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CAUSES AND IMPACTS OF FLOOD-2000 IN THE BORDER DISTRICTS OF THE SOUTHWEST REGION AND POSSIBLE MITIGATION MEASURES: A CASE STUDY

REPORT NUMBER – RES-1 (2001)

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RIVER RESEARCH INSTITUTE

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PREFACE

The occurrence of flood is nothing new in context of Bangladesh. But the late monsoon flood of 2000 in the border districts of Southwest Region (SWR) drew special attention of all not only for its severity but also for its being very abnormal and unusual in nature. There was no example of occurrence of such a flood in the living memory of the people of that region. The sudden onrush of floodwater from across the border left no time for the people to take any defense measure for the protection of their lives and properties. All standing crops had been damaged and most of the homesteads had been damaged fully or partially. What was more alarming, the flood gave serious jolt to the prevailing socio-economic relations to the detriment of the landless people and small and marginal farmers.

River Research Institute (RRI) took up a study program to find out causes and impacts of the flood and to suggest some possible mitigation measures as per decision of the 17 th meeting of the Board of Governors (BoG) of RRI. Accordingly a five-member study team with a co-ordinator was formed to carry out a case study. The study team collected and analyzed the available information within limited time period and reported their findings with some recommendations. The findings of this study will provide comprehensive information on the various facets of flood disaster in the study area.

The researchers are very much grateful to the officials of the different concerned agencies particularly of BWDB in the study area for providing necessary information and to the respondents who participated spontaneously in the interview. If the study proves useful to policy makers and planners, the efforts of the research team would be considered fruitful.

11/4/01

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

Introduction

Introduction

Bangladesh has been facing recurrent pattern of floods during monsoon and scarcity of water during dry season since time immemorial. The people of Bangladesh have learnt to make necessary adjustments to minimize the effects of floods on their lives and the ecology. But there are years when floods exceed the normal limits thereby upsetting the balance between man and nature. The situation becomes worse if the flood is of very unusual in nature. Such was the very abnormal late monsoon flood that had been experienced by the people of the Southwest Region (SWR) of Bangladesh in the year 2000. The area is generally considered as a flood-free region because it did not face a flood of such a magnitude in the last 55 years or so. In the absence of advance information everyone was taken by surprise during the onslaught of such abnormal flood. The flood was caused by sudden onrush of water from West Bengal in India and people had little time to evacuate with their valuables. The severity of the flood took a heavy toll in human and animal lives damaging homesteads, crops and other properties on an extensive scale. The unprecedentedly long duration of the flood had added to the sufferings of the people. A vast area of Meherpur, Chuadanga, Jessore and Satkhira districts were gone under water. Near about 2.5 million people were affected.

The main aspects of this flood are that it occurred in such a period during which no flood occurs in Bangladesh and the affected region is generally considered as a flood free area. In some cases the severity of this flood exceeded all past records. In this context the reasons behind the occurrence of this flood have become a matter of great concern among the concerned agencies, newspapers and politicians. A joint Taskforce Committee was constituted on October 12, 2000 by Ministry of Water Resources to study the causes of flood, probable flood mitigation measures and probable options for evacuation of floodwaters hastily. The Taskforce Committee submitted their study report on November 6, 2000. The report contains a number of suggestions for different flood mitigation measures on short, medium and long-term basis. Besides a number of papers have been published in different newspapers, journals etc. on various aspects of the flood. Some of the writers laid stress on the need for ascertainment of the socio-economic and environmental impacts of the flood.

River Research Institute (RRI) had taken up the study on " Causes and Impacts of Flood-2000 in the Border Districts of the Southwest Region and Possible Mitigation Measures: A Case Study" as per decision made in the 17th meeting of BoG. A five-member team was formed and given with the responsibility to carry out the study. The findings of the study are based on available information. The sources of information are field visit, questionnaire survey, discussions with the concerned officials in the flood-affected region and hydrological and morphological data of some rivers of the region. The random sampling technique was followed in the questionnaire survey. The questionnaire was prepared to assess the household socio-economic characteristics of the flood affected region, socio-economic impacts of the flood and awareness, preparedness and response of the flood affected people to cope with the disaster caused by the recent and likely future

floods. The study team also made attempt to understand the social problems and conflicts that had arisen out of the flood.

It is revealed from the study that the long duration of flood resulted from the lack of adequate drainage facilities. The polder areas of Satkhira district are subjected to water logging during heavy rainfall and it was seen that water remained stagnant in those areas when flood water was drained off from most of the affected region. In addition to the unplanned constructions of roads, bridges and culverts many other obstacles to the draining away of the floodwater were reported by the local people and concerned officials. Removal of some of such obstacles may result in social conflicts. In some localities people managed to protect their lives and properties or to reduce the extent of damage through united endeavor by obstructing the entrance of flood water or by releasing water through cutting existing roads or embankments. In some cases such actions were proved to be detrimental to the neighboring localities. It is revealed from the study that most of the affected people are poor and most of the damaged homesteads are made of raw materials. Therefore, rehabilitation of the flood stricken population was of utmost importance. The lessons from this flood need to be assimilated and reviewed in order to shape policies to find a long-term solution to similar floods apprehended in the future.

Objectives of the study

The specific objectives of the study are:

- To find out the causes of flood
- To find out the causes of drainage congestion
- To assess the socio-economic impacts of the flood
- To address the awareness, preparedness, adjustment measures and responses of the flood-affected people to the recent and likely future floods
- To report the condition of the rivers in the flood affected region
- To recommend mitigation measures for likely future floods.

Area, Location and physiographic condition of the flood affected region

The flood-affected region includes parts of Meherpur, Chuadanga, Kushtia, Jhenaidah, Jessore and Satkhira districts bordering with West Bengal in India. It is located between 22 ^{0}27' and 23 ^{0}40' north latitude and between 88 ^{0}25' and 89 ^{0}20' east longitudes. The region represents the typical physiographic characteristics of moribund Gangetic delta. The average annual rainfall is about 170 cm. The area is generally low-lying with gentle slopes with few elevations exceeding 10 m above sea level. While the northern part is characterized by a rolling topography which drops at a slope of 1:7500 to about 6 m above sea level along a line through Jessore and Faridpur, the topography south of this line becomes much flatter and the number of beels and depressions increases. The tidal limit is approximately co-incident with the 6 m contour. In most of the areas of the region the average inundation depths range from 30 to 90 cm. In rest of the areas the average inundation depths vary between 0 and 30 cm. The inundation in the region generally results from the local heavy rainfall and over bank spill of the rivers. However, some

areas south of Satkhira town suffer from tidal flooding. The rivers flowing through this region are either dead or dying.

River system of the Southwest region of Bangladesh

The river system of the Southwest Region (SWR) of Bangladesh has been shown in Figure 1. It can be seen from the figure that some of the rivers namely the Mathabhanga, the Bhairab and the Gorai are distributaries of the Ganges and some others namely the Nabaganga, the Kobadak, the Beghabati etc. take off from the Ganges distributaries at different places.

Mathabhanga:

The river Mathabhanga is a distributary of the Ganges.It takes off from the Ganges at Jalangir, in the district of Murshidabad, West Bengal, India. It enters Bangladesh at Insufnagar in the district of Kushtia. Then it flows towards the south through Daulatpur, Bheramara, Alamdanga, Chuadanga and Meherpur. It again enters Indian Territory near Chuadanga and finally discharges into the Bhagirathi after joining the river Churna in India. Within Bangladesh territory its length is about 130 km. Kumar, Chitra, Nabaganga and Kobadak are its main distributaries. The offtake position of the river is very unstable.

Gorai:

The river Gorai is an important distributary of the Ganges. It takes off from the river Ganges at Talbaria, 19 km downstream of Hardinge Bridge. It flows through the district of Kushtia and enters into the district of Jhenaidah at Goneshpur. Then it travels along the border of Kushtia-Jhinaidah and enters into Rajbari district at Chadat. From Rajbari it follows the borderline of Faridpur-Magura as Gorai-Madhumati to enter the district of Bagerhat . Then it flows through the district of Barishal and falls into the Bay of Bengal at Haringhata. Gorai is a long and wide river. The total length of the river from its source to Haringhata is about 372km of which 89km from its source upto Mohammadpur in the district of Magura is named as the Gorai; therefrom upto 137 km downstream is named as the Modhumati and last 146 km upto Haringhata is named as the Baleshwar. Kumar, Kaliganga, Dakua, Burigorai, Barishal etc. are its main distributaries and Chandana is the tributary of the Gorai. The river Gorai is a very old river and its former name was Gouri. The water level gauging stations of the river are at Gorai Railway Bridge, Kamarkhali, Nazirpur and Pirozpur. As the river flows through the district of Kushtia, Jessore, Faridpur, Khulna, Barishal and Patuakhali, agricultural development of this region is largely dependent on the use of the water of this river. Due to large-scale siltation at the Gorai mouth the offtake of the Gorai was completely disconnected from the Ganges particularly in the dry season. Due to reduced dry season flow of the Gorai the environmental quality of the Southwest region was at stake. At present government has taken up Gorai River Restoration Project to ensure minimum dry season flow of the Gorai.

Nabaganga:

The Nabaganga is one of the distributaries of the river Mathabhanga. It takes off from the Mathabhanga near Chuadanga town and flows towards the southeast upto Magura. Then it changes its course towards south and travels through Kalachandpur, Lohagara and Kalia Upazila and joins the Chitra at Gazirhat. Therefrom the combined flow of the Nabaganga and the Chitra joins the Bhairab at Daulatpur, Khulna. The total length of the river is about 230 km. The Nabaganga is a meandering river. Its average width is 200m. There are water-gauging stations at Magura and Jhenaidah in this river.

Chitra:

The source of the Chitra is at the low-lying area in between Chuadanga and Darshana. It travels towards southeast through Darshana, Shalikha and Kalia Upazila and joins the Nabaganga at Gazirhat. After traversing a distance of 130 km this combined flow falls to the river Bhairab at Daulatpur Khulna. It is not navigable from its source upto Shalikha but therefrom upto Gazirhat it is tidal and navigable. The tidal range is about 1 m.

Bhairab:

The Bhairab is the longest river of the Greater Jessore-Khulna region. It is a distributary of the Ganges and its offtake is right at the opposite bank where the Srutakirti meets the river Ganges at Maldaha, West Bengal. After travelling quite a distance the Bhairab meets the river Jalongir, another southward flowing distributary of the Ganges. After getting separated from the conflux the Bhairab meets the river Mathabhanga in the district of Meherpur. Then the Bhairab again gets separated from the Mathabhanga near Dharshana railway station and flows eastward upto Kotchandpur of Jhenaidha district. Therefrom it flows southward.

Kobadak:

It takes off from the Mathabhanga near Darshana. It then travels through Chowgacha, Jhikargacha, Chakla, Jibannagar, Kotchandpur, Sagardari, Tala, Kupilmani, Chandkhali, Bedkashi etc. and meets the Kholpetua in Sundarbans. The river first meets the Bhadra and the Bhairab near Taherpur and the Marichap near Debuduar in its course. The combined flow meets the river Kachua near Jaigirmahal and then near Bedkashi it meets the river Kholpetua. The combined flow of the Kobadak and the Kholpetua named as Arpangsia meets the river Malanch and finally falls into the Bay of Bengal.

Betna:

The source of the Betna is at the northwest region of Jessore. The river flows towards the south through Navaron of Sarsa Upazila. It then enters into the district of Khulna through Kalaroa Upazila. It meets the Marichap river near Chapra. Its total length is about 192km and average width is about 125m. In the dry season there remains no perennial source of the river and the river mainly drains the water that seeps from local beels and haors.

Bhadra:

The river takes off from the Kobadak near Jhikargacha in the district of Jessore. But now its offtake gets separated from the Kobadak. It flows by the side of Keshabpur Upazila of Jessore district upto 50 km. After crossing Keshabpur Upazila it travels about 8 km along the Khulna-Jessore border and meets the river Harihar. The river then enters the district of Khulna named as Bhadra. After passing through Dakop Upazila it meets the river Shibsha, 8 km downstream of Nalian.

Beghabati:

The river Beghabati is a distributary of the river Mathabhanga. It takes off from the Mathabhanga near Chuadanga town and travels through Bishoykhali 16 km south of Jhenaidah town and falls into the Bhaduri beel. Therefrom it flows eastward and meets Alamkhali khal which originates from the Nabaganga and travels upto Arpara. Then it meets the Chitra near Shalikha and the combined flow traverses towards Narail named as Chitra. The total length of this river is about 72 km from its source to Shalikha.

CHAPTER TWO

Flood in 2000

Beginning of the flood

In the Southwest region of Bangladesh more than 450 mm rainfall occurred on September 18 –24, 2000 (BWDB report on flood). The average rainfall in the region for the month of September is 250 mm (BWDB report on flood). In fact heavy rainfall started to occur throughout the country on September 16. As a result almost all low-lying lands went under water. In this period no tidal bore occurred in the coastal areas of this region. The sudden onrush of flood water from across the border first occurred in the afternoon on September 22 and several unions of Mujibnagar Upazila of Meherpur district and Damurhuda Upazila of Chuadanga district had gone under 1.5 to 2m water depth. The floodwater entered Bangladesh through the Sharwashati khal situated near Bagwan union bordering with West Bengal in India. This flood spill came from the overflowing Kodla and Ichamati rivers and entered Kobadak and Betna rivers in Meherpur, Mahespur and Sarsa areas. The district of Satkhira witnessed the onslaught of flood first on September 27 when floodwater entered Chandanpur of Kalaroa Upazila bordering with India. The floodwater engulfed the whole of Kalaroa Upazila within October 2. The flood infiltration then occurred when floodwater of the border river Sonai forced a breach in the embankment of Polder-1 at Khaitala 2 km north of Baikari border. Another source of spill was at Keragachi just north of Polder-1.

Extent of the flood

The flood-affected region of Greater Kushtia district has been shown in Figure 2. Flood water that entered into Mujibnagar Upazila of Meherpur district first engulfed most of the areas of Meherpur Sadar Upazila. By the next day floodwater entered into Chuadanga and Jhenaidah district through Damurhuda and Maheshpur Upazila respectively. The fully flood affected Upazilas of Chuadanga district are Damurhuda and Jibannagar and partially flood affected Upazilas are Chuadanga Sadar and Alamdanga. In Jhenaidah district the extent of the flood was upto Kotchandpur Upazila. In Jessore district the areas of Chowgacha, Jhikargacha and Sarsa Upazila first began to witness the onrush of floodwater on September 24. From that date more and more areas were seen to be engulfed by the floodwater. On September 28 floodwater started to enter into Keshabpur and Manirampur Upazila by overtopping the Jessore-Benapole highway. About 16.5 km of the highway was seen to be submerged by the floodwater at Sarsa, Navaron and Jhikargacha areas. The flood affected areas of Jessore district appear in Figure 3. According to a report of BWDB, Jessore (10.10.2000) under Jessore district 325 sq. km area of Sarsa Upazila, 210 sq.km area of Jhikargacha Upazila and 72 sq. km area of Maniampur Upazila were affected by the flood.

In Satkhira district 12 (twelve) unions of Kalaroa Upazila went under water on September 28. From that date floodwater began to engulf new areas everyday and within October 2 almost all of the areas under Kalaroa Upazila became flooded. Afterwards onslaught of flood started to occur on October 2 by breaching the embankment of polder-1 and heavy onrush of floodwater soon engulfed many areas of Sadar and Debhata Upazila. On October 6 flood water entered into Satkhira town after flooding rest of the areas of the

Sadar Upazila. Floodwater lastly entered Tala and Assasuni Upazila by breaching Herkata embankment at Tala. A map of the flood affected Satkhira district has been shown in Figure 4.

Damage done by the flood

The flood was unprecedented and unusual. It is reported that the region did not witness any flood of such magnitude for long 55 years. It is therefore natural that the people were not at all ready to face such a flood. Moreover, they did not get any prior warning. The drainage system was poor and the rivers and canals got silted up losing in their drainage capacity. All these facts made the flood devastating one in terms of loss of homesteads, crops, trees, livestocks, fishes and other valuable properties. Almost all except the brick-built houses damaged fully or partially in the flood-affected region. It is known from the unofficial sources that at least 38 people were died. The reasons of death are known to be water borne diseases, snake biting and drowning. Floodwater submerged thousands of acres of agricultural fields causing severe damage to the Aman rice and Rabi crops. The stagnation of floodwater for longer time made the situation worse. Many of the flood-affected families lost all or some of their livestocks. Many of them had little or no time to move to safer places with their livestocks. For the same reason they also had to lose all of their portable belongings. Floodwater also caused damage to the trees, vegetable gardens, and loss of fishes from the ponds. During the occurrence of flood innumerable infrastructures namely schools, colleges, government and private establishments, roads, bridges and culverts had gone fully or partially under water. In many areas of the flood affected region drinking water crisis resulted from the damage of tubewells by the flood. It is reported that the flood in Satkhira district damaged about 23,000 tubewells. A serious disruption in the communication network caused due to the damage of both unmetalled and macadamized roads in many areas. In different Upazilas of Jessore district about 70 km macadamized road and 785 km unmetalled road had been damaged (Report on flood damage, BWDB, Jessore). In the flood-affected areas of Satkhira district about 155 km macadamized road and 1709 km unmetalled road had been subjected to full of partial damage (Weekly Chinta, December 15). Many bridges, culverts and water development infrastructures namely regulators, ring dikes etc, also damaged fully or partially. In many areas people cut roads, closures and ring dikes to facilitate quick drainage of floodwater.

CHAPTER THREE

Causes of the flood and delayed drainage

Since time immemorial Bangladesh has been facing recurrent pattern of floods during monsoon. Although inundation is a recurring natural phenomenon the country has seen several extreme flood events in recent times during which the extent and duration of flooding has been far greater than normal thereby upsetting the balance between man and nature. Miseries and sufferings know no bound during such catastrophe. The late monsoon flood of September and October of 2000 was such an extreme event. However, the character of this flood is quite different from some other extreme events that the country experienced in the recent past. This is firstly because the flood occurred at such a period when nobody expects flood. Secondly, the flood-affected region is generally considered as a flood free area that did not witness such a flood for long 55 years. The causes for the occurrence of such an unusual extreme flood event have drawn the attention of different agencies. Based on the available information the causes of the recent flood and also the reasons for delayed drainage is discussed below.

Excessive rainfall

The average annual rainfall in the flood affected southwest region of Bangladesh is about 1700 mm (Bangladesh Meteorological Department,1994). The average rainfall for the month of September in the region is 250 mm. During the period September 18-24 the recorded rainfall was 450 mm (BWDB, Jessore report on flood, October 11). At the same time it is reported that about 1700 mm rainfall occurred in some parts of West Bengal within a span of seven days. The reason behind the occurrence of such exceptionally heavy rainfall was the presence of low pressure system on September 17-18 over Bihar and adjoining Gangetic West Bengal which became a well marked low over Gangetic West Bengal and neighborhood on September 19. Due to heavy rainfall most of the beels and other depressions of the flood-affected region were filled with water. Flood condition also arose in West Bengal due to excessive rainfall and influx of water from upper riparian states.

Onrush of water from West Bengal

The floodwater came into Southwest region of Bangladesh from the overflowing border rivers of Ichamati, Kodla and Sonai. These rivers on the other hand received flood spills from the Bhagirati-Hooghly system. It is mentioned in the previous section that West Bengal, a state of India, witnessed severe flood due to heavy rainfall. The river Bhagirati-Hooghly has a number of tributaries. Damodar, Kopai, Ajay, Khari and Mayurakhshi are some of the tributaries of the Bhagirati-Hooghly. There are several multipurpose large dams in the Mayurakhshi and the Damodar valley areas. During monsoon these reservoirs are generally kept full so that the stored water could be used for irrigation during dry period. Naturally these reservoirs did not have any space to accommodate excess water in the month of September 2000. As a result when unexpected heavy rainfall started to occur the concerned authorities for reservoir operation were compelled to release large volume of water to avoid the risk of failure of the dams. It is reported that on September 21 the

release from the dams in the Mayurakhshi and Damodar basin was over 11,000 cumec. At the downstream of the reservoirs the rivers were not in a position to carry such large volume of flow that was generated from the dam release as well as heavy local rainfall. This led the river water to infiltrate into the adjoining areas by breaching or overtopping existing dikes or roads at many places. The inflow of water into the river Bhagirati-Hooghly from its parent river and tributaries far exceeded its carrying capacity. Consequently flood spill from the river Bhagirati-Hooghly occurred by breaching or overtopping all barriers and obstructions in the floodplains. The floodwater then flowed towards Bangladesh as the natural topography of West Bengal allows drainage from the northwest to the southeast direction. When the flood flow reached the border rivers of Bangladesh flood spill started to occur from these rivers because of their insufficient capacity to convey such huge volume of water.

Flood spill from the Ganges

The river Ganges was flowing above the danger level for most part of September. The river started spilling into the Bhairab and the Mathabhanga from September 17. These rivers on the other hand spilled into their distributaries. The fact that the river Bhairab, Mathabhanga and their distributaries were flowing above their respective danger level is revealed from the recorded water level of these rivers at different gauging stations during September 18-30. It can also be seen that the recorded water level at that period of 2000 is far higher than the water levels recorded at the same period of the previous years. The following table presents the mean daily water levels of the Bhairab and the Kobadak for the period September 18-30 recorded at water gauging station kathuli and Jhikargacha respectively.

Table: 3.1 : Mean daily water level of the Bhairab and the Kobadak in different years for the period September 18-30

River	Gauging Station	Mean daily water level (m PWD) for the period September 18-30)						
		1982	1983	1986	1988	1992	1994	2000
Bhairab	32 Kathuli	12.27	-	12.91	-	-	11.88	14.21
Kobadak	162 Jhikargacha	-	2.64	-	2.56	2.22	2.30	4.78

It is clear from the above information that the rivers were flowing at spate during September 18-30 due to flood spill from the Ganges. At the gauging station Hatboalia the water level of the Mathabhanga was recorded as 13.95 m PWD on September 25, 2000. The recorded water level on the same date of 1999 was 13.20 m PWD.

Breach at the ring dike

Flood occurred in the protected polder areas of Satkhira district by breaching the ring dikes. Three breaches occurred at the ring dike within 1 km span near Baikari of Satkhira Sader Upazila that allowed infiltration of floodwater from across the border. It is reported by the local people that the high stage of water at the Indian side of the dike caused the breach. However, no incidence of overtopping is reported. The crest level of the dike at

Baikari is 4.75 m PWD. It appears that the long duration of high stage weakened the dike and eventually caused the breaches.

Reduction in the transport capacity of the rivers and canals:

The major drainage routes for the floodwater of Meherpur and Chuadanga district are the upper Bhairab, the Mathabhanga and the Ichamati. These rivers discharge into the lower Bhairab, the Kobadak, the Kumar and the Betna. The floodwater of Jessore district is generally drained by the Ichamati, the Betna, the Kodla and the Kobadak. The border river Ichamati is reported to have undergone major siltation. Large-scale siltation is reported to have occurred in the Betna and the Kobadak due to reduced fresh water flow. Moreover encroachment upon floodplains and watercourses either for fish cultivation or for agriculture resulted in reduction in the carrying capacity of the rivers. In the polder areas of Satkhira district the restriction of tidal over bank spill caused the deposition of sediments at the upper end of the confined channels. Marichap, Bhakal, Satkhira and many other tidal channels have lost their drainage capacity due to deposition of sediment.

Unplanned floodplain development

The government agencies and the general public developed flood plains of the rivers in an unplanned and uncontrolled manner. In the polder areas there was a false sense of security in floodplain development. The infrastructures constructed in the floodplains acted as barriers to the flood flow. Such unplanned developments also served to maximize flood damages.

Poor drainage facilities

In the flood affected region infrastructure development was done without following any guideline for drainage management. There was no co-ordination in the development activities of the different agencies working for infrastructure development The road bridges and culverts were not designed to match flow conditions. During flood the openings of the bridges and culverts were found unable to pass flood discharge. Many bridges and culverts are reported to have collapsed due to non-fulfillment of basic design requirements. In polder areas normal drainage was impeded due to siltation in the drainage channels of different sluices. Moreover, sluices and culverts were not of enough capacity to drain huge volume of floodwater that entered into the polder areas. According to BWDB, Jessore report on flood a vast area of Sarsa Upazila of Jessore district is subjected to drainage congestion every year due to onrush of water from across the border. The beels within the coastal polder areas undergo waterlogging during heavy rainfall.

Construction of shrimp enclosures

After the implementation of the coastal Embankment Project in the sixties the polder areas of Satkhira district did not witness any flood. There was no attempt on the part of the concerned authority to maintain the natural watercourses. This official apathy encouraged greedy people to encroach upon natural watercourses and floodplains to construct shrimp enclosures. These shrimp enclosures proved to be an obstacle to the

draining away of the floodwater, and are likely to cause permanent drainage congestion in many areas. It is known from the local people that a handful of very rich group of people is involved in shrimp farming. It is also known that during flood the shrimp cultivators obstructed the floodwater to move downstream towards their Ghers by closing the bridges and culverts and constructing earth embankments The flood affected people wanted to remove the obstructions and to cut the illegally constructed embankments to allow the floodwater to drain away. The shrimp farmers did not permit them to do so. It resulted in tremendous social dissatisfaction that was reflected in the wall writings against the shrimp farmers where they and their associates were termed as 'enemy of the flood affected people'.

High tide level

During the flood the presence of the spring tide in the Bay of Bengal did not allow the floodwater to drain out into the Bay of Bengal. It aggravated the flood situation in West Bengal. It is reported that the spring tide rose to about 5 (five) meters in the south of Calcutta city

CHAPTER FOUR

A profile of the case study area

In order to address the socio-economic characteristics of the flood affected region and to assess the socio-economic impacts of the flood six Upazilas of different flood affected districts were selected for questionnaire survey. These Upazilas are Kalaroa, Debhata, Satkhira Sadar, Jibannagar and Mujibnagar. Random sampling technique was followed in the questionnaire survey. A number of 300 people were interviewed.

In the study area Sarsa is found to be better than any other Upzila in terms of literacy rate, commerce and economic status of the people. Agriculture is the main source of occupation in the study area. Most of the people have access to the tube well water. However, water extracted by most of the tubewells was found to be arsenic contaminated. In some cases iron content in the tube well water is reported to be high. The flood 2000 caused severe damage to the lives and properties in the study area. Table 4.1 presents characteristics of the different Upzilas in the study area.

Vulnerability

The average annual inundation depths vary between 0 and 90 cm in the study area. The inundation generally results from the heavy local rainfall and over bank spills of the river. Debhata and Satkhira Sadar Upazila is protected from tidal flooding by the ring dikes. However, due to lack of adequate drainage facilities and maintenance of natural water courses drainage congestion occurs in many areas. The study area experienced a high flood more than 55 years ago. After that till September 2000, there is no report of occurrence of such a flood. Generally minor flooding occurs due to heavy rainfall, over bank spills of the rivers and combination of the both that inundates flood plains and adjacent low-lying areas. The areas within the Polders can be considered as safe because these areas are protected from flooding by the ring dikes. On the basis of the above facts the following conclusions can be made regarding the vulnerability of the study area to the flooding;

- In the study area most of the areas outside of the Polders can be considered as safe unless an extreme event like that of September, 2000 occurs
- The areas within the Polders are protected from flooding and thereby can be considered as safe areas
- As the rivers of the study area are undergoing major siltation due to lack of fresh water flow and thereby losing in their transport capacity, more and more areas in the unprotected region are likely to be vulnerable to the flooding.
- The protected areas will remain no more safe if breach occurs at the ring dikes due to high flood stage as was happened during the recent flood.

Household Characteristics

Household characteristics of the study area are shown in Table 4.2. Most of the household heads are males. Average age of the household age is 41 years with a standard deviation of 12.9. Larger household size and high male to female ratio are two other notable characteristics in the study area. The average age of household heads (41 years) indicates

Table 4.1 : Characteristics of the Upazilas of the study area

Upazilas	Characteristics
Kalaroa, Satkhira	• Generally a flood free area • Low literacy rate • Fertile land. Arsenic contaminated drinking water • Majority of the inhabitants are poor • Poor drainage facilities • Lacks infrastructure development
Debhata, Satkhira	• Generally affected by low flooding • Low literacy rate • Arsenic contaminated drinking water • Protected by flood control embankment • Main source of income is fish cultivation and agriculture • Inadequate drainage facilities • Lacks infrastructure development
Satkhira Sadar, Satkhira	• Generally affected by low flooding • Low literacy rate • Relatively good drinking water facilities • Fertile land • Majority of the inhabitants are poor • Protected by flood control embankment.
Sarsa, Jessore	• Generally a flood free area • Relatively high literacy rate • Arsenic contaminated drinking water • Main sources of income are agriculture and business • Business is relatively good • Poor drainage facilities • Fertile land • Not protected by flood control embankment • Middle class economic status of the people.
Mujibnagar, Meherpur	• Generally affected by low flooding • Relatively high literacy rate • Main source of income is agriculture • Better drinking water facilities • Fertile land • Better infrastructure development • Better communication facilities • Inhabitants mostly poor • Undeveloped slums
Jibannagar, Chuadanga	• Generally a flood free area • High literacy rate • Better drinking water facilities • Lacks infrastructure development • Poor drainage facilities • Fertile land • Inhabitants mostly poor • Not protected by flood control embankment • Main source of income is agriculture.

Table 4.2 : Respondents Profile

Household Characteristics	Respondents	Standard deviation
Average age (years)	41	12.9
Literacy rate (%)	68	
Household size	7	4.9
Household sex ratio (male/female)	1.28	0.594
Household dependent to income earning member ratio	3.65	1.35
Affected by flood 2000 (%)	98	
Landless to land owning household ratio	0.32	

that households are predominantly headed by prime working age members. The total average household size is found to be as 7 with a standard deviation of 4.9. The corresponding national figure for household size is 5.6 (BBS 1993a, P.38) which is less than the study area figure. The male to female ratio in the study area is 1.28 which is significantly higher than the national average figure of 1.06 (BBS,1993b; 75 and BBS, 1993a; 38). The larger households size and higher households sex ratio in the study area compared to national figures may be an indication of the following;

- greater dependence on agriculture requiring more male workers
- higher female mortality due to less attention to health care of female members
- greater need of male members for security reason

The average household dependent to income earning member ratio in the study area is 3.65 with a standard deviation of 1.35. About 68 percent of the households are literate. Among the literate household 63.6% of respondents are found to be better educated (secondary and above). Of the total respondents, 24 % are landless. 98 % of the total respondents reported that they had suffered loss due to recent flood.

Housing Characteristics

The construction material of the roof defines the housing characteristics of the study area. The percentage distribution of roof construction material of the dwelling houses of the respondents in rural and urban areas appears in Table 4.3. It can be seen from the table that construction material of roof of most of the dwelling households of the study area is straw/bamboo and tiles/CI sheet.

Table 4.3: Construction Characteristics of the households

Locality	Materiel of Roof (%)			Row Total
	Straw/Bamboo	Tiles/C.I.sheets	Cement	
Rural	44	52	4	100
Urban	10	60	30	100
Study area	37	54	9	100

Occupation

The occupational involvement of the household heads is shown in Table 4.4. It can be seen that agriculture was mentioned as the primary occupation of the household heads by 62 % of the respondents. Other notable primary occupations are; business (15%), Salaried jobs (11%) and daily labor (8%). Of the total respondents, 75% have no secondary source of income, 20% have an additional source of income and 5 % have two other income sources in addition to the primary one. The secondary occupations of the household heads whose primary occupation is agriculture are; retail business (25%), daily labor (7%) and fishing (3%). It is to be noted here that about 9 % of the household heads whose primary occupations are other than agriculture are involved in any other secondary occupation.

Table 4.4 : Occupational involvement of the household heads

Types of Occupation	Percentage of respondents
1. Agriculture	62
2. Day labour	8
3. Business	15
4. Fishing	2
5. Driving	2
6. Salaried job	11

It is clear from the occupational data that households in the study are by and large dependents on agriculture; but retail business and salaried jobs are also important means of livelihood. Involvement of the households with Agriculture as the primary occupation in secondary activities can be seen as a contingency measure that the households adopt for reducing dependency on agriculture. Examination of the relationship between education and households occupation shows that among households heads whose primary occupation is farming 33% are illiterate, 33% have primary level education and 34% are better educated. In contrast, in the business and salaried jobs the illiterates account for only 10%. However, about 80% of those who are involve in fishing, driving and daily labour are illiterate. It is important to note here that only 10% of the illiterate household heads with primary occupation agriculture are involved in secondary activities. This suggests that education and skills allow people to diversify income-earning opportunities.

Land ownership

Land ownership pattern in the study area is shown in Table 4.5. About 24% of the respondents are land less in the study area. Land owning and landless status of households in different Upazilas of the study area is shown in table 5.6. It can be seen that the concentration of landless households is higher in Debhata and Mujibnagar Upazila. The percentage of households owning land in the category of 1.01 to 2 acres is found to be the highest (34%), which is followed by the households owning land in the category of 3.01 to 4 acres (13%). The households having land above 7.5 acres is 4%. Of the landowning households in the categories of upto 0.5 acre, 0.51-1.00 acre and 1.01-2 acres, 50% are found to be sharing-in some amount of land for cultivation, however, 20% are sharing-out some amount or all of their land and 30% are neither sharing-in nor

Table 4.5 : Land ownership pattern in the study area.

Size of land ownership (acre)	Percentage of households
Landless	24
Up to 0.50	6
0.51-1.00	4
1.01-2.00	34
2.01-3.00	5
3.01-4.00	13
4.01-5.00	4
5.01-7.50	6
Above-7.50	4

sharing-out any of their land. It is found that among these categories the primary occupation of the households who are sharing-out their land is other than agriculture. Of the households having land more than 3 (three) acres, 55% are found to be sharing-out some of their land, 18% are sharing-in land and 27% are not involved in sharing-in or sharing- out any land. It is found that agriculture dependent households with large household size are mainly sharing-in land despite having land more than 3 (three) acres of their own.

Economic status

From the reported yearly income and expenditure by the respondents the economic status of households in different Upazilas and the study area as a whole is shown in Table 4.6. It can be seen from the table that in the study area the average yearly income and expenditure of households are Tk. 51,350 and Tk. 51,830 respectively. It means Tk 480 negative savings of the households as a whole. Regarding economic status of different Upazilas, Sarsa is found to be better off than the other Upazilas in terms of both average yearly income and net savings. The lowest yearly average income of the households is found in Mujibnagar. To some surprise the income-expenditure of the households of Mujibnagar shows a net yearly positive savings. It is only reflection of the low living standard of the households.

Table 4.6 : Economic status of the Households in different Upazilas of the study area

Upazilas	Average yearly income (Tk.)	Average yearly expenditure (Tk.)	Net Savings (Tk.)
Sarsa, Jessore	78000	74000	+4000
Satkhira Sadar, Satkhira	48000	50000	-2000
Debhata, Satkhira	44000	45000	-1000
Kalaroa, Satkhira	42000	44000	-2000
Mujibnagar, Meherpur	39000	38000	+1000
Chuadanga, Jibannagar	65000	67000	-2000
Study area	51350	51830	-480

It is to be noted here that regarding net yearly savings 45% of the respondents reported zero savings of their households. Of the total respondents who have reported household yearly income-expenditure difference, 40% are found to be involved in nonfarm activities as primary occupation. Mostly respondents involved in salaried jobs and business reported net positive savings whereas those involved in fishing, driving etc. reported net negative savings.

Water supply

In the study area most of the people have access to the tubewell water facility. However, the problem of arsenic contamination is reported by about 70% of the respondents. Some of the others do not have any idea about the quality of their drinking water as no water quality test is done yet. Some respondents of Debhata and Sarsa Upazila reported the problem of high iron content in the tubewell water.

Health

As to the availability of health care services and the most common types of treatments applied, the figures in the following table show the severe lack of modern medical services and the major role of quack doctors in the study area.

Table 4.7: Frequency of different types of treatments

Types of treatments	Percentages
Quack doctor	85
Trained / MBBS or hospital/clinic	15
Indigenous (tabiz /hakim)	0
No treatment	0
Total	100

Cropping pattern and cropping intensity

Agriculture is the major source of income in the study area. The types of crops that are grown in the study area include paddy, wheat, pulses, cash crops such as jute, sugarcane and vegetables. Paddy is the main crop in the study area. Wheat production is now on the increase. Jute is sown in March and harvested in June/July. Rabi crops such as wheat, mustard, potatoes etc. are sown in November/December and harvested in April/May. Sugarcane is also grown in some areas. Among fruit plantations there are banana and papaya. Cropping pattern generally followed by the farmers paddy, jute and locally Rabi crops.

The cropping intensity (%) in different Upazilas and in the study area as a whole is shown in Table 4.8. It can be seen from the table that the cropping intensity in the study area as a whole is 196%. Among different Upazilas cropping intensity in Mujibnagar is the highest (225%) and in Sarsa is the lowest (171%).

Table 4.8 : Cropping intensity in different Upazilas of the study area

Upazilas	Cropping intensity (%)
Sarsa, Jessore	171
Satkhira Sadar, Satkhira	188
Debhata, Satkhira	200
Kalaroa, Satkhira	200
Mujibnagar, Meherpur	225
Jibannagar, Chuadanga	200
Study area	196

CHAPTER FIVE

Socio-economic impacts of the flood

Household economic loss

In the study area 98% of the total respondents reported that they had suffered household economic loss in varying degree. The lost properties include livestock, homesteads, crops, trees and other valuables. Table 5.1 shows the distribution of types of loss suffered by the homesteads in the study area. It can be seen from the table that most of the respondents have lost their homesteads. It is to be noted here that in reporting the extent of loss of homesteads both fully and partially damaged homesteads have been considered. The loss

Table 5.1 : Distribution of types of loss suffered by the households in the study area

Types of loss	Percentage of respondents
Only livestock (cattle, goat, poultry)	7
Homesteads and livestock	9
Only crops	7
Homesteads and crops	17
Homesteads, crops, fishes and trees	60

of homesteads is followed by the loss of crops. It is found that 60% of the respondents are most sufferers as they had to lose homesteads, crops, fishes and trees together. Of the total respondents, 16% have lost their livestock. It is reported that the loss of livestock occurred because of lack of enough time to shift them to safer places. In the case of fish, respondents reported that because of submerging of fishponds fishes reared were lost in floodwater.

Employment and wage rate

In the study area employment problem as a consequence of flood is reported by about 90% of the total respondents. This problem resulted mainly from the disruption of economic activities due to flood. Trade and commerce almost came to a halt due to disruption of communication. The flood damage of crops dampened the wage rate. Moreover, about 30% of the households having land of their own had to keep all or some of their land fallow.The reasons for keeping land fallow have been shown in Table 5.2. It can be seen from the table that lack of capital to buy seedlings (43%) was the main reason for keeping the land fallow. It is followed by waterlogging (37%). Crisis of seedlings (13%) was also reported as a reason for keeping the land fallow . It is to be mentioned here that most of the respondents who have reported waterlogging as the reason for keeping the plots fallow are from Satkhira district. It reveals the facts that in some areas of Satkhira floodwater remained stagnant although it had drained off from

generation. However, the problem continued to exist for the time being. The employment

Table 5.2 : Reasons for keeping land fallow after the flood

Reasons	Percentage of respondents
Plots remained under water	37
Crisis of seedlings	13
Lack of capital to buy seedlings and fertilizer	43
Others	7

Note: The above distribution is made among the respondents who kept all or some of their land fallow.

situation was found to be improved as soon as agricultural activities started after the flood. The flood rehabilitation programmes initiated by the government further improved the employment situation. About 90% of the total respondents reported about the migration of the people from their locality to urban areas in search of employment. It indicates that after the flood the extent of employment in the study area was insufficient.

Transfer of land

In the study area it is found that 30% of the respondents having land of their own were involved in land transfer after the occurrence of flood. The transfer of land was made both by selling and mortgaging-out of land. About 30% of the respondents involved in land transfer are found to have transferred their land by selling-out and the rest (70%) have transferred their land by mortgaging-out (Table 5.3). As to land transfer it is revealed from the study that most of them who transferred land belonged to categories of marginal

Table 5.3: Land transfer (selling and mortgaging-out) during and after the flood

Types of land transfer	Percentage of respondents
Selling	30
Mortgaging-out	70

Note: The above distribution is made among the respondents who were involved in full or partial transfer of their land.

and small farmers. It is reported that all the sold-out and mortgaged-out land were accumulated in the hands of some rich people. The reasons of land transfer during and after flood as reported by the respondents are shown in Table 5.4. It is clear from the

Table 5.4: Reasons of land transfer during and after the flood

Reasons	Percentage of respondents
For purchasing food	35
For meeting the farming expenses	35
For repayment of loan	11
For rebuilding of damaged houses	19

figures in the table that the most prominent causes of land transfer were the purchase of food and meeting the farming expenses. Rebuilding of damaged houses (19%) and repayment of loan (11%) were also reported as reasons for land transfer.

Sale of livestock and other properties

In the study area 83% of the total respondents were found to be involved in selling livestock during and after flood. However, most of them sold some of their livestock. The sold out livestock include cattle, goat and poultry. Of the total respondents who sold out livestock, 48% were involved in selling cattle, 33% were involved in selling goat and 19% were involved in selling poultry (Table 5.5). Some of the respondents who were not involved in selling livestock reported that they had lost all of their livestock during flood

Table 5.5: Sale of livestock during and after flood

Types of livestock	Percentage of respondents
Cattle	48
Goat	33
Poultry	19

Note: 17% of the total respondents were not involved in selling livestock. The above distribution is made among the respondents who were involved in selling livestock.

and therefore could not sell livestock. It is clear from the above mentioned facts that in the flood affected area there was an urgent need for selling livestock. The reasons behind the selling of livestock in the study area as reported by the respondents were: purchasing food, want of feed for livestock and meeting various family expenses. In fact the need for meeting emergency expenses was such that people had to sell out their livestock at a selling price which was about 30 to 50 percent lower than those of the prices that prevailed before the occurrence of the flood.

Together with the selling of livestock people had to sell out other family properties like ornaments, trees, etc. It was found that 47% of the total respondents were involved in selling out properties other than land and livestock. Of them, 50% sold out trees, 19% sold out ornaments and 31% sold out other properties (Table 5.6). Here also, like those of livestock, the selling prices were very low as compared to the prices in normal time.

Table 5.6: Sale of other properties during and after flood

Name of properties	Percentage of respondents
Ornament	19
Tree	50
Others	31

Note: The above distribution is made among the respondents who were involved in selling other properties.

People were compelled to sell out other properties firstly because they had no other option other than to do this and secondly because they found that earning from selling out land or livestock was not enough for meeting the emergency expenses.

Indebtedness

In the study information on credit taken by the households in the study area both before and after the occurrence of flood from different sources were collected. It was found that 65% of the total respondents were indebted (Table 5.7). Of the total indebted respondents, 65% were indebted to only one source and 35% were indebted to more than one sources.

Table 5.7: Indebtedness of the respondents

Description	Respondents
Indebted respondents (% of the total)	65
Indebted to only one source (% of the total indebted)	65
Indebted to more then one sources (% of the total indebted)	35
Indebted respondents having land of their own (% of the total indebted)	75
Indebted landless respondents (% of the total indebted)	25
Indebted before the occurrence of flood (% of the total indebted)	35
Indebted after the occurrence of flood (% of the total indebted)	35
Indebted before and after the occurrence of flood (% of the total indebted)	30

Among the indebted households, 75% are land-owning households and 25% are landless households. It is also found from the collected information that of the indebted households, 35% took credit before the occurrence of flood, 35% took credit after the occurrence of flood and 30% were involved in taking credit both before and after the occurrence of flood. It means that due to flood the number of indebted households was increased as compared to situation before the occurrence of flood. Moreover, some households already in debt had to take credit after the flood.

Sources of credit

There were both formal and informal sources of credit. These sources were banks, friends, relatives, money lenders, co-operatives and NGOs. Table 5.8 shows the distribution of indebted households in relation to the sources. It can be seen from the table that banks played the major role in providing the households with credit. It is followed by the money lenders. 19% of the indebted households took credit from friends and relatives. It can also be seen that NGOs and co-operatives played a role to some extent in extending credit facilities in the study area. It was found that the landless and small

Table 5.8: Distribution of indebted households in relation to the sources

Sources	Percentage of respondents indebted
Banks	46
Friends	9
Relatives	10
Bank and money lenders	12
Bank and co-operatives	8
Money lenders and NGOs	15

farm households had little access to the bank credit facilities. Most of them had to depend on money lenders for taking credit. The interest rate for taking credit from the money lenders was reported to be high.

Use of credit

The heads of using credit by the indebted households are shown in Table 5.9. It is revealed from the table that most of the indebted households used the credit for

Table 5.9: Heads of using credit by the indebted households

Heads of using credit	Percentage of respondents
Agricultural operations	55
Purchase of food	9
Repayment of loan	3
Purchase of food and agricultural operations	17
Rebuilding of damaged houses	16

agricultural operations. It is followed by the purchase of food. In some cases the borrowers were found to utilize the credit for more than one purposes. Only 3% of the indebted households used the credit for repayment of loan.

Relief operation

Respondents were asked about the receipt of relief materials both during and after the occurrence of flood. About 95% of the flood-affected respondents reported that they had received some amount of relief materials from different sources. These sources as reported by the respondents are: government, NGOs, relatives, friends and local leaders. The distribution of households in relation to the sources of receiving relief materials is shown in Table 5.10. It can be seen from the table that most of the households received relief materials from the government. Many of them also received cash money. NGOs were found to have played a notable role in relief operation. It was also found that a large number of households (57%) received relief materials and cash money from more than

Table 5.10: Distribution of households in relation to sources of receiving relief materials

Sources	Percentage of households
Government	30
NGOs	7
Government and NGOs	45
Relatives and friends	12
Local leaders	6

one sources. Only 6% of the respondents reported that they had received relief materials from the local leaders.

Place of refuge during flood

Due to sudden onrush of flood many people had to leave their houses with some of their belongings in order to save lives and to reduce losses in goods and property. When asked about the place of refuge during the flood the respondents reported about different places such as own house, rooftop of the own house, rooftop of the neighbor's building, floodshelter, nearby road or embankment etc. Table 5.11 shows the distribution of households in relation to the place of refuge during the flood. It can be seen from the table

Table 5.11: Distribution of households in relation to the place of refuge during the flood

Place of refuge	Percentage of households
Own house	26
Rooftop of the own house	20
Rooftop of the neighbor's building	9
House of the friend/relative in safe area	19
Floodshelter	13
Nearby road or embankment	13

that 54% of the total respondents reported that they had to abandon their houses for safety. A substantial number of respondents who did not abandon their houses reported that they took shelter on the rooftop of their own houses. It was found that 13% of the households took refuge in the floodshelters. There were no special arrangements or infrastructure to provide shelters for the flood affected people. However, educational institutions, mosques etc. were used as temporary floodshelters. The presence of social cohesion to some extent is reflected by the fact that 9% of the households took shelter on the rooftop of the neighbor's buildings and 19% of the households took refuge in the houses of friends and relatives in the safe areas. The households that moved onto nearby high ground, roads and flood embankments were found to be 13% of the total flood affected households. The nearby high ground, roads and embankments were preferred by the people as refuge areas because therefrom they could keep eye on their own land and

houses. However, the households that took shelter on these high ground suffered much due to lack of sanitary and drinking water facilities.

Diseases

In the study area there was incidence of diseases connected with flood. About 67% of the total respondents reported that at least one of their family members suffered from diseases during and after the flood. Table 5.12 presents the type of diseases suffered by human beings during and after the flood. It is revealed from the table that most of the people

Table 5.12: Type of diseases suffered by human beings during and after the flood

Type of diseases	Percentage of households
Dysentry	24
Diarrhoea	48
Cold and fever	12
Skin disease	6
Others	10

Note: The above distribution is made among the households suffering from the diseases during and after the flood.

suffered from diarrhoea (48%) which is followed by dysentry (24%). The other diseases suffered by the households are cold and fever (12%), skin disease (6%), etc. Most of the households suffering from the diseases could not take preventive measures against diseases due to lack of medical services. It was revealed from the collected information that the average size of the households suffering from the diseases was 7.16 and on an average 3.23 member of each household suffered from the diseases.

Women's situation

Due to the occurrence of flood the most sufferers were the landless and small farm households. They had lost their homesteads and most of their belongings. Moreover, due to damage of crops and stoppage of local trade and commerce many of them became jobless. As a result, they had to migrate to urban areas in search of employment leaving behind their families in a destitute situation. In the absence of male heads of families the females had to take responsibility of their families. Because they had little scope to earn to feed their families the effects of hardship were felt most by them. In such a situation the incidence of women trafficking was likely to increase.

Cross-border smuggling

The local trade and commerce was at a standstill during and after the occurrence of the flood. It had turned the local traders to smuggling from across the border. Some unemployed people and destitute women were reported to be engaged in such illegal enterprises to face the miserable situation that arose out of the occurrence of the flood.

CHAPTER SIX

Preparedness, awareness, adjustment measures and responses of flood affected people

The occurrence of the flood took everybody by surprise in the study area. The people were not at all ready to face the onslaught of the flood. Still they did not accept losses done by the flood without any response strategies. So long as they were not forced to accept losses passively and to abandon their households, people tried to reduce damage by adopting various strategies. The flood has awakened the people and the sense of security that was prevailing before the occurrence of flood is now non-existent. The people are now thinking of doing whatever they can to live with the floods.

Preparedness and perception of the risk

It was found that during the recent flood, the inhabitants of the flood affected areas were more dependent on indigenous strategies to cope with the flood. There was little institutional support and the people undertook incidental rather than purposeful approaches to relieve themselves from flooding. In most of the cases they were seen to cut roads and dikes to release floodwater from their localities which in turn deteriorated the flooding situation in the neighboring localities. The other strategies they adopted were: construction of dikes to prevent the propagation of flood, construction of temporary earthen barriers around the fish ponds, selling out livestock and other properties, moving belongings etc.

It is revealed from the information collected during the study that the perception of the risk of occurrence of a future high flood is significant among the people in the flood-affected area. In this regard attention is drawn to the following table (Table 6.1).

Table 6.1: Perception of the risk of occurrence of a future high magnitude flood.

Respondents in	Percentage of "yes" answers
Protected area	75
Unprotected area	93
Study area	85

It can be seen from the table that 85% of the respondents in the study area as a whole perceive the risk of occurrence of a future high magnitude flood. However, the percentage of respondents in the unprotected area who perceive the risk is higher than that of the protected area. It may be due to the fact that despite the incidence of dike breaching during the recent flood some people still do not like to believe that such dike breaching can also occur in future. Table 6.2 show that the majority of the respondents perceive the risk of occurrence of a flood comparable in magnitude with the recent flood in the very short term. It indicates their present anxiety on flood issues. It was found that 76% of the respondents were thinking of doing something to face a future flood whereas 24% of them did not think of doing anything yet (Table 6.3). The respondents who did not

Table 6.2: Expected time of occurrence of a future high magnitude flood

Time (year)	Percentage of respondents
Any year	27
1 year	48
2 to 5 years	17
6 to 10 years	2
11 to 20 years	4
More then 20 years	2

Table 6.3: Present status of readiness to face a future flood

Present status of readiness	Percentage of respondents
Thought of doing something to face a future flood	76
Thought of doing nothing yet	24

think of doing anything yet were either still maintaining "safe feeling" or not capable of doing something. Table 6.4 presents the nature of preparatory works the respondents were thinking of doing against flood damage. It can be seen from the table that most of the respondents (71%) were thinking of raising their houses to prevent the ground floor from being flooded. Of the rest, 15% were thinking of building pacca houses, 10% were thinking of shifting to a safer area and 4% were thinking of providing walls in brick and concrete around their houses. It is important to note here that most of the respondents

Table 6.4: Nature of preparatory works for protection against flood damage

Nature of preparatory works	Percentage of respondents
Building pacca house	15
Raising house	71
Shifting to a safer place	10
Providing wall in brick or concrete around house	4

who were thinking of raising their houses and building pacca houses reported that they were in need of monetary assistance in this regard. On the other hand, most of the respondents who were thinking of shifting to safer places were found to be destitute and landless. The sources of assistance expected by the respondents in case of a future flood have been shown in Table 6.5. It is important to notice from the information presented in the table that 60% of the total respondents considered government as reliable source of assistance. On the other hand, a significant proportion (22%) liked to rely on God. The relief agencies were considered as reliable sources of assistance by 12% of the total respondents. Only 3% of the total respondents liked to rely on social relationship assistance. The reliance on local leaders as expected source of assistance is also found to

Table 6.5: Expected sources of assistance in case of a future flood

Sources	Percentage of respondents
Government	60
Allah	22
Relief agencies	12
Relatives and friends	3
Local leaders	3

insignificant (3%). Nobody considered society as reliable source of assistance.

Awareness and perception

Perception and awareness of flood play a significant role in preparedness and adaptation behavior of the people living in flood-prone areas. Table 6.6 shows the views of the respondents regarding the causes of the recent flood. It can be fairly stated that the people of the study area perceived the causes of the flood rationally. The percentage

Table 6.6: Views of the respondents regarding the causes of the flood

Causes of the flood	Percentage of respondents
Onrush of floodwater from across the border	37
Collapse of flood control embankment	32
Excessive rainfall before the onrush of floodwater from across the border	12
Reduction in the transport capacity of the rivers and canals	7
Lack of drainage facilities	5
Do not know	4
Will of Allah	3

of respondents who were ignorant about the causes of the flood was found to be insignificant (4%). Only 3% of the total respondents were fatalistic and considered flood to be the will of God.The respondents of different Upazilas were asked about the depth of inundation and duration of the flood in their localities. Based on their answers the average depth of inundation and duration of the flood in different Upazilas have been shown in the following table (Table 6.7). The figures in the table indicate respondents' recognition of the flood as devastating and long lasting. It can be seen that the flood lasted for about two months in Kalaroa and Satkhira Sadar Upazila. The floodwater drained out more quickly from Mujibnagar and Sarsa Upazilla compared to the other Upazilas. In Debhata Upazilla of Satkhira district people cut ring dike to release floodwater. As to the inundation depths respondents of all Upazilas were seen to be dependent on guess. However, reported depths were high enough to give one an impression of the severity of the flood. The respondents reported that the long duration of the flood was mainly caused by the delayed drainage of the floodwater. The perception of the respondents regarding the reasons of delayed drainage was also found to be quite rational (Table 6.8). It can be

Table 6.7: Average inundation depth in different Upazilas in the study area as reported by the respondents

Respondents in	Average inundation depth (m)	Duration of flood (days)
Sarsa, Jessore	3.21	35
Satkhira Sadar, Satkhira	3.05	56
Debhata, Satkhira	3.27	40
Kalaroa, Satkhira	3.38	60
Mujibnagar, Meherpur	2.87	29
Jibannagar, Chuadanga	3.27	45

seen that most of the respondents reported loss of transport capacity of the rivers/canals and unplanned construction of roads, bridges and culverts as main reasons for the delayed drainage of floodwater. The respondents who reported inadequate bridges and

Table 6.8: Reasons of delayed drainage as perceived by the respondents

Reasons of delayed drainage	Percentage of respondents
1. Loss of transport capacity of the river/canals	29
2. Unplanned construction of roads, bridges and culverts	15
3. Both of the above	26
4. Inadequate bridges and culverts	10
5. Construction of ring dikes	6
6. Poor drainage facilities	8
7. Shrimp enclosures	6

culverts as reason of delayed drainage were of the opinion that the existence of more bridges and culverts could facilitate safe passage of the floodwater. On the other hand, most of the respondents who reported construction of ring dikes, poor drainage facilities and shrimp enclosures as reasons of delayed drainage were from the polder areas.

It was revealed from the study that the people of the study area perceived well the flood control measures required for the protection of their localities from flooding. Attention is drawn in this regard to the information presented in Table 6.9. The views of the respondents of each Upazila were scrutinized and summarized to depict the flood control measures required for that Upazila as a whole. It is clear from the information presented in the table that the study area lacks drainage facilities. There are drainage facilities in Debhata Upazila of Satkhira district but the existing facilities are not enough to manage a flood of high magnitude. Moreover, due to lack of maintenance the existing facilities are getting inoperative. Every year many areas are subjected to drainage congestion due to unplanned construction of infrastructures and encroachment on natural watercourses.Natural drainage routes like rivers, khals etc. get silted up losing in their conveyance capacity. Re-excavation of these natural drainage routes is therefore

Table 6.9: Respondents views regarding flood control measures required for protecting different Upazilas from flooding

Respondents in	Flood control measures
Sarsa, Jessore	• Construction of flood control embankment • Providing drainage facilities • Re-excavation of rivers and canals • Raising the Jhikargacha-Banapole highway to a higher level and providing the existing bridges with clearance • Construction of bridges and culverts with sufficient opening
Satkhira Sadar, Satkhira	• Improving drainage facilities • Re-excavation of rivers and canals • Construction of more bridges and culverts • Strengthening of heightening of existing flood control embankment • Increasing awareness among the people regarding flood
Jibannagar, Chuadanga	• Re-excavation of rivers and canals • Providing drainage facilities • Construction of earthen barrier along the border • Construction of more bridges and culverts
Debhata, Satkhira	• Re-excavation of rivers and canals • Improving existing drainage facilities • Strengthening of ring dikes • Removal of shrimp enclosures built by shrimp cultivators • Raising the crest level of the existing dike • Repair and maintenance of flood control infrastructures
Kolaroa, Satkhira	• Construction of flood control embankment • Re-excavation of rivers and canals • Improve existing drainage facilities • Construction of more bridges and culverts • Building of floodshelter •
Mujibnagar, Meherpur	• Re-excavation of rivers and canals • Construction of earthen barrier along the border • Construction of bridges and culverts with adequate opening

very much important. Some of the respondents of different Upazilas put in specific suggestions to relieve their areas from flooding and drainage congestion. These suggestions appear in Table 6.10. It is evident that the suggestions were made in local perspective but still appears to be very much helpful to recognize the problems in local scale. Every year floodwater from across the border inundates a vast area of Sarsa

Table 6.10: Specific suggestions made by the respondents to relieve their areas from flooding and drainage congestion

Respondents in	Specific suggestions
Kalaroa, Satkhira	• Construction of dikes along the river Ichamati • Re-excavation of Ichamati river • Re-excavation of Noakhali khal
Satkhira Sadar, Satkhira	• Re-excavation of Dadbhanga khal • Re-excavation of Satkhira khal • Digging of a canal from Khaitala to Shakra khal • Re-excavation of Labanyabati khal • Digging of a canal from Gozalia beel to Dadbhanga khal
Sarsa, Jessore	• Re-excavation of small khals originating from the Betna • Removal of all obstructions from the natural drainage routes • Blockade of the onrush of floodwater from West Bengal by constructing barriers • Re-excavation of Kobadak river
Jibannagar, Chuadanga	• Re-excavation of Bhairab river
Mujibnagar,Meherpur	• Re-excavation of Kagmari khal

Upazila but the water can not drain off from the area due to encroachment upon the natural drainage routes for fish cultivation. Most of the respondents of Sarsa Upazila were of the opinion that all the obstructions created at these drainage routes should be removed.

Adjustment measures

It was found that in the recent flood 98% of the respondents were affected but only 10% of them were thinking of shifting to a safer place. The rest were either rebuilding houses or repairing their damaged houses. However, it was revealed that the percentage of migrant people would likely to increase in case of occurrence of a future high magnitude flood. Those who reported that they would migrate to a safer area if they would have to

Most of the farm households reported that they would continue to live with the floods. In this regard their expectation for necessary assistance from national government was found to be very high. They did not like to rely on social relationship assistance. It was found that most of the people were thinking to reduce flood damage by raising their houses. Only an insignificant proportion was thinking of building pacca house. However, whatever they intended to do could not be materialized without any external assistance.

It appeared from the study that the occurrence of flood would result in massive unemployment and the landless laborers and marginal farmers would migrate to the urban areas in search of employment. The job seekers and destitute women would likely to be involved in cross-border smuggling. The members of the farm dependent households would try to be involved in non-farm activities and it would cause major occupational change in the study area.

The landless and marginal farmers were found to be the most affected groups of people. Their houses were made of raw materials and therefore were more vulnerable to flood damage. In fact they had to lose almost everything whatever they had. It made them more dependent on money lenders and they were expected to lose their last possessions at the hands of the money lenders. It would ultimately create serious class divide.

It was known from the study that 95% of the respondents received relief materials and cash money during and after the flood. Government and NGOs were played significant role in relief operation. But the relief assistance was not sufficient enough to meet their emergency needs. Scarcity of food was experienced by most of the households in varying degrees but the landless households and marginal farmers were worse hit. Many of them were seen to be forced to sell out their land, livestock and other properties to meet emergency requirements like purchase of food, rebuilding/repairing of damaged houses etc. It was found that most of the respondents who were involved in land transfer through sale or mortgage were small and marginal farmers. Mortgaging-out of land, in most cases leads to selling-out when the mortgager can not accumulate fund to release the land. It is anticipated that in this process many will end up being landless while others will come down in socio-economic ladder changing status from small to marginal farmers. It was reported by the respondents that they had to sell out their land, livestock and other properties at a price much lower than those of normal prices.

Most of the medium and small farmers were in need of credit for agricultural operations. In this regard they were dependent on banks as source of credit. On the other hand, the poor and the marginal farmers did not enjoy the facility of bank credit. They had to depend on informal sources for taking credit.

As to the addition of family assets after the occurrence of flood it was found that 12% of the total respondents could not add any asset for want of money. Of the rest, 79% of the respondents invested for reconstruction and repair of houses, 9% were involved in purchasing cattle and 6% were involved in purchasing other properties (Table 6.11). The addition of goat and poultry was found to be insignificant. Some of the respondents who were involved in reconstructing or repairing the houses could not complete the repair/reconstruction till March, 2001. All the above mentioned information bear explicit testimony of the fact that the people of the flood affected area were struggling hard for recovery of their lost properties.This task was more hard for the poor and landless people.

Table 6.11: Addition of family assets after the flood.

Name of assets	percentage of respondents
Cattle	9
Goat	3
Poultry	3
Repair/reconstruction of houses	79
Others	6

Responses to the flood

It was found from the study that being perplexed by the sudden onrush of floodwater 15% of the total respondents virtually did nothing other than shifting their families with some belongings to a refuge area. Some of them reported that they had no option other than to do so while some others reported that they did not respond to the flood by adopting any control measure thinking that it would come to no effect. On the other hand, 85% of the respondents reported that they had applied various indigenous technologies and other measures to reduce the flood damage. The applied measures in response to the flood as reported by the respondents are stated below:

- Removal of obstructions hindering free flow of water
- Cutting dikes in order to release floodwater
- Blocking bridge opening to prevent floodwater from entering to non-protected area
- Reinforcement and repair of flood control infrastructures
- Closing gaps in dikes
- Cutting roads to release floodwater
- Clearing drainage canals
- Building temporary earthen barriers
- Helping in evacuation of people and property
- Selling out properties

Most of the people tried to protect their localities from flooding by constructing temporary earthen barriers. They applied indigenous technologies collectively in constructing earthen barriers. However, in most of the cases such measures could not bring any positive result. Only in a few cases the expected success was achieved by deploying extraordinary efforts. Relieving one area from flooding caused deterioration in the flooding situation of other areas. The respondents of Satkhira Sadar Upazila reported that they tried collectively to stop the dike breaching at Khaitala. On the other hand, at Parulia of Debhata Upazila local people cut the ring dike at four places to release the floodwater from the polder area. It was reported by the local people that at one place public cutting of dike caused immense damage to the properties of the people living outside of the polder. However, at other places the released water directly entered to the nearby river Ichamati.

It was revealed from the study that people responded to the flood either individually or collectively. There was little or no institutional support for them. In most of the cases the social solidarity was very much visible. In fact they left no stone unturned before giving in. However, there was lack of planning in making responses.

CHAPTER SEVEN

River condition in the flood affected region

The major drainage routes of floodwater in the flood-affected region are the rivers flowing through it. These rivers have lost in their transport capacity due to deposition of sediments and consequent rise in the bed levels. It is mainly caused by the large variation in the discharge and sediment load. If this situation is allowed to continue most of the rivers will die shortly. In this chapter the changes in the river condition in terms of variation in the stage-discharge, cross-sectional area, mean bed level etc. have been discussed based on the hydrological and morphological data of some rivers.

Kobadak

The river Kobadak originates from the river Mathabhanga. It can be seen from Figure 5 and Figure 6 that the dry period (February/March) water area of this river has been reduced almost in all cross-sections over the period from 1993-94 to 1996-97 and 1994-95 to 1996-97. This reduction is much higher at the downstream. Figure 7 shows that the elevation of the deepest points at almost all cross-sections have a trend to go up. It means that the mean bed elevation is rising. It is noticeable from Figure 8 that the average annual water level has been reduced significantly particularly in the nineties. It indicates the reduction in the freshwater flow of this river.

Bhairab

The river Bhairab is a distributary of the Ganges. The annual maximum and minimum discharges of the river measured in different years are shown in Figure 9. It is important to notice from the figure that in the year1988-89 the annual maximum discharge was greater than 90 cumec whereas the annual minimum discharge was less than 1 cumec. It means a high maximum to minimum flow ratio. It is interesting to note that in the next year (1989-90) the annual maximum discharge reduced to about 13 cumec and no major change occurred in the magnitude of the annual minimum flow. In 1992-93 situation the annual maximum flow was only about 6 cumec. In 1993-94 the maximum to minimum flow ratio was 5.28. All the above mentioned facts indicate major change in the flow regime of the river. Figure 10 shows the change in cross-section of BH # 1 from 1994-95 to 1997-98. The cross-sectional area and mean bed level at that cross-section for the year 1994-95 and 1997-98 have been shown in the following table (Table 7.1).

Table 7.1: Cross-sectional area and mean bed level at BH # 1 in 1994-95 and 1997-98

Year	Cross-sectional area (sq.m)	Mean bed elevation (m PWD)
1994-95	304.5	271.16
1997-98	7.13	7.37

It is important to note from the information presented in the above table that in 1997-98 situation the cross-sectional area is decreased and the mean bed level is risen compared to the situation in 1994-95.

Mathabhanga

The river Mathabhanga is a Ganges distributary. From the recorded discharges of this river at Darshana it is found that great variability exists in the annual maximum and minimum discharges and also in the maximum to minimum flow ratio in different years. The annual maximum to minimum flow ratios found in different years has been shown in the following table (Table 7.2). The table shows an increasing trend in the annual maximum to minimum flow ratio with time.

Table 7.2: Annual maximum to minimum flow ratio of the river Mathabhanga in different years

Year	Maximum to minimum flow ratio
1975-76	31.44
1980-81	36.52
1984-85	30.98
1988-89	52.8
1993-94	43.78

The mean monthly discharges of this river for the year 1975-76, 1984-85 and 1993-94 have been plotted in the Figure 11. It is noticeable from the plot that over the period from 1975 to 1994 little change occurred in the dry season mean monthly flow. However, in the monsoon period mean monthly discharge is found to have increased in 1984-85 compared to the situation of 1975-76. In 1993-94 situation the monsoon period mean monthly discharge is seen to be decreased again and between mid of June and mid of September it is even much lower in magnitude than that of 1975-76 situation.

Betna

From the recorded water levels at the Kalaroa gauging station, two graphs have been plotted and shown in Figure12 and Figure 13. The mean monthly high water levels for the year 1968-69, 1980-81 and 1994-95 appear in Figure.12. It can be seen that compared to the situation in 1968-69 the mean monthly high water levels have been risen significantly in 1980-81. However, in 1994-95 situation the mean monthly high water levels have been risen further in the monsoon period and lowered somewhat mainly in the dry period compared to the situation in 1980-81. In case of mean monthly low water levels it is interesting to see that in the year 1980-81 the water levels are higher than that of the year 1968-69 mainly in the dry period. On the other hand, in 1994-95 situation the mean monthly low water levels are much higher than both of that in 1968-69 and 1980-81 situation. The mean monthly tidal ranges are seen to have decreased in 1994-95 in comparision with the situation of 1968-69 and 1980-81.

CHAPTER EIGHT

Conclusions and recommendations

Conclusions

The following conclusions have been drawn from the study:

- There was no means to authorities to forecast the occurrence of such a flood. The flood originated outside the Bangladesh and no information was imparted to Bangladesh authorities by Indian authorities regarding the flood.
- In the flood-affected area the protection level against flooding was very limited. Moreover, due to lack of any prior warning people of that area were not at all aware of flood risk. They had virtually no preparation to adopt any means to reduce flood damage. The concerned authorities also could not provide any realistic means to reduce flood damage due to lack of preparation.
- Many rivers and khals of the flood-affected region are either dead or dying. In rivers like the Bhairab, the Mathabhanga, the Kobadak and the Betna the fresh water flow during the dry season has been reduced terribly. These rivers are undergoing major siltation and thereby losing in their transport capacity. The small rivers and khals originating from these rivers are also getting silted up.
- In the polder areas the restriction of tidal over-bank spill has caused the deposition of sediments at the upper end of the confined channels blocking the outlets of drainage sluices. It has caused drainage congestion in the polder areas for longer periods than designed.
- The natural drainage routes had not been maintained. As a result, people encroached upon these watercourses either to extend their agricultural lands or to cultivate fish causing hindrance to the free flow of water.
- In polder areas the shrimp enclosures built by the shrimp cultivators are acting as obstacles to the draining away of the floodwater.
- Many agencies were involved in the past development activities in the region and there was no co-ordination in the development activities of these agencies. Sufficient bridges and culverts were not built to allow the safe passage of floodwater during the construction of roads. Moreover, sufficient clearance was not kept under the constructed bridges and culverts to enable the floodwater to drain out quickly.
- There was no control of floodplain development. Floodplains were developed without any comprehensive plan. The infrastructures in the floodplains were barriers to the natural drainage of floodwater . Unplanned and uncontrolled floodplain development increased the potential for flood damage.
- The protected areas within the polders were flooded due to the dike breaching at Khaitala under Satkhira Sadar Upazila. Long duration of high stage might have weakened the dike and eventually caused the breach.
- Excessive (higher than normal) rainfall occurred in the flood-affected region prior to the onrush of floodwater from across the border. All beels and depressions were already filled up with rainwater.
- About 98% of the people were affected by the flood in varying degrees

- The households in the study area are predominantly male headed. The average household size is 7 (seven) with a standard deviation of 4.9. Landless to land owning household ratio is 0.32.
- The construction material of roof of most of the dwelling households of the study area is straw/bamboo and tiles/C.I sheets.
- Agriculture is the main occupation in the study area. Retail business and salaried jobs are also important means of livelihood.
- Most of the people have access to the tubewell water facility. However, the tubewell water in all cases is not free from arsenic contamination.
- There is severe lack of modern medical services in the flood-affected region.
- The cropping intensity in the study area is 196%.
- The recent flood caused severe damage to the homesteads and crops of most of the people (> 80%).
- The damage done by the flood resulted in massive unemployment for the landless laborers and small and marginal farmers. Many people migrated to the urban areas in search of employment.
- Many people transferred land and sold out livestock and other properties mainly for purchase of food and meeting the farming expenses.
- The number of indebted households had been increased due to the occurrence of flood. The main source of taking credit was bank. The poor and marginal farmers did not enjoy the facility of bank credit. They had to depend on money lenders and other informal sources for taking credit.
- Most of the people received relief materials and cash money from both government and NGOs. The received assistance was not enough to meet the emergency requirements.
- More than 50% of the people had to abandon their houses for safety. The major refuge areas were: house of the friend/relative in safe area, floodshelter and nearby road or embankment. There was no planning of evacuation.
- About two third of the households suffered from different diseases. The average size of the households suffering from the diseases was 7.16 and on an average 3.23 member of each household suffered from the diseases.
- The hardship caused by the flood was felt most by women as their male partners migrated to the urban areas in search of employment.
- Stoppage of local trade and commerce due to the flood triggered an increase in the cross-border smuggling.
- Most of the people in the study area perceive the risk of occurrence of a future high magnitude flood in the very short term.
- 76% of the people were thinking of taking preparatory measures to face a future flood comparable in magnitude with the recent flood and most of them liked to rely on government for assistance in this regard.
- The people of the study area perceived the causes of the flood and delayed drainage rationally.
- Most of the farm households liked to live with the floods whereas most of the non-farm households were likely to migrate to safer areas if they would have to suffer flood damage again.
- After the occurrence of the flood most of the people invested for reconstructing and repairing the houses. The addition of other family assets was insignificant.
- Despite having no prior preparation people responded to the flood very well. In most of the cases the flood fighting measures deployed by the people came to no effect.

Recommendations

Establishment of a reliable flood forecasting and warning system

It was seen that in the recent flood due to lack of prior information neither the responsible authorities nor the populations involved could take any planned decision to reduce the detrimental consequences of the imminent flood. People responded to the flood instantaneously by adopting various strategies to protect their land and homesteads but in most cases they had to give way to the flood lastly. The responsible authorities also could not take any emergency flood control measure for being unprepared. The flood-affected region is generally considered as a flood free area and therefore not included in the existing flood forecasting system. It is learnt from the recent flood that the area is not flood free and an extreme event can occur at any time. In order to reduce potential flood damage in case of a future flood comparable in magnitude with the recent flood it is therefore recommended to develop a reliable flood forecasting and warning system in the area. The reliability of flood forecasting systems depend for the most part on the quality and amount of the basic data collected on the hydrological and hydraulic functioning of the drainage basins involved. The basic data include antecedent precipitation information, flow, water level and water storage capacity and levels in any reservoirs in the basin. Appropriate measures should therefore be taken for collection, processing and transmission of data. By use of the available data and information a flood forecasting model should be developed. Meteorological forecasts of risks, locations and levels of predicted precipitation may also be incorporated. However, as river basins extend across international boundary, reliable forecasting will not be possible if the model is not improved by extending into West Bengal, India. In this regard Bangladesh needs to have timely access to data for the upstream parts of the basin. There should have a system of exchanging data and information related to floods between Bangladesh and India.

The agency responsible for flood warning will interpret the information received from flood forecasting centres and communicates it to various organizations in charge of operational decisions. These organizations in turn will make decisions and inform the public and enforce the instructions, according to their assigned responsibilities. It is very important in this regard to have better communication facilities between flood warning agency and operational organizations. If the communication of information is not rapidly carried out it will be difficult on the part of operational organizations to make decisions and to inform and instruct the people.

Development of evacuation planning system

In the recent flood people had to abandon their houses by their own decisions. Many of them took refuge in the nearby roads and embankments or floodshelters. Since these refuge areas were not provisioned with water supply, sanitary facilities etc. the evacuated people had to face great trouble. The roads and embankments can be enlarged and provisioned with necessary facilities so that in case of emergency these areas can be allocated to the people. Floodshelters should be built in different areas at safe elevations, to which the population from the vicinity could be evacuated. Between floods these floodshelters can have social and economic functions. Evacuation is the ultimate measure of flood defense and should be conducted through advance planning. It is therefore important to develop evacuation planning system. The system will consist of institutions and individuals responsible for conducting evacuation.

Control of floodplain development

In the past few decades there was no control of floodplain development. People and different agencies developed floodplains indiscriminately without taking into account the risks of flood damage. It was observed during the recent flood that the infrastructures in the floodplain acted as barriers to the free flow of floodwater. It is therefore imperative that control measure should be applied on future floodplain development. It will help reduce future potential for flood damage. However, it will not reduce risk to existing floodplain development. Corrective measures can be considered in this regard through a case study.

Restoration of previous flow regime

The major rivers in the flood affected region are the Bhairab, the Ichamati, the Mathabhanga, the Kobadak etc. The dry season flow of these rivers has been reduced significantly. Small rivers and khals originating from these rivers are also facing the same situation. Due to reduction in the fresh water flow during dry season rivers of this region are undergoing major siltation and losing in their transport capacity. In the polder areas the restriction of tidal over-bank spill by constructing embankments has caused the deposition of sediments at the upper end of the confined channels blocking the outlets of drainage sluices (FCPO/Halcrow, 1993). All these have caused major change in the flow regime. The problems associated with this change can only be overcome by restoring the previous flow regime. A comprehensive study plan is required to this end.

Removal of obstacles from natural drainage routes

In the past the natural drainage routes were not maintained properly. As a result, people encroached upon these natural drainage routes by creating obstructions for irrigation, fish cultivation etc. In the recent flood these obstacles created hindrance to the quick drainage of floodwater. The natural drainage routes should therefore be opened up by removing all obstacles for quick drainage of floodwater. If necessary these natural drainage routes should be improved by re-excavation.

Coordination in the development activities of different agencies

In the flood affected region different agencies are involved in development activities with different development objectives. There is no coordination in development activities of these agencies. Over the last few decades roads, dikes and other infrastructures had been constructed indiscriminately without taking into account drainage requirements. Adequate drainage passages were not kept in roads and embankments. The bridges and culverts do not have sufficient opening under them to enable the floodwater to drain off quickly. Coordination in the development activities of different agencies should therefore be ensured for future developments. At the same time based on the experience of the recent flood the existing drainage condition should be reviewed and a realistic action plan should be taken for drainage improvement. The following actions may have to be considered:

- Construction of new sluices and culverts
- Improvement of existing sluices and culverts
- Removal of structures from the floodplain

- Increase in the openings of existing bridges
- Rehabilitation of the damaged bridges, culverts and sluices

Strengthening and heightening of existing embankments

It is seen during the recent flood that the existing embankments are not free from the risk of breaching and overtopping. The reasons behind the embankment collapses should be reviewed and strengthening of embankments should be done to reduce the possibility of such future collapses. Overtopping of embankment may lead to subsequent collapse. Therefore the embankments should be heightened at locations where it may overtop.

Raising of houses and structures

In the flood most of the damaged houses were made of mud, straw, bamboo etc. Brick-built houses were less susceptible to the flood. In the present economic situation most of the people can not afford to have a brick-built house. The only alternative left for them is to raise houses and structures. However, many of them need external assistance in this regard.

Flood assistance to the most affected households

Landless and small and marginal farm households were most affected by the occurrence of the flood. They need assistance in the form of aid, grant and loan for recovery. Otherwise they have to lose whatever little left to them at the hands of the money lenders and a handful of very rich group of people.

Creation of post-flood employment opportunities

Stoppage of agricultural activities and local trade and commerce resulted in massive unemployment among the landless people and small and marginal farmers. Many of them migrated to the urban areas in search of employment. Some others involved in cross-border smuggling. Therefore, post-flood employment opportunities should be created for these people.

Improvement of women's situation

The hardship caused by the flood is felt most by poor and destitute women. They should be provided with micro credit for purchasing and rearing up cattle, goat, poultry etc. In the absence of such measure they may get involved in cross-border smuggling.

In addition to the above mentioned recommendations the following is strongly recommended:

Integrated water resources planning and management

An integrated approach should be followed in water resources planning and management. It requires a strong centralization of coordination activities although other managerial action usually is decentralized at various levels of government and also includes public participation. It also requires an integration of objectives and interests at various levels ranging from local to international. Models should be developed to improve formulation and analysis of water resources projects or to support managerial decision making.

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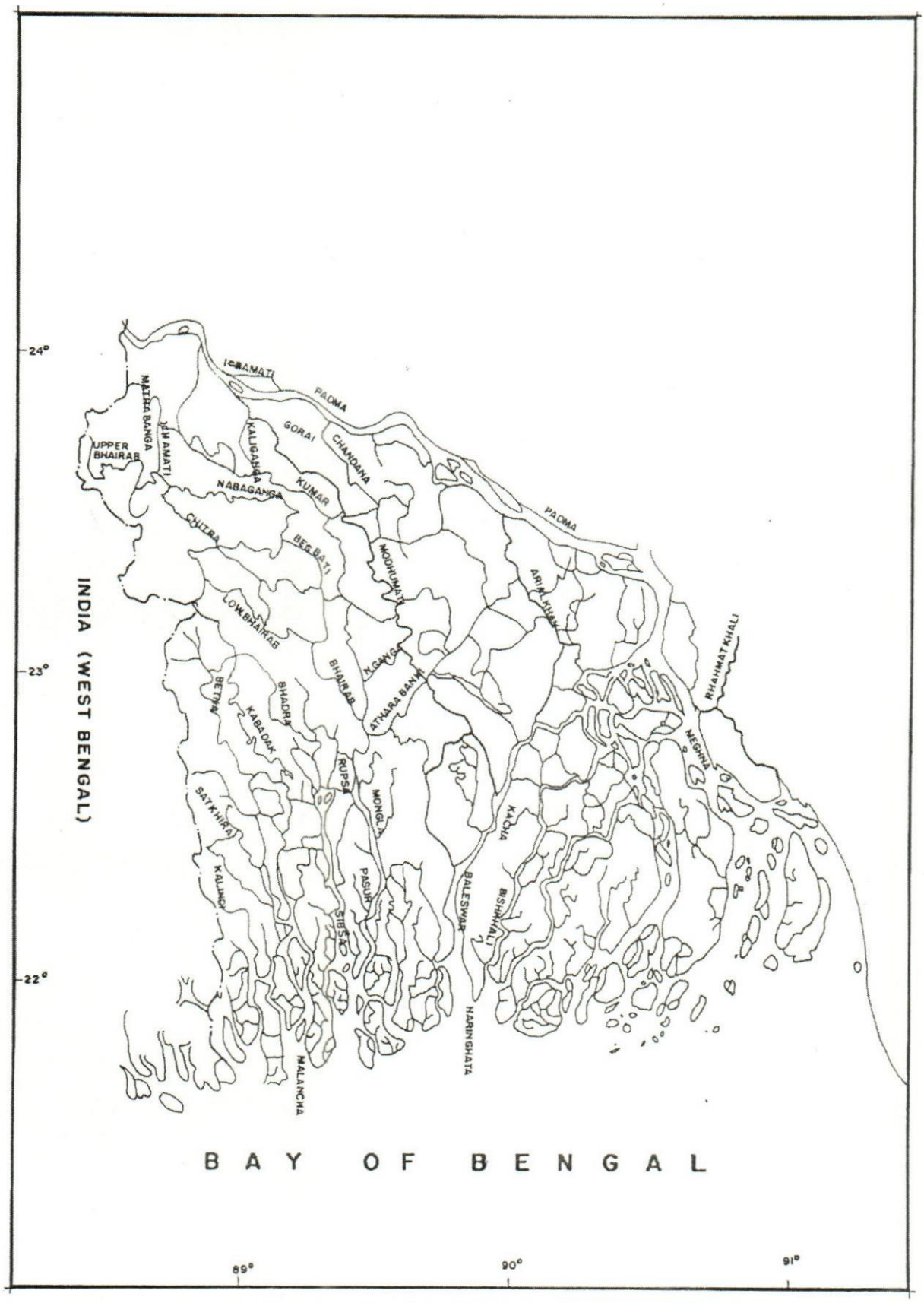

Figure1: River system of the Southwest Region (SWR)

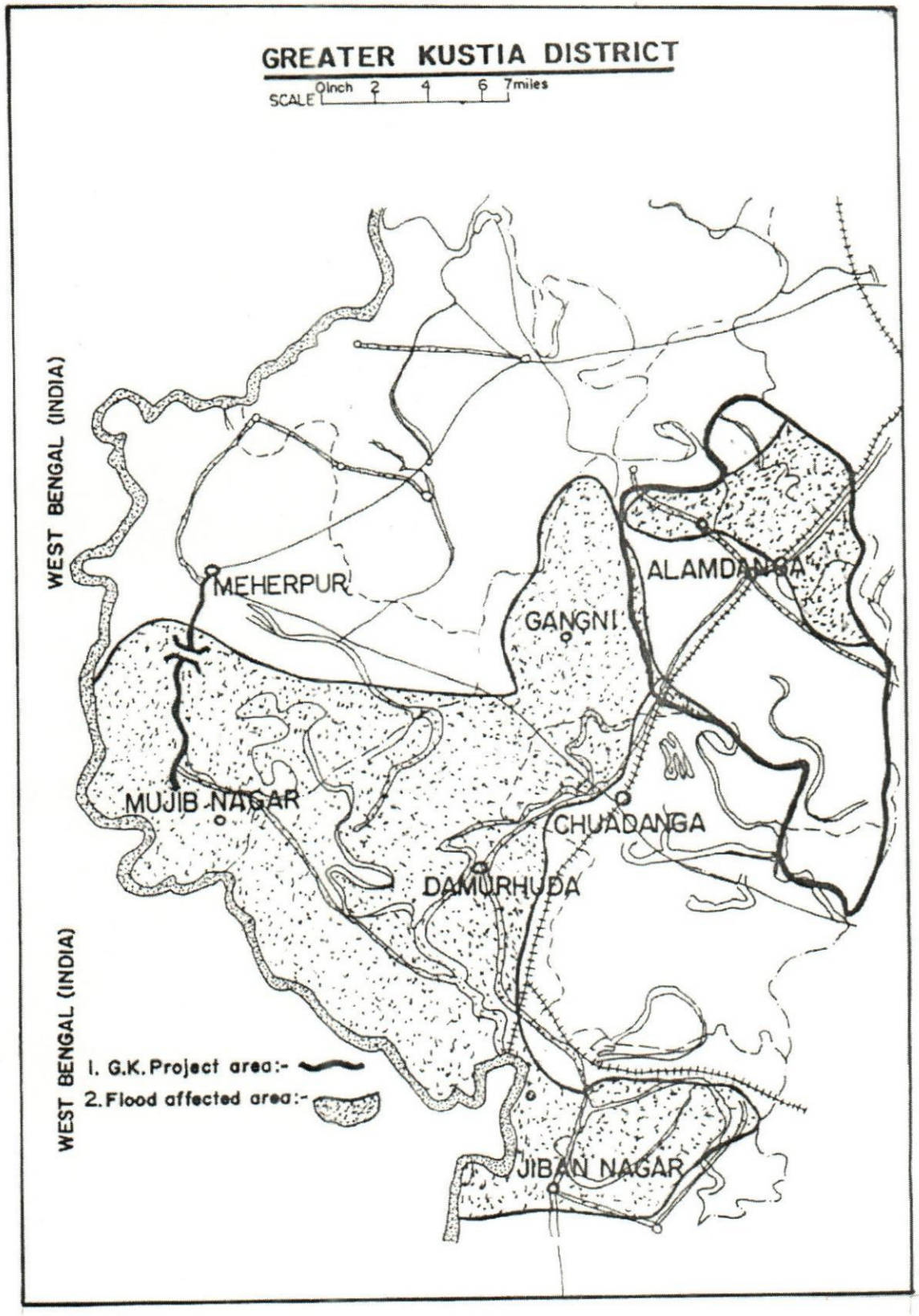

Figure 2: Flood affected areas of Greater Kushtia district

Figure 3: Flood affected areas of Jessore district

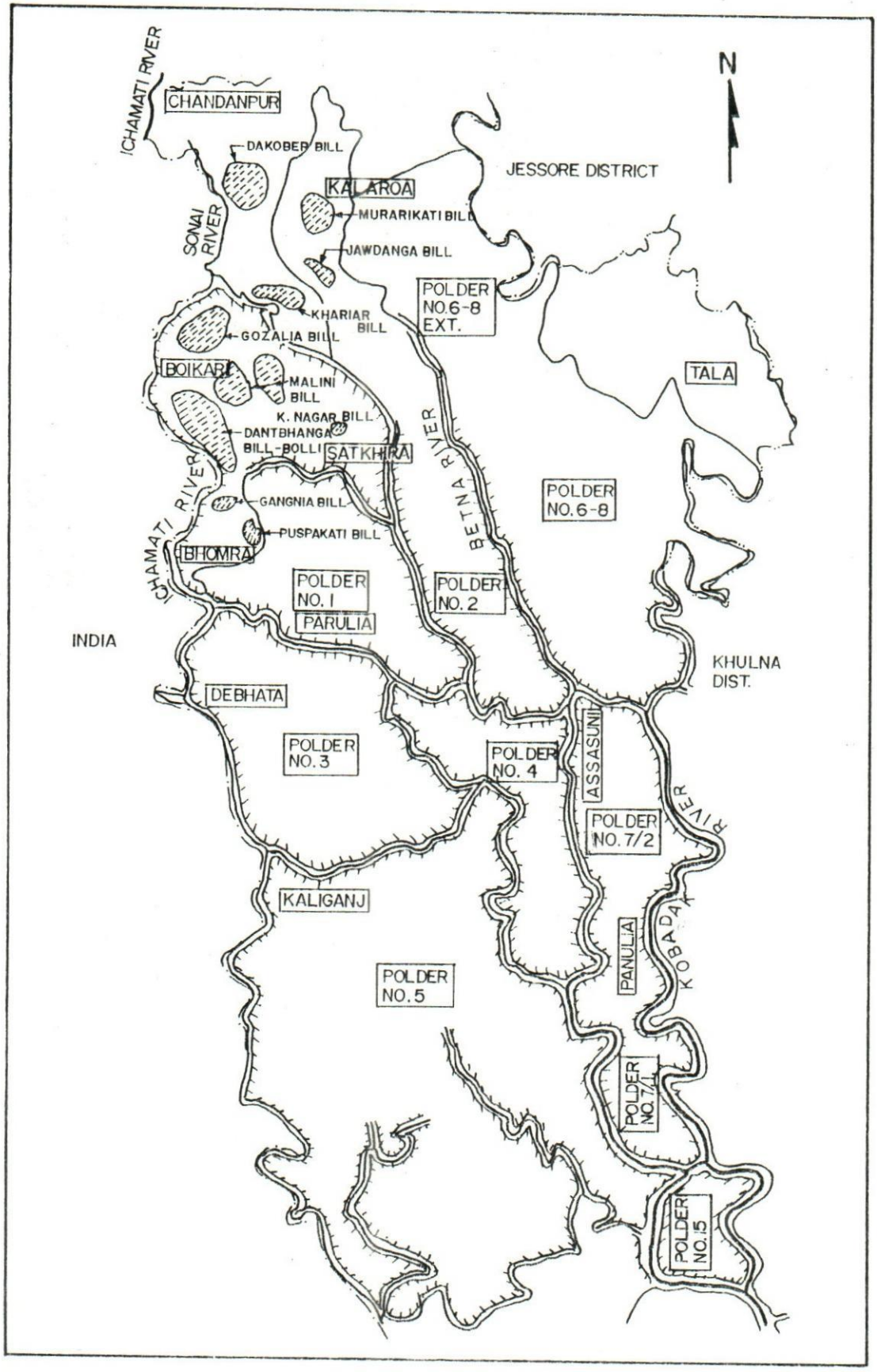

Figure 4: A map of flood-affected Satkhira district

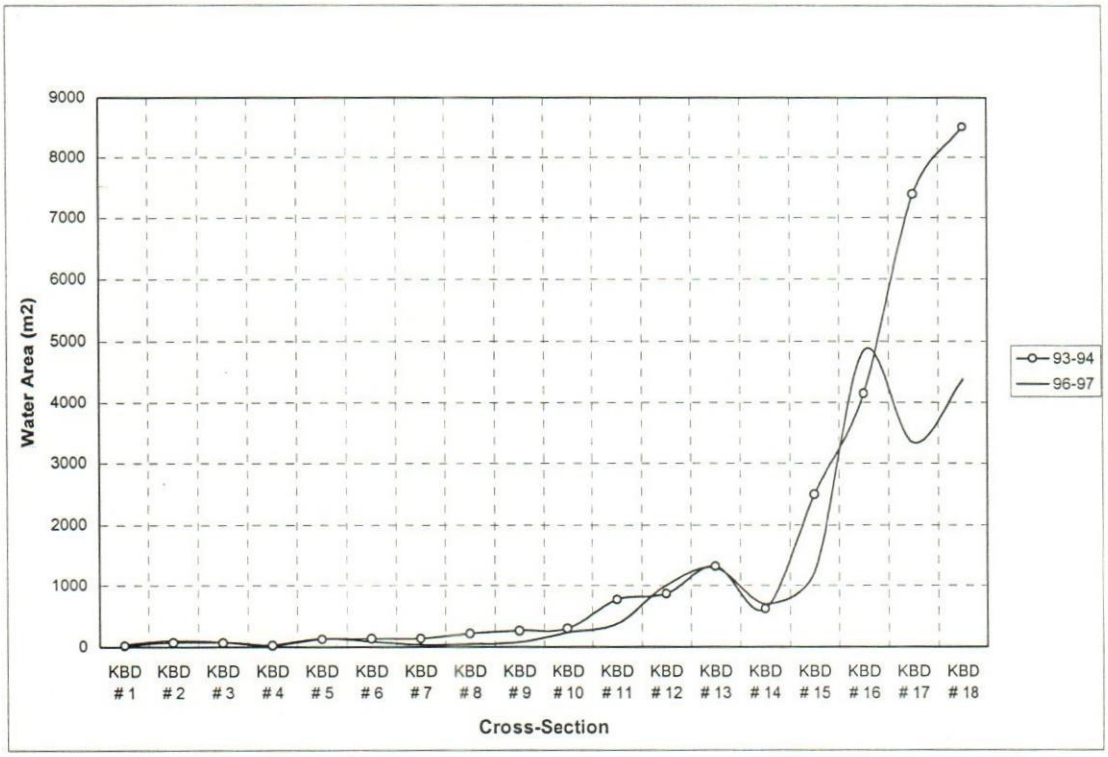

Figure 5: Variation in the water area at different cross-sections of the Kobodak River over the period from 1993-94 to 1996-97

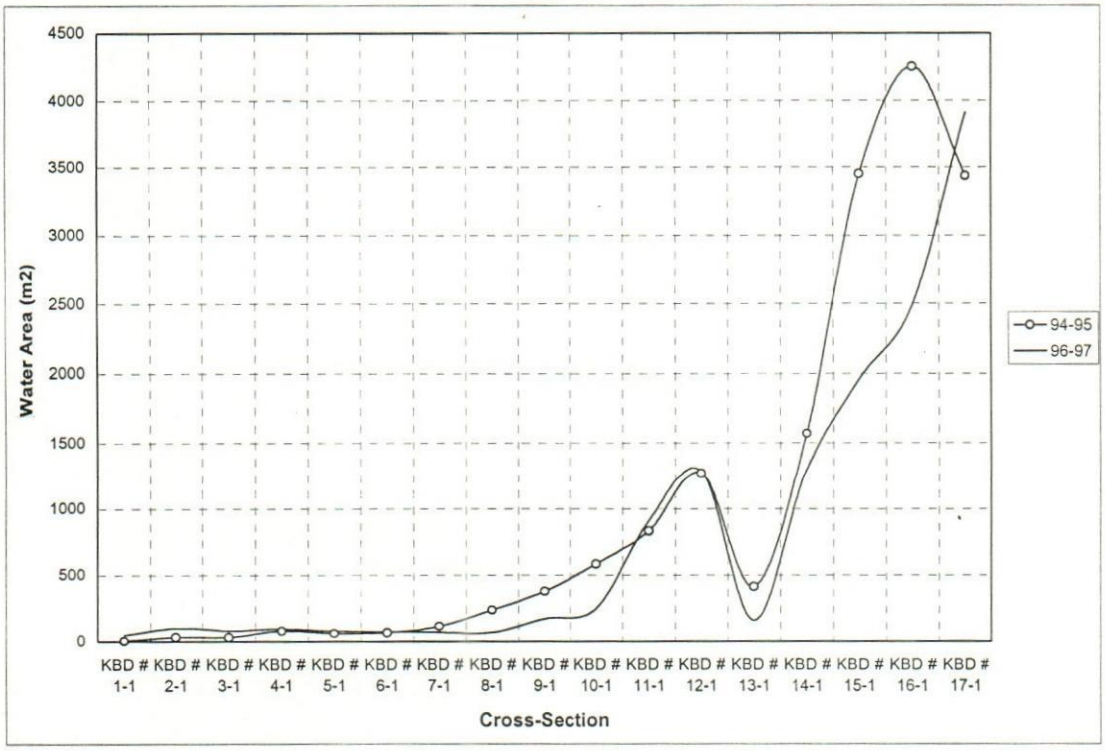

Figure 6: Variation in the water area at different cross-sections of the Kobodak River over the period from 1994-95 to 1996-97

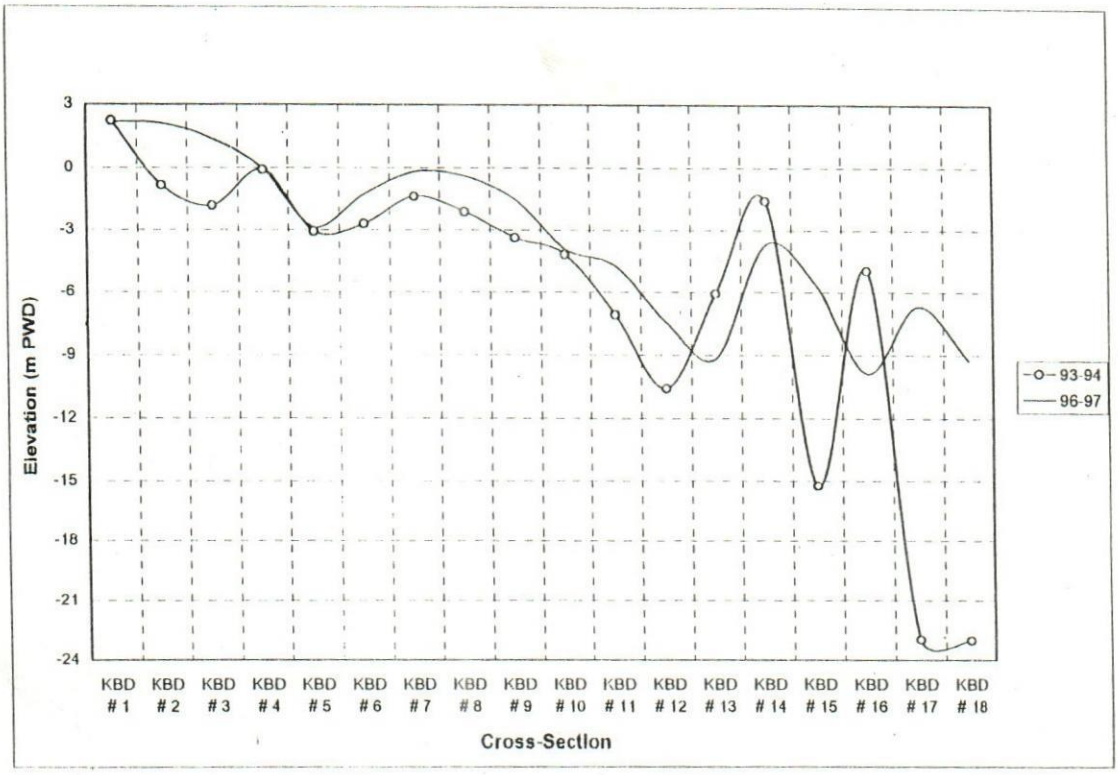

Figure 7: Variation in the elevation of the deepest points in different cross-sections of the Kobadak River over the period from 1993-94 to 19996-97

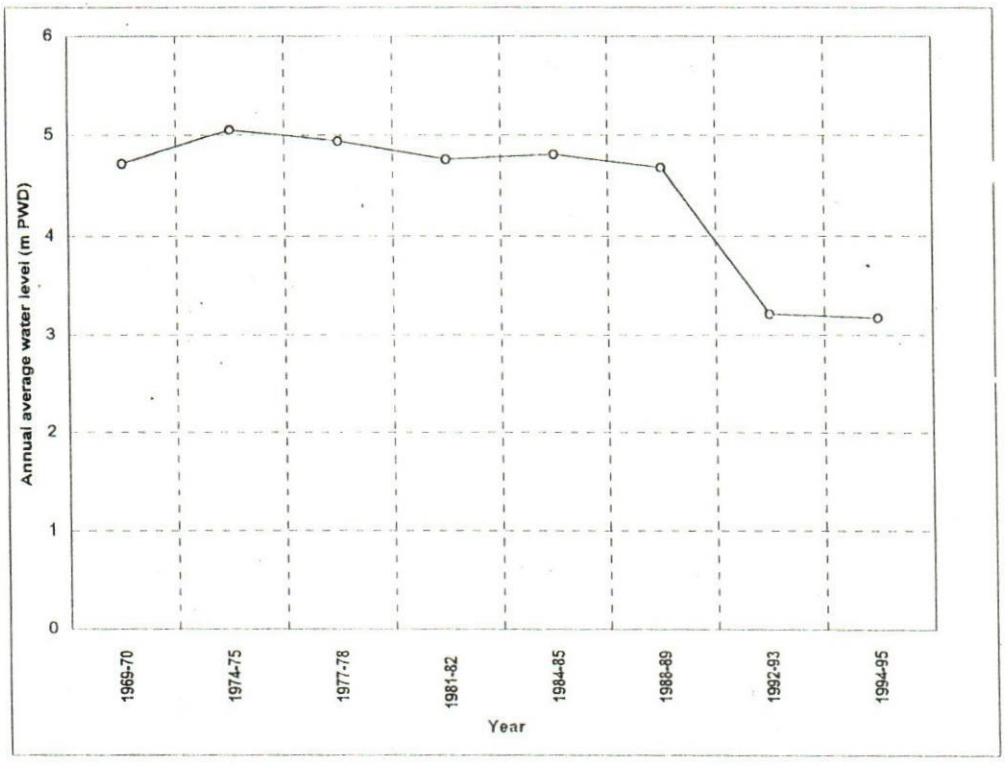

Figure 8: Variation in the annual average water level of the Kobodak River

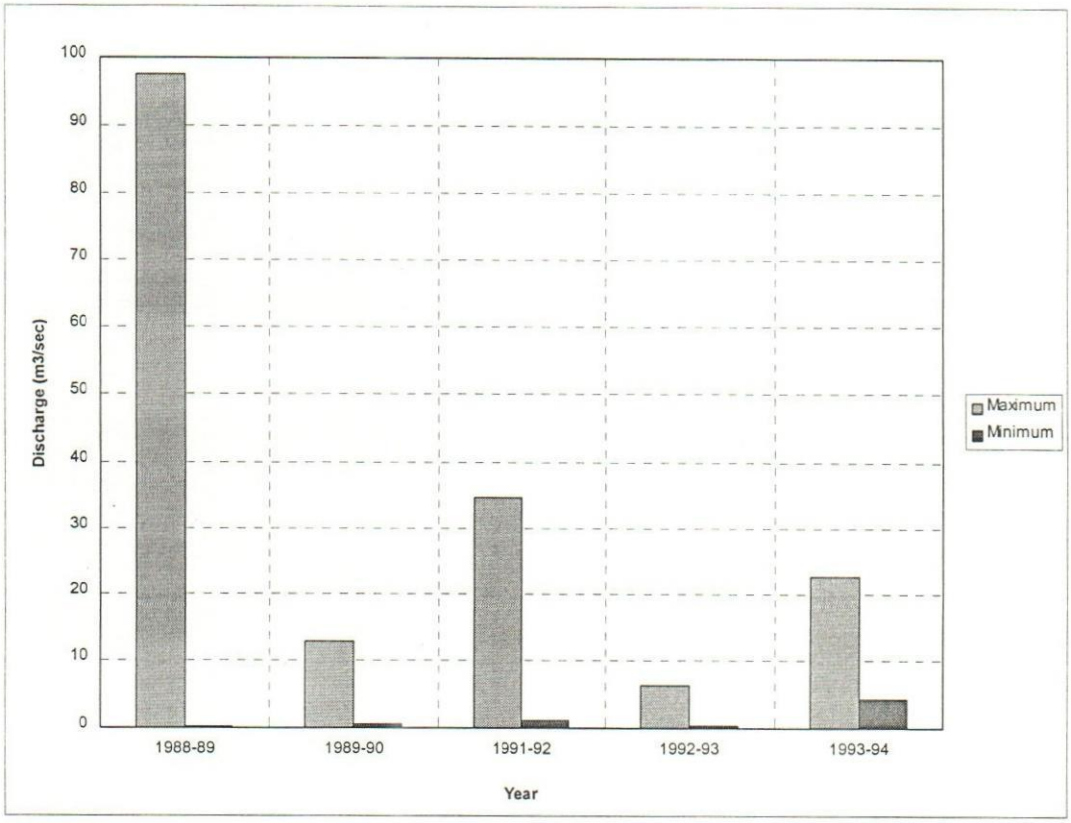

Figure 9: Variation in the annual maximum and minimum discharges of the River Bhairab

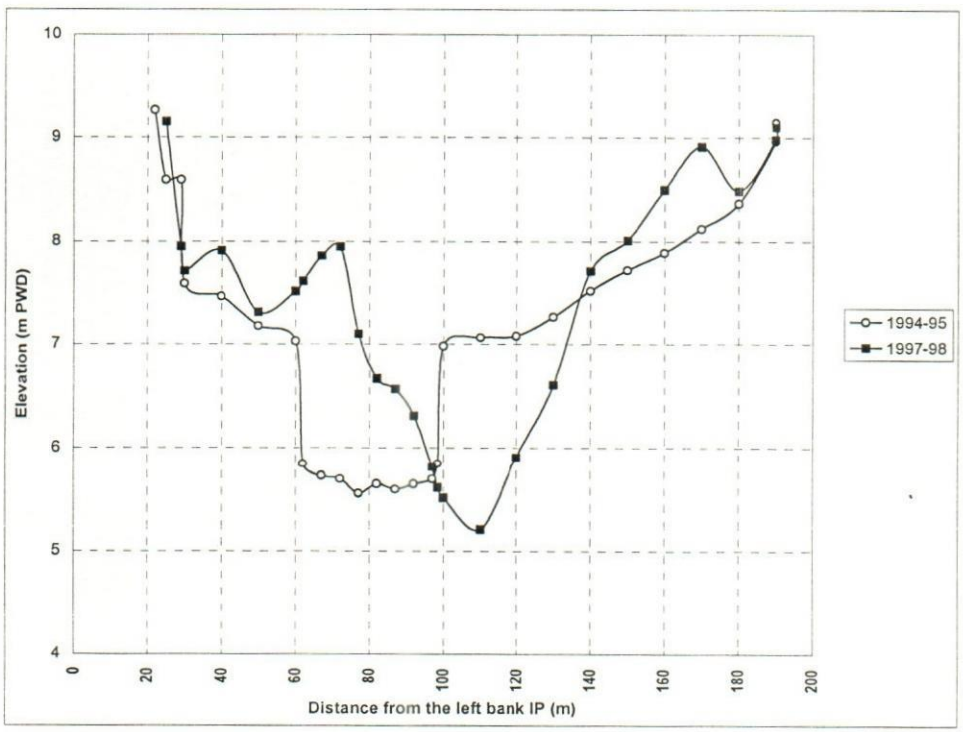

Figure 10: Change in the cross-section (BH # 1) of the Bhairab River from 1994-95 to 1997-98

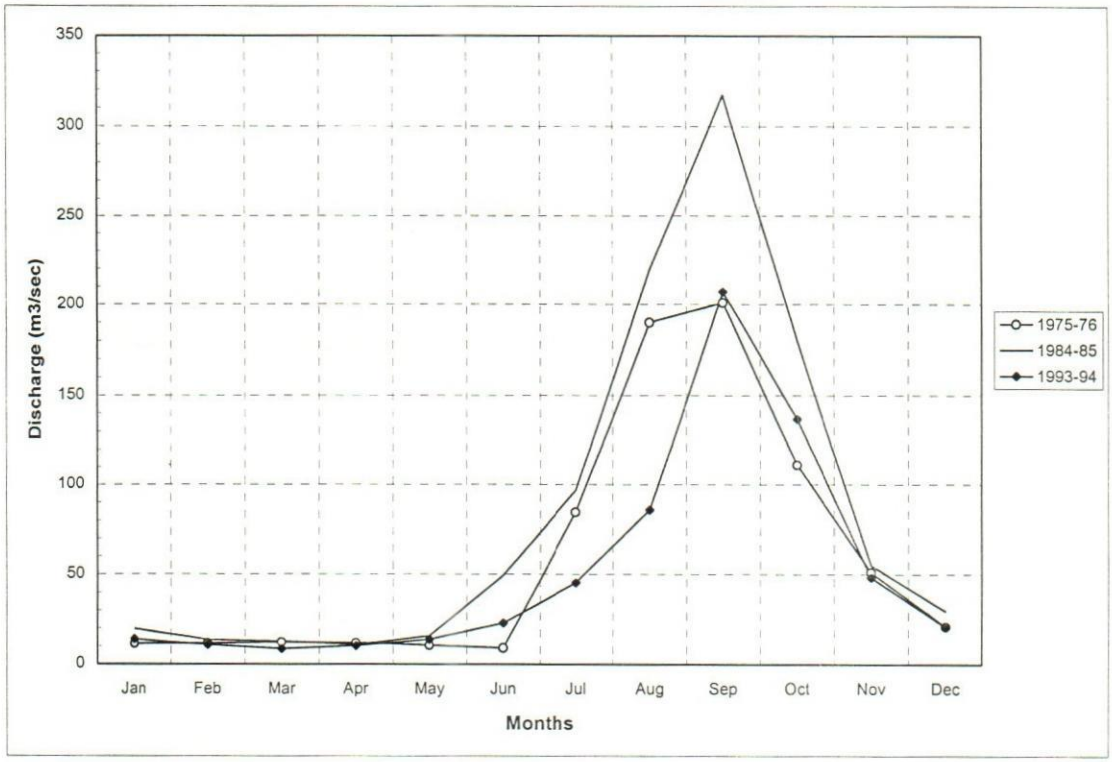

Figure 11: The mean monthly discharges of the River Mathabhanga for the year 1975-76, 1984-85 and 1993-94

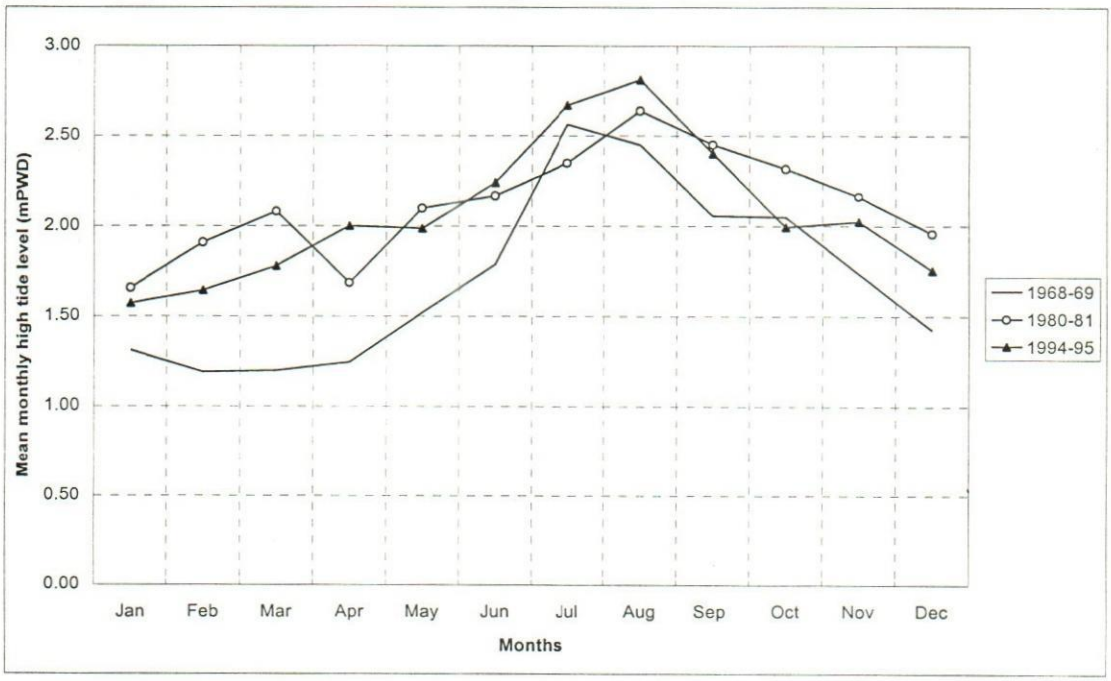

Figure 12: The mean monthly high water levels of the River Betna measured at Kalaroa for the year 1968-69, 1980-81 and 1994-95

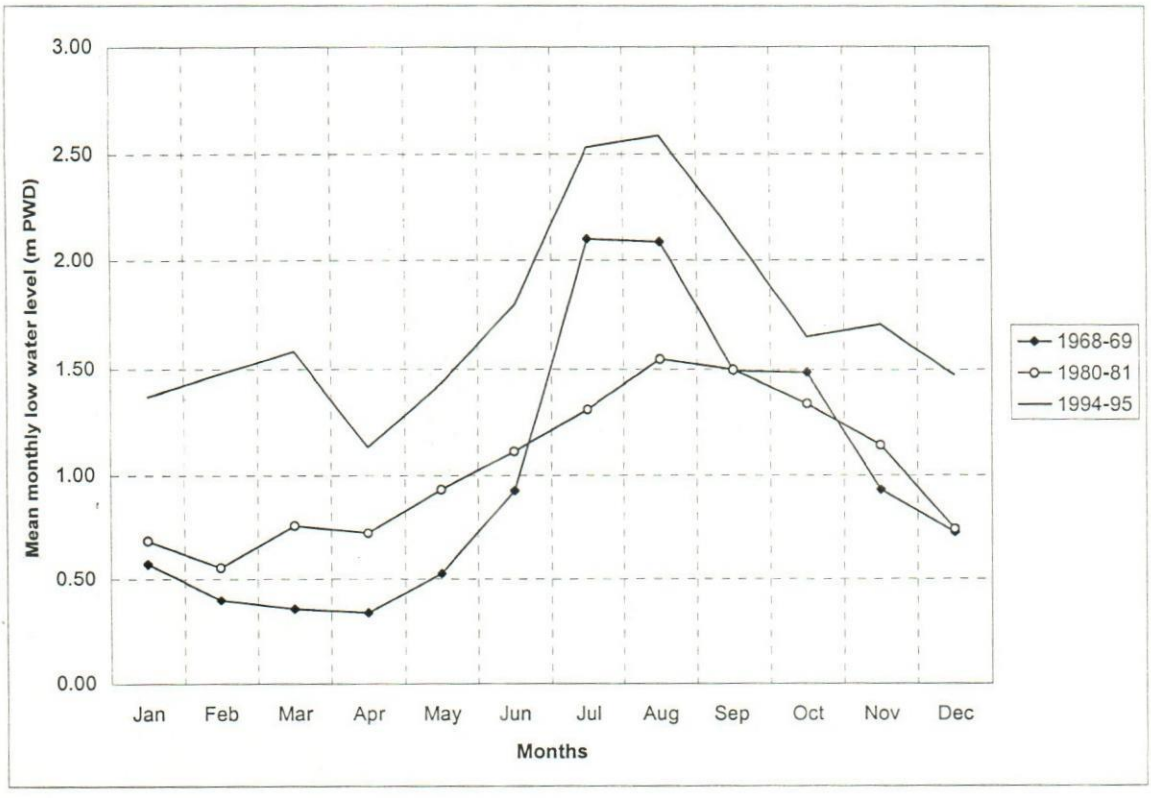

Figure 13: The mean monthly low water levels of the River Betna measured at Kalaroa for the year 1968-69, 1980-81 and 1994-95