthly minimum water levels (m/PWD) 1970 - 2000
Station : 99 Gorai Rail way Bridge, River : Gorai

Year	Jan	Feb	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1970	5.385	5.065	4.880	4.745	4.875	5.400	8.740	11.300	11.235	7.915	6.315	5.670
1971	-	-	-	-	-	-	-	-	-	-	-	-
1972	5.055	4.850	4.640	4.300	4.360	5.695	7.425	10.470	10.775	7.315	6.320	5.765
1973	5.555	5.020	4.640	4.640	4.795	5.725	9.110	11.765	11.775	9.560	7.290	6.185
1974	4.785	4.615	4.320	4.710	5.025	5.595	8.170	12.525	10.835	8.425	6.415	5.385
1975	4.410	4.025	3.325	4.260	4.295	5.240	9.010	11.705	11.255	8.440	6.280	5.150
1976	5.000	4.645	4.405	3.355	3.355	4.655	7.345	10.220	11.215	7.530	6.225	5.480
1977	5.090	4.907	4.572	4.496	4.740	5.410	7.376	11.765	10.622	8.504	6.782	5.669
1978	4.877	4.968	4.542	4.724	5.166	6.569	9.815	11.964	11.430	8.474	6.355	5.486
1979	4.084	3.734	3.612	4.511	4.755	4.694	5.944	10.866	7.955	6.675	5.090	4.724
1980	3.566	3.048	2.804	3.566	4.023	4.938	7.727	12.131	11.186	7.757	5.669	4.420
1981	3.195	3.150	2.880	2.743	3.597	4.785	6.377	11.673	10.253	6.754	5.204	4.060
1982	4.095	3.930	3.350	2.920	3.710	3.980	7.680	10.710	10.760	6.590	5.613	4.530
1983	5.095	4.940	4.335	3.295	3.780	4.700	6.015	10.740	11.935	9.250	6.820	5.620
1984	4.850	4.400	4.090	4.240	4.430	5.650	10.930	10.930	11.310	7.720	6.090	5.220
1985	4.070	3.800	3.105	4.070	4.110	4.300	6.500	11.500	11.390	10.280	7.200	5.190
1986	4.740	4.180	3.800	.3060	3.440	3.230	7.770	10.530	10.600	8.170	6.420	5.430
1987	3.270	3.220	3.180	3.800	4.310	4.430	6.930	11.900	11.640	7.280	4.780	3.480
1988	4.070	4.010	3.940	3.160	3.160	4.240	6.130	11.680	9.680	6.560	5.080	4.110
1989	4.370	4.340	4.310	3.930	3.930	5.320	7.680	10.700	11.140	7.360	5.720	4.510
1990	3.890	3.670	3.630	4.290	4.320	5.410	8.420	10.980	10.180	7.940	5.810	4.430
1991	4.390	4.340	4.260	3.610	3.610	4.620	8.030	10.620	10.360	6.470	5.390	4.620
1992	4.090	4.070	4.030	4.160	4.160	4.190	5.650	9.330	9.430	7.700	5.350	4.170
1993	4.180	4.180	4.140	4.030	4.040	4.510	6.980	10.260	11.530	7.690	5.770	4.270
1994	4.300	4.260	4.220	4.030	4.090	4.210	8.240	11.220	9.920	5.970	4.450	4.360
1995	4.590	4.540	4.450	4.170	4.160	4.810	8.660	10.390	10.930	7.300	6.560	4.60
1996												
1997	5.320	-	4.860	4.600	4.600	4.620	6.140	10.320	10.370	6.560	5.260	6.210
Recorded MWL	3.195	3.048	2.804	2.743	3.160	3.230	5.650	9.330	7.955	6.560	4.780	4.110

Source : BWDB, Dhaka.

Table -2.5 : Monthly minimum water levels (m/PWD) 1970 - 2000
Station : 46 9L Bahadurabad, River : Brahmaputra - Jamuna

Year	Jan	Feb	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1970	13.220	13.030	13.030	13.760	15.565	16.565	18.235	18.235	17.190	15.960	14.575	13.625
1971	13.310	13.060	13.000	13.550					17.325	16.430	14.590	13.655
1972	13.245	13.045	13.395	13.715	14.635	16.805	17.770	17.685	17.630	16.040	14.440	13.685
1973	13.395	13.365	13.425	13.395	15.045	16.015	17.280	17.640	17.280	16.130	14.375	13.890
1974	13.485	13.350	13.350	13.920	15.970	15.875	19.140	18.030	18.965	16.610	14.750	13.900
1975	13.140	13.010	13.150	13.440	14.525	15.735	18.485	17.890	17.665	16.320	14.615	13.800
1976	13.110	12.885	13.295	13.860	14.920	15.890	17.790	17.685	17.465	15.725	14.385	13.665
1977	13.175	13.030	13.015	14.055	16.305	17.405	18.460	19.110	18.085	16.130	14.560	13.680
1978	13.335	13.090	13.015	13.105	14.815	16.590	18.120	17.505	17.280	15.695	14.735	13.855
1979	13.564	13.503	13.625	13.259	14.478	15.423	17.303	17.877	17.556	16.231	14.752	14.021
1980	13.326	13.244	13.244	13.890	16.307	16.322	18.395	19.004	18.065	16.435	14.569	13.807
1981	13.120	13.040	13.070	13.870	14.780	16.200	18.425	18.460	17.465	15.305	14.160	13.645
1982	13.220	13.120	13.295	13.480	15.000	15.540	18.565	17.465	17.370	15.570	14.325	13.680
1983	13.350	13.070	13.050	13.880	14.880	16.500	18.400	17.870	18.550	16.360	14.430	13.680
1984	13.600	13.480	13.480	13.600	15.130	17.220	18.310	17.830	18.260	16.480	14.720	14.100
1985	13.440	13.320	13.240	14.350	15.570	16.470	18.690	17.640	17.980	15.850	14.480	13.900
1986	13.360	13.150	13.190	13.470	15.140	15.140	17.900	17.160	17.930	16.090	14.540	13.820
1987	13.550	13.380	13.580	13.700	15.010	16.070	18.540	18.200	18.290	16.390	14.680	13.960
1988	13.760	13.368	13.790	14.230	15.130	16.860	17.50	18.300	17.370	16.620	14.890	14.180
1989	13.680	13.660	13.690	13.940	15.260	17.240	18.190	18.090	18250	16.700	14.990	14.110
1990	13.520	13.350	13.350	13.950	15.720	16.950	18.370	18.210	18.030	16.570	14.700	13.920
1991	13.890	13.770	13.750	14.080	14.620	16.870	18.330	18.320	18.410	16.430	14.800	14.230
1992	13.840	13.670	13.840	15.020	15.610	16.010	18.200	17.650	17.320	16.190	14.570	13.990
1993	13.520	13.310	13.290	14.230	15.140	06.630	18.390	18.650	17.900	16.420	14.810	13.940
1994	13.060	12.920	13.060	14.680	15.430	16.630	17.270	17.730	17.260	15.570	14.130	13.390
1995	13.550	13.230	13.340	13.460	14.850	17.320	18.490	17.710	17.710	16.180	14.850	14.060
1996	13.370	13.370	13.230	14.390	15.790	16.610	18.730	17.310	17.310	15.970	14.790	13.870
1997	13.100	12.950	13.000	14.280	14.330	16.219	17.800	17.440	17.440	-	14.290	13.580
RLWL	13.110	12.885	13.000	13.259	14.330	15.140	17.270	17.160	17.310	15.570	14.130	13.390

Source : BWDB, Dhaka.

Table -2.4 : Monthly maximum water levels (m/PWD) 1970 - 2000
Station : 46 9L Bahadurabad, River : Brahmaputra-Jamuna

Year	Jan	Feb	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1970	13.610	13.260	13.440	15.375	18.000	19.365	20.195	19.965	19.340	19.280	16.305	14.475
1971	13.655	13.610	13.730	13.615					17.920	18.745	16.310	14.530
1972	13.670	13.430	13.740	14.880	17.255	19.355	19.970	19.980	18.745	17.760	16.580	14.405
1973	13.860	13.565	13.930	16.015	17.265	19.805	19.300	19.880	19.280	18.505	16.115	14.400
1974	13.885	13.570	13.900	16.180	17.645	19.660	20.040	20.255	20.045	19.155	16.605	14.695
1975	13.775	13.135	13.890	14.965	15.975	18.455	19.600	19.600	18.840	18.020	16.235	14.575
1976	13.620	13.110	14.250	14.950	15.840	19.340	19.865	19.255	18.750	17.425	15.735	14.570
1977	13.655	13.165	13.230	16.280	17.755	19.210	19.665	19.990	19.910	18.805	16.080	14.525
1978	13.835	13.335	13.265	14.875	17.060	19.630	19.410	18.945	18.515	18.030	15.595	14.720
1979	14.006	13.615	14.134	14.417	16.709	17.023	19.650	19.498	19.782	19.605	16.130	14.905
1980	13.783	13.365	13.990	16.511	16.907	18.913	19.757	20.102	18.882	18.501	16.535	14.554
1981	13.620	13.185	13.445	14.995	15.985	18.305	19.480	19.240	19.210	17.575	15.275	14.125
1982	13.695	13.350	14.175	15.170	16.985	18.800	19.380	19.330	19420	18.000	15.550	14.325
1983	13.680	13.470	13.710	15.200	17.110	18.950	19.290	19.280	19.930	18.760	16.330	14.410
1984	14.080	13.590	14.520	15.350	17.860	18.930	19.970	19.870	20.110	18.250	16.400	14.700
1985	13.900	13.480	13.760	15.790	16.500	18.980	19.620	19.250	18.840	18.350	15.800	14.480
1986	13.820	13.350	13.740	15.590	15.710	18.560	18.680	18.730	19.150	18.100	16.020	14.510
1987	13.940	13.650	14.890	15.590	16.230	18.570	19.460	19.710	18.990	19.060	16.320	14.660
1988	14.170	13.950	13.960	15.510	18.180	18.270	19.610	20.620	20.350	18.590	16.540	14.990
1989	14.100	14.020	13.940	15.540	17.930	18.710	19.580	18.920	19.190	18.840	16.630	14.960
1990	13.910	13.510	14.080	16.270	17.100	19.190	19.390	19.300	19.12C	19.290	16.500	14.690
1991	14.250	13.900	15.250	15.540	17.820	19.370	20.080	19.220	19.200	18.670	16.390	14.790
1992	14.120	14.400	14.420	16.220	17.010	19.200	19.190	18.690	18.600	17.670	16.120	14.560
1993	13.930	13.540	15.410	15.210	17.410	18.840	19.900	19.470	19.350	18.640	16.360	14.780
1994	13.390	13.140	13.440	1.620	16.840	18.710	18.750	18.490	18.040	17.240	15.520	14.110
1995	14.050	13.540	14.820	14.790	18.290	19.480	19.600	19.600	19.230	19.120	16.129	14.840
1996	13.860	13.390	15.000	16.460	18.040	19.110	19.180	19.180	19.050	18.190	16.820	14.780
1997	13.560	13.090	14.420	14.880	16.600	18.860	18.900	18.900	19.220	-	15.350	14.280
Recorded HWL	14.250	14.400	15.410	16.460	18.290	19.480	20.080	20.620	20.350	19.605	16.820	14990

Source : BWDB, Dhaka.

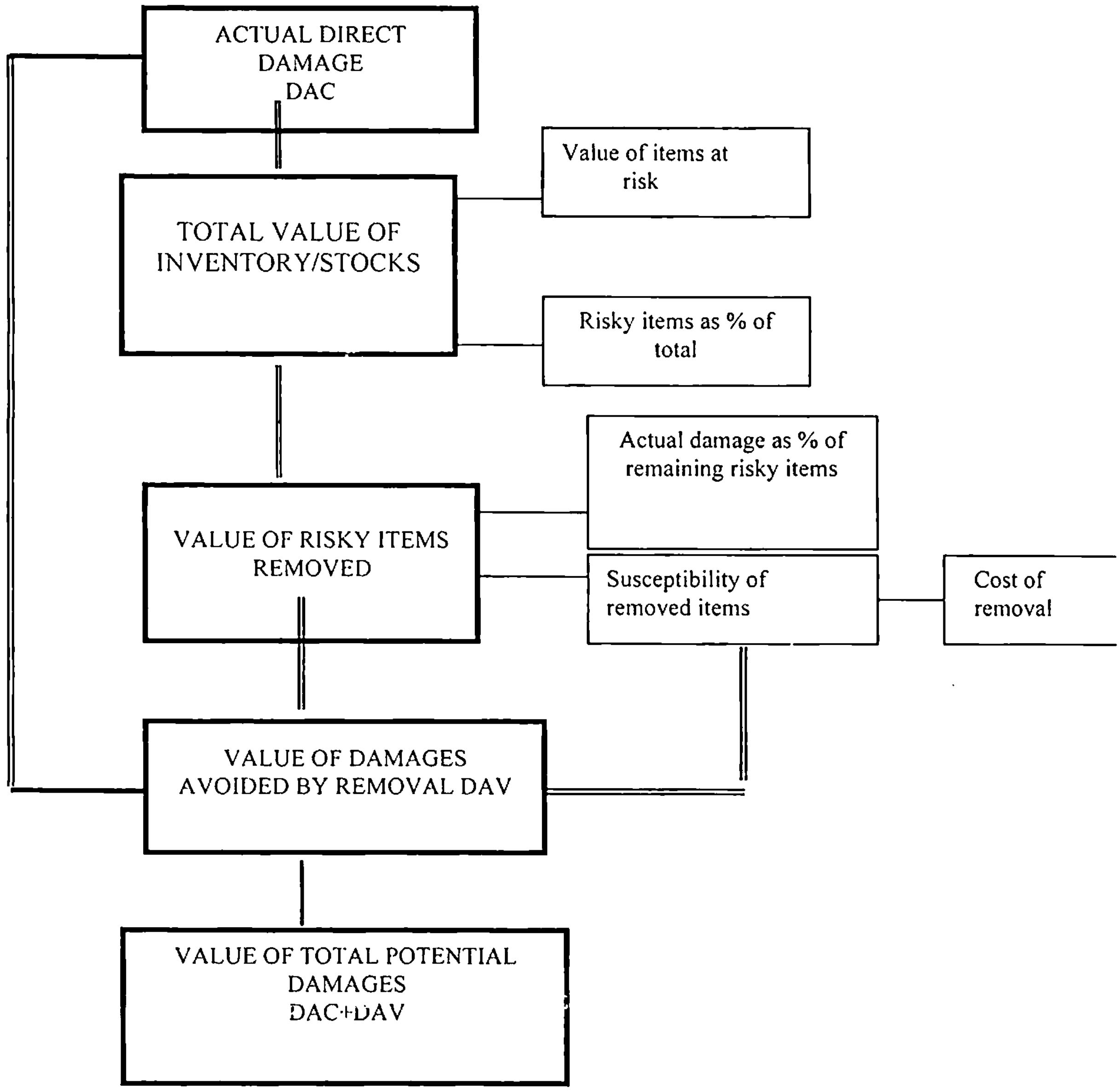
APPENDIX- III

Table- 1 : Comparative advantages and disadvantages of loss models

Factors	Regional econometric model	Unit-loss model	Input-Output model
Data and source	Time series data from secondary sources	One-short field survey data	Time series data from secondary sources
Hazard scale	Large scale	Small scale	Small & large scale
Adjustment of recovery and damage-reduction	Incorporation difficult	Incorporation feasible	Incorporation not feasible
Trade adjustments	Incorporation not feasible	Incorporation feasible	Incorporation not feasible
Supply side factors	Cannot adequately capture	Can capture	Cannot adequately capture
Range of impacts	Model almost full range of impacts	Model direct & primary indirect impacts	Model only multiplier effects
Level of estimates	Usually not much refined	Usually relatively refined & disaggregated	Not refined
Damage category	Tangible impacts feasible	Tangible & intangible feasible	Tangible impacts feasible
Vulnerability assessments	Assessment not feasible	Assessment by impact/sector/area feasible	Assessment not feasible
Depth-damage/loss-probability relationships	Not feasible	Feasible	Not feasible
Appraisals of range of protection	Not feasible	Feasible	Not feasible
Hazard applicability	Most earthquake modeling	Mostly flood loss modeling	Most earthquake modeling

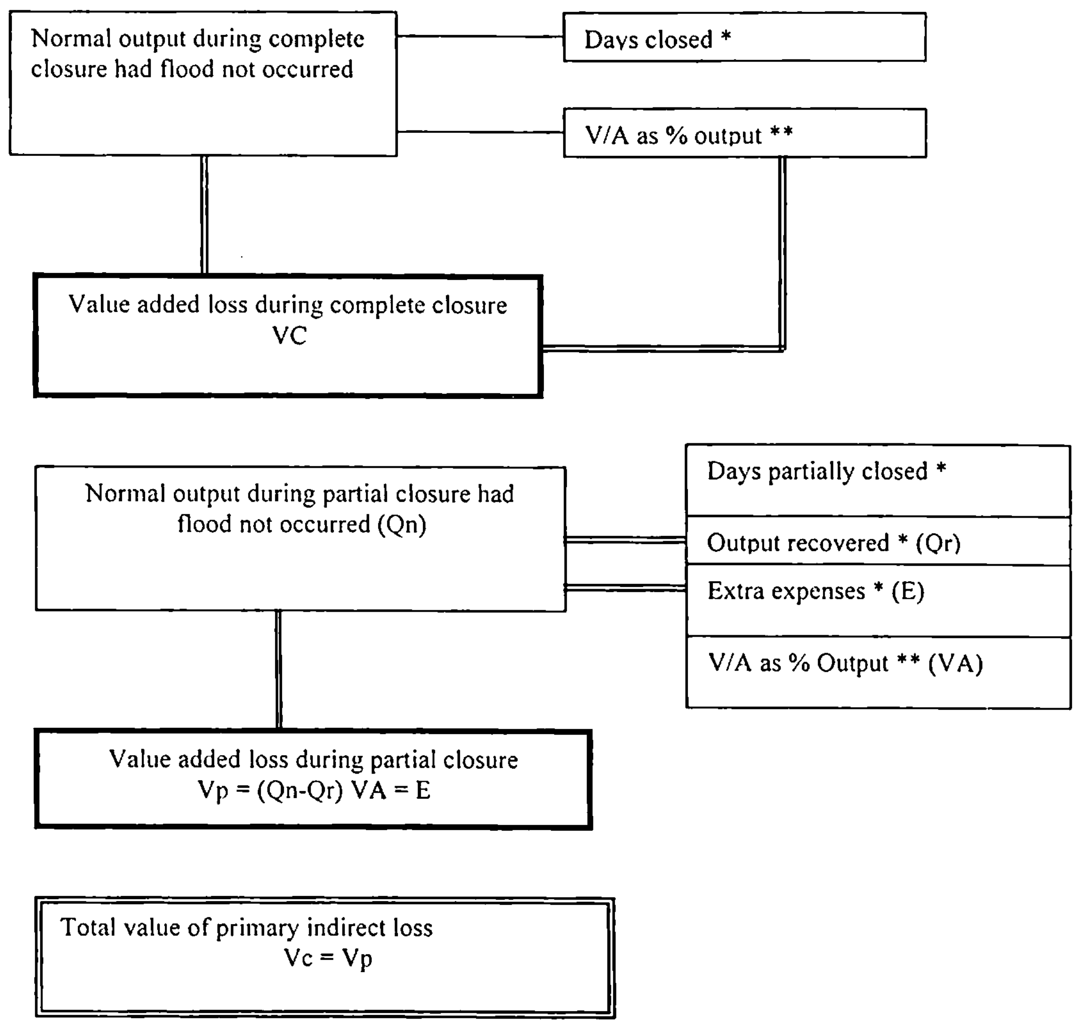
Source : N. Nabi,

Fig 1.1 : Principal methodology for estimation of direct damage potential (from actual damage) to inventories and stock



Source : N. Nabi, 1997

Figure 1.2 : Principal steps for estimation of indirect loss from flood disruption in commercial sector.



* From site survey. ** From secondary sources/field survey
V/A = Value Added
For business enterprises, output is replaced bt Turnover, and value added is replaced by Gross margin.

Figure 1.3 : Flood loss (Total loss) model : Model – 1

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Direct Loss Model

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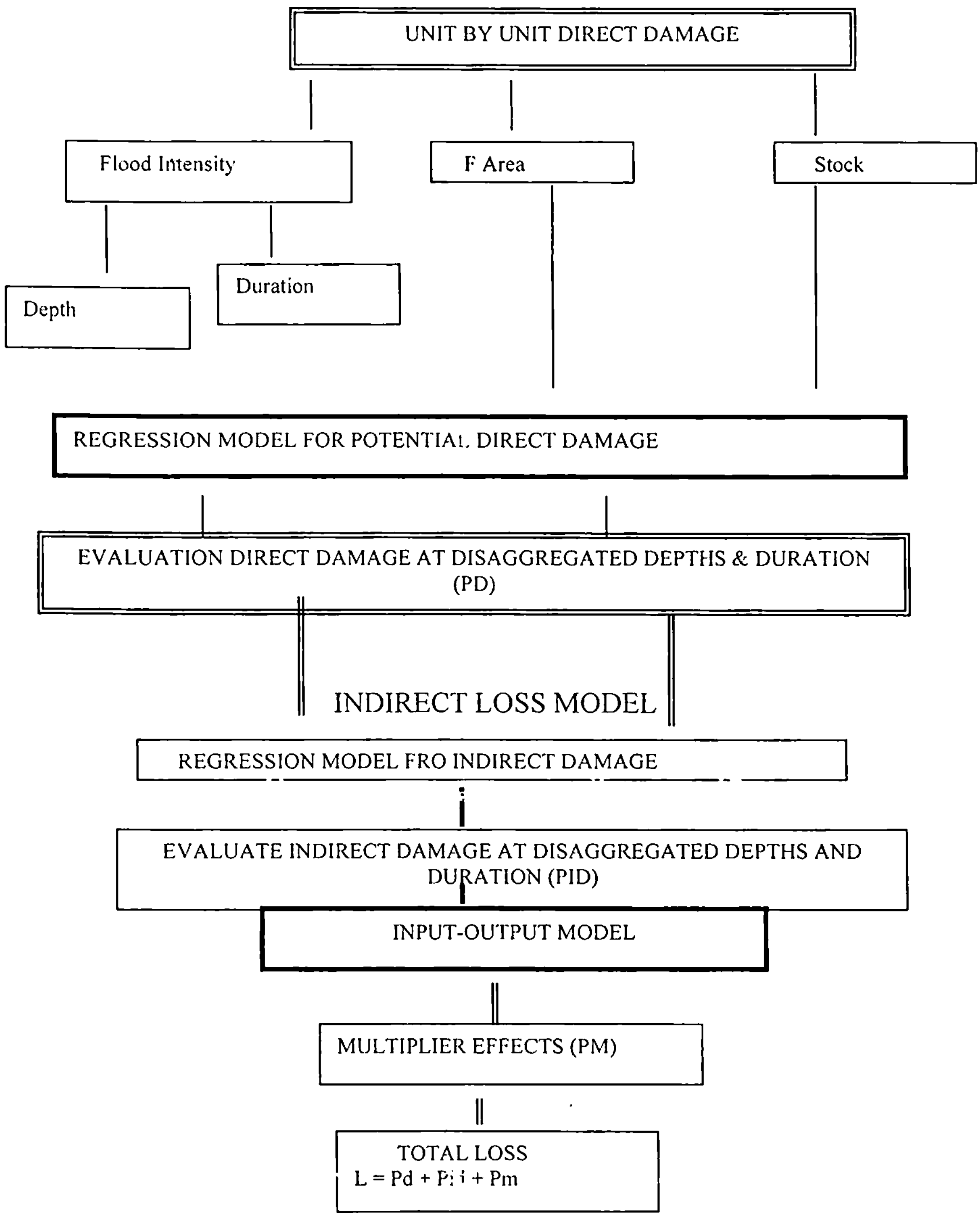

Source : N.Nabi, 1997

APPENDIX – IV

Review of Existing Literature (On abroad)

Research on flooding impacts and their modeling is carried out in a few advanced countries. The major contributing countries are the USA, UK, and Australia. In USA, the collection of flood damage information has been in practice as far back as 1902. In the UK, the practice started only in the late 1960s. Nevertheless, with the exception of the USA these countries started using these data for appraisal of flood alleviation schemes comparatively recently. The following section presents an overview of flood research in abroad.

In the USA, various federal agencies used to carry out rapid assessment of flood loss potential9so called windshield surveys), from only a examination of the external appearance of the affected residential buildings(US Department of Agriculture, Soil Conservation Service,1970). Flood loss potentials for future floods used to be assessed or rather projected on the basis of actual events (US Army Crops of Engineers 1979). The actual damages so assessed were used mainly for appraisals of flood control projects at regional level, having no application at national levels.

The approach of exploring future damages from actual flood were subsequently modified and the synthetic method of flood damage assessment started to be adopted in the USA. The approach initially developed by White (1964) AND Kates (1965), was followed by the Tennessee Valley Authority (TVA) and the US Army Corps of Engineers (USACE). Both TVA (1969) and USACW (1970) concentrated on the generation of synthetic direct damage data in response to specific requirements of the federal flood insurance administration. The two agencies developed a series of depth-damage curves based on direct damages to a group of residences, the properties grouped according to aspect, e, g, number of rooms, storeys and

construction materials. The susceptibility at each hypothetical depth for each house type was estimated from different sources, e.g. relevant builders and manufacturers. These curves from the basis of estimating potential damages to different groups of residences, which were then generalized to similar residences in other areas of USA. James and Lee (1971) suggested an empirical linear function for shallow flooding, correlating damage with depth and property values. For a deeper flooding, they argued that the curve was likely to be of a non-liner form.

In Australia, Aitken (1976) regressed empirical damage data of depth fo flooding and floor areas to predict future flood damage for the Brisbane river. The regression analysis, based on a sample of 400 households, derived the value of r.... as 0.34 and 0.27 for the structural and contents damage respectively, was criticized by Penning-Rowsell and Chatterton (1977) for being too `poor to be used in future damage assessments`. The low coefficients of determination in all the cases indicated, not surprisingly, the presence of a large variability in the existing damage data. However, given the large sample size and degrees of freedom, the coefficient of determination for all the cases were found to be statistically significant.

In the UK, methods of modeling damages to residential buildings used in the 1960s were rudimentary. Foe example, Porter (1970) assessed damages as a fixed percentage of property values. Yet crude in nature, during the early 1970s, the water authorities in the UK employed a flat rate, 10 per cent values, to represent losses in all depths of flooding. The Wessex Water Authority (1974) used an absolute rate of .... 500 per dwelling as potential losses, calculated on the basis of insurance payment for flood damages. Roberts (1968) was probably the first in the UK to adopt survey techniques to assess flood damage potentials. The approach was, however, criticized by penning-Rowsell and Chaerton (1977) as notorious for underestimating past damage.

Researchers, centered mainly in the Flood Hazard Research Centre, appear to have made a breakthrough in the field of flood loss modeling in the mid 1970s. after years of continuous research and development, a series of approaches and methodologies were developed. In the UK (and perhaps, USA), the assessment of potential flood damages based directly upon actual events was found to be impracticable for many resins. The major reasons related to the scarcity of observable floods over various depths or durations and large number of house types occupied by a large number of socio-economic groups. Consequently, the synthetic approach was adopted for the assessment of residential flood loss potentials (Parker and Penning Rowsell 1972; Parker 1976; Penning-Rowsell and Chatterton 1977.)

The most comprehensive study of flood loss potentials in the residential sector in the UK is the one by Penning-Rowsell and Chatterton (1977), popularly know as 'Blue Manual'. Indeed, the study was a breakthrough in flood loss research in the UK, specially in the residential sector. The study adopted the synthetic approach in constructing nationally applicable standard data sets for various depths and durations. The depth variable has been explored for high levels of desegregations, while, not surprisingly (in view of the UK flood characteristics), the duration variable has been highly aggregated. The high-level depth desegregations has warranted fine-level damage estimates with the availability of fine-level hydrological information. However, the skewed distribution of samples over depths and durations posed limitations on performing statistical tests. Some of the methods and data have subsequently been revised and updated, incorporating technological and other changes (Suleman et al 1988). Fordham et al(1994) tested the fit of logarithmic functions for the residential damage, using interview data in the UK. The study correlated damages with depths of flooding in structural damages. For content damages, depths of flooding and the proportion of recovered losses were used as explanatory variables, in addition to 'time of flooding' which was used as a dummy variable.

7.2 Research on Flood Loss in Commercial Sectors

Research on flood losses in commercial sectors is center around indirect losses, as assessment methods for direct losses are relatively straightforward. Hitherto, a limited number of studies have been carried out on commercial flood losses. Research on indirect losses is particularly meager. Until recently, industrial flood loss potentials for future floods used to be predicted on the basis on actual events. This approach used to suffer from many estimation biases, such as those raising out of the tendency to record replacement cost rather than depreciated costs. Projections of indirect losses in future floods used to be made through obtaining crude rations between direct losses and production disruptions (White 1964; Kates 1965; Smith and Greenway 1984b).

In the study of industrial losses in the Leigh Valley (USA), Kates(1965) found it methodologically difficult to obtain the relationship of production losses (indirect loss) with depths of flooding of past events. The study recognized that firm's financial losses were to be designed from national economic losses. The study also concluded that although the 'synthetic' approach is feasible, it is a highly involved task

Smith et al (1979b) addressed flood damage assessment in the Richmond River Valley in Australia based on past floods. They largely adopted the assessment techniques developed by Penning-Rowsell and Chatterton (1977). The research succeeded in constructing depth-damage curves, by which future potential damages were predicted at disaggregated levels of depths and durations. However, the approach of estimating indirect losses based on the gross trading profit/ turnover ratio method potentially led to an underestimation of true losses, as the best measures of indirect loss is value added on production lost. Additionally, the study has ignored production transfers and recoveries within the economy, which possibly led to an over estimation of indirect loss.

Taylor et al's users'(ANUFLOOD 1983) recommended that crude ratios of indirect to direct losses be used to project indirect loss in the future floods in Australia. This approach is fraught with the problem that damage characteristics and susceptibility to flood water are subject to changes in technological development in the production process. Parker and Penning-Rowsell (1981) criticized the approach saying that the 'ratios' are likely to vary 'between places and between return periods in the same place', Thus, given that indirect losses as a whole are likely to be 'highly variable' (Parker et al

1987) due to different flood conditions and diversity in activities, it is almost impossible to appropriately standardise damage ratios.

The British methods of loss assessment in commercial sectors are based on interview techniques. The Blue Manual constructed depth-damage data for industrial enterprises in the study area of lower Severn (UK) based on site survey questionnaires. However, the study acknowledged methodological weaknesses and recognized the 'need for further research into these problem's. Based on several researches, carried out mainly by the Flood Hazard Research Centre, a series of assessment methods were developed. The fundamental loss estimation method involved deriving damage estimates in hypothetical floods, based upon 'expert judgments' through interviewing industrial managers. The recent most pioneering research on loss assessments in commercial sectors is the one by Parker et al (1987), popularly known as 'Red Manual'. The study devised methods with special reference to indirect losses, the aspects the least covered in terms of research. This study also addressed flood loss potential in other sectors of the urban economy, e.g. communication, life-line outages and emergency services. The level of analysis ranged from preliminary desk-based to refined-level analysis and used area of the premise for standardization. The research overcame many problems associated with a the approaches used in past research. The study distinguished national economic losses from firms 'financial loses, through incorporating production transfers within economy. It also addressed the problem of over-estimation of direct loss potential through incorporating average remaining values. However, the estimates of damages were heavily dependent management personnel and are likely to be subject to 'personal' bias, especially where respondents have no prior flood experience.

For example, the Blue Manual pointed out the problem of using full replacement of plant and equipment in producing direct loss data in manufacturing sectors.

As for linkage effects of flooding or multiplier effects, research has been far more limited. Conventionally, benefit-cost analysis takes account of national economic losses, and it is argued that multiplier effects are likely to be counterbalancing in many economies. In an earthquake study, Ellson et al (1983) concluded that the long-term regional economic impact of earthquakes upon major urban areas in the USA may in fact be positive, compared to a 'without earthquake' case. The intensive mobilization of resources into the effected region in the process of recovery and restoration could be the major factor leading to this conclusion. Likewise, Grigg and Helweg (1975) (American Water Resources Association) argued that in the USA, 'the secondary impacts tend to be offset by secondary benefits', and thus recommended that such impacts are excluded from appraisals. There seem to have been very few empirical studies to support this conclusion, either at the micro or macro level. Exceptions are the study by North and Bibby (1990) which contemplated secondary indirect impacts (e.g. income and employment multipliers) in the Herne Bay coastal region; and the study by Penning-Rowsell et al (1992) assessed 'knock-on' effects of the flooded economy on a wider regional economy in terms of employment and income.

THE END