Government of the People's Republic of Bangladesh
Bangladesh Water Development Board
Flood Plan Coordination Organisation

FLOOD ACTION PLAN

NORTHEAST REGIONAL WATER MANAGEMENT PROJECT (FAP 6)

UPPER KANGSHA RIVER BASIN DEVELOPMENT

Draft Final
January 1994

Shawinigan Lavalin (1991) Inc.
Northwest Hydraulic Consultants

in association with

Engineering and Planning Consultants Ltd.
Bangladesh Engineering and Technological Services
Institute For Development Education and Action
Nature Conservation Movement

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ACRONYMS AND ABBREVIATIONS

BBS	Bangladesh Bureau of Statistics
BFRSS	Bangladesh Fisheries Resource System Survey
BRDB	Bangladesh Rural Development Board
BWDB	Bangladesh Water Development Board
DAE	Department of Agricultural Extension
DPHE	Department of Public Health Engineering
EIA	environmental impact assessment
EIRR	economic internal rate of return
EMP	Environmental Management Plan
EPWAPDA	East Pakistan Water and Power Development Authority
FAP	Flood Action Plan
FFW	Food for Work
FPCO	Flood Plan Coordination Organization
FW	future with project scenario
FWO	future without project scenario
HTW	hand tube well
HYV	high yielding variety
IBRD	International Bank for Reconstruction and Development
IEE	Initial Environmental Evaluation
ISPAN	Irrigation Support Project Asia Near East
LLP	low-lift pump
LT	local transplanted
MPO	Master Planning Organization
NERP	Northeast Regional Water Management Planning Organization
NGO	non-governmental organization
NHC	Northwest Hydraulic Consultants
NPV	net present value
PD	person-day
PWD	Public Works Department
RCC	reinforced concrete
SLI	SNC-Lavalin International

US $1 = Tk 38

MPO Land Classification Terminology

Class F0	Land inundated to a depth of less than 0.3 m
Class F1	Land inundated to a depth of between 0.3 m - 0.9 m
Class F2	Land inundated to a depth of between 0.9 m - 1.8 m
Class F3	Land inundated to a depth of more than 1.8 m
Class F4	Land inundated to a depth of more than 1.8 m and on which deepwater aman cannot be grown

EXECUTIVE SUMMARY

The purpose of the project is to protect rice crops from pre- and monsoon flood damage, to provide flood relief to homesteads and infrastructure, to relieve drainage congestion and support pond aquaculture, and to reduce the risk of channel avulsions and the corresponding loss of land and property.

The Upper Kangsha basin extends over much of the western seasonally flooded area. There is good potential to increase productivity in both agriculture and pond aquaculture. However, flash floods in the region damage crops, flood fish ponds, damage roads and bridges, and submerge homesteads. The following general principles were applied in identifying interventions:

- Embankments were considered only where the protected area had alternate drainage routes;
- The protected areas are kept open on at least one side to facilitate fish migration; and,
- Major structural interventions were to be avoided on the unstable alluvial fans.

The proposed initiative identifies four strategic intervention points along the Kangsha system:

- *Improving the Malijhee River drainage*, which involves straightening the Bhogai, Malijhee, and Kangsha Rivers;
- *Diverting a portion of the Malijhee River* flows through an excavated channel into the Mogra River basin, along with improving the Mogra River channel to prevent aggravating flood conditions there;
- *Extending the Konapara embankments* for 20 km from Bahirshimul to the present confluence of the Malijhee and Bhogai Rivers;
- *Extending Kangsha right bank embankments* for 35 km from Jaria to Kharia River outfall;
- *Improving the Someswari River* by upgrading, paving and closing all bridges on the Durgapur-Jhanjail road which would then serve as an embankment. In addition, the newly avulsed Atrakhali channel would be closed and flows diverted back to the Someswari and old Someswari Rivers.

The project would be implemented by BWDB at an estimated cost of US $21.4 million

NERP DOCUMENTS

The Northeast Regional Water Management Plan is comprised of various documents prepared by the NERP study team including specialist studies, the outcome of a series of public seminars held in the region, and pre-feasibility studies of the various initiatives. A complete set of the Northeast Regional Water Management Plan Documents consists of the following:

Northeast Regional Water Management Plan

Main Report
Appendix: Initial Environmental Evaluation

Specialist Studies

Participatory Development and the Role of NGOs
Population Characteristics and the State of Human Development
Fisheries Specialist Study
Wetland Resources Specialist Study
Agriculture in the Northeast Region
Ground Water Resources of the Northeast Region
Surface Water Resources of the Northeast Region
Regional Water Resources Development Status
River Sedimentation and Morphology
Study on Urbanization in the Northeast Region
Local Initiatives and People's Participation in the Management of Water Resources
Water Transport Study

Public Participation Documentation

Proceedings of the Moulvibazar Seminar
Proceedings of the Sylhet Seminar
Proceedings of the Sunamganj Seminar
Proceedings of the Sherpur Seminar
Proceedings of the Kishorganj Seminar
Proceedings of the Narsingdi Seminar
Proceedings of the Habiganj Seminar
Proceedings of the Netrokona Seminar
Proceedings of the Sylhet Fisheries Seminar

Pre-feasibility Studies

Jadukata/Rakti River Improvement Project
Baulai Dredging
Mrigi River Drainage Improvement Project
Kushiyara Dredging
Fisheries Management Programme
Fisheries Engineering Measures
Environmental Management, Research, and Education Project (EMREP)
Habiganj-Khowai Area Development
Development of Rural Settlements
Pond Aquaculture
Applied Research for Improved Farming Systems
Manu River Improvement Project
Narayanganj-Narsingdi Project
Narsingdi District Development Project
Upper Kangsha River Basin Development
Upper Surma-Kushiyara Project
Surma Right Bank Project
Surma-Kushiyara-Baulai Basin Project
Kushiyara-Bijna Inter-Basin Development Project
Dharmapasha-Rui Beel Project
Updakhali River Project
Sarigoyain-Piyain Basin Development

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1. INTRODUCTION

1.1 General Information

BWDB Division:	Mymensingh and Tangail O&M and Netrokona WD
District:	Sherpur, Mymensingh and Netrokona
Thanas:	Sherpur, Sribardi, Jhengaighati, Nalitabari, Nakhla, Haluaghat, Phulpur, Dobaura, Purbadhala, Durgapur, Netrokona, Barhatta and Kalmakanda
MPO Planning Area:	Portions of 19, 21 and 22
Gross Area:	233,770 ha
Net Area:	195,740 ha

1.2 Scope and Methodology

This is a pre-feasibility study that was undertaken over a period of two months in mid and late 1993. The study team consisted of a water resources engineer, modelling specialist, social anthropologist, agronomist, fisheries specialist, and wetland resources specialist. Additional analytical support was provided by an environmental specialist, a senior modelling engineer, and an economist.

1.3 Data Base

Project analyses presented in this document was based mainly on secondary data supplemented by information obtained during field inspections and discussions with project area residents. Information and data sources used by the various analysts are as listed below.

Engineering analysis: Existing topographic maps, historic climatological and hydrological records, river and khal cross-sections surveyed by BWDB Morphology Directorate and by SWMC, BWDB reports, MPO Reports, personal field observations and interviews with beneficiaries, recommendations by BWDB officials and by local representatives.

Agricultural analysis: Data published in the "Land Resources Appraisal for Agricultural Development in Bangladesh" (AEZ Reports) for soils information, data published by the Water Resources Planning Organization (WARPO) for agricultural inputs, data assembled through the "Agriculture Specialist Study" by NERP, interviews with individuals and groups of farmers in different areas and on each land type, and hydrological data developed by the hydrology and engineering sections of the NERP.

Fisheries analysis: Topographic maps, BFRSS data, CIDA Inception Report, NERP Fisheries Specialist Study, field observations and local interviews, information provided by local representatives during field seminars held in Netrokona and Sherpur.

Wetland analysis: Topographic maps, local revenue department records, personal field observations and interviews with local people, and the "Wetland Specialist Study" published by NERP.

Socio-economic analysis: Published BBS data on demographic features, education and agriculture; reports of the Directorate of Public Health and Engineering, and the NERP data base on Population and Human Development, personal field observation and field interviews with various cross-section of local people, the opinions and suggestions from various local level representatives including NGO personnel and the Honourable Members of the Parliament.

1.4 Report Layout

A description of the biophysical features of the Upper Kangsha River Basin area is provided in Chapter 2. Chapter 3 describes the current status of development and resource management including a summary of the types of problems faced by people living in the basin. Chapter 4 briefly reviews previous studies directed towards development of the water resources and Chapter 5 lists trends which are occurring and which will continue if no interventions are made. Chapter 6 reviews water resource development options which were considered and recommended for the area.

In this basin, four areas have been identified for potential water development projects. Analyses for these identified projects have been provided in Chapter 7 (The Malijhee River Improvement Project), Chapter 8 (Extension of Konapara Embankment), Chapter 9 (The Greater Dampara Project) and Chapter 10 (The Someswari River Project). The annexes provide detailed information to support the main body of the report. Most tables are presented in the main body of the report where it is convenient to do so, but several tables which are more detailed are presented in Annex A and are referenced as Table A-1, A-2, and so on. The annexes include figures, the initial environmental examination, and other data in support of the main report text.

2. BIOPHYSICAL DESCRIPTION

2.1 Basin Boundaries

The Upper Kangsha River Basin extends over Sherpur, Mymensingh and Netrokona Districts between latitude 24°57'N and 25°16'N and between longitude 90°0'E and 90°58'E. It is bounded on the north by the international border, on the south by the Sherpur-Nakhla-Phulpur Road as well as the Mogra River, on the east by Netrokona-Kalmakanda Road and on the west by the Sherpur-Jhenaighati Road (Figure 1, Annex B).

2.2 Climate

There are no climatological stations within the basin. Mymensingh climatological station, though located outside the basin, is the nearest relevant station. Climatological data for this station is provided in Table A-1 (Annex A).

Maximum temperatures vary from about 29°C to 30°C with the highest temperatures experienced during the period between March and October. Minimum temperatures range between 16°C and 20°C.

Rainfall distribution shows an increasing trend from south to north. The mean annual rainfall varies from 2800 mm to 4400 mm. Just under 70% of the annual rainfall occurs in the four monsoon months (May-August) of each year. Annual potential evapotranspiration as measured at Mymensingh is 1506 mm with the lowest monthly amount in December (87 mm) and the highest monthly amount in April (162 mm).

2.3 Land (Physiography)

2.3.1 General Description

The basin is partly situated on the Meghalaya Fan and on the Old Brahmaputra floodplain. Alluvial fans are generally found along the Meghalaya foothills which are located along the northern border of the basin. The fans are characterized by sudden, irregular, channel shifts (avulsions) which result in periodic abandonment of some channel and development of new channels across the fan surface.

The Old Brahmaputra floodplain land consists of sediments that were laid down prior to the Brahmaputra River's avulsion in the 18th century. Geological Survey of Bangladesh (1990) described the Old Brahmaputra floodplain as containing poorly stratified fine sandy to clayey silt.

The topography slopes from the northwest to the southeast with land elevations varying from 31.5 m,PWD to 5.0 m,PWD. The basin elevation versus cumulative area relation is provided in Table A-2 and is illustrated graphically in Figure 2.

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2.3.2 Soils

The Upper Kangsha River Basin is covered by Old Brahmaputra Floodplain in the southern part, Piedmont Alluvial Plains in the northern part, and hill areas in the north-western margin.

The Old Brahmaputra Floodplain comprises a large area of Brahmaputra sediments laid down in broad ridges and basins. Ridge soils are mainly silt loams and silty clay loams while clays predominate in the basins and beels. Noncalcareous Dark Grey Floodplain Soils (dark grey silty clays and heavy clays) are the most significant type and occupy 40% to 60% of the area in the lowest basins and beels. Ridges have varying proportions of Noncalcareous Grey Floodplain Soils. Grey or finely mottled brown silt loams and silty clay loams are typically found in the highest ridges (10% to 30% of the area) and dark grey silty clay loams are found in the lower ridge sites (approximately 30% of the area).

The Piedmont Alluvial Plains occupy a narrow strip of land at the foot of the northern hills. They consist of complex soil patterns due to the irregular deposition of different textured sediments during successive flash floods. Deposits range from sand to clay with some older soils (Grey Terrace Soils) and a grey silty topsoil over a grey and red mottled clay loam subsoil. Grey Piedmont Soil and Noncalcareous Grey Floodplain soils are the major general soil types.

The hill soils in the north-western margin are yellow-brown to strong brown, friable, loamy and very strongly acid. Brown hill soils are the predominant type. Soil patterns are generally complex due to local differences in sand, silt and clay content of the underlying sedimentary rocks, and in the amount of erosion that has occurred. The relief varies from very steeply dissected to gently rolling. Floodplain land occupies less than 10% of this unit.

In general, the soil fertility level in the Upper Kangsha River Basin is low to medium. Phosphorous content is medium and potassium content is low on highlands and medium in lowlands.

The more loamy ridge soils have rapidly permeable subsoils and high moisture holding capacity, while the heavy basin or valley clays and the puddled topsoils and ploughpans used for transplanted rice cultivation have low permeability and low-to-medium moisture holding capacity. Permeability is impeded in the lower parts of the hill soils where soils cover clay rocks. Hill soils generally have low moisture content in the upper soil layers.

The cultivated topsoil is usually medium to very strongly acidic; the acidity is higher in permeable ridge soils and lower in basin soils as well as those soils puddled for transplanted rice cultivation. Subsoils are neutral in reaction.

2.4 Hydrology

2.4.1 River System

The major river network includes the Kangsha, Malijhee, Chillakhali, Bhogai, Nitai and the Someswari Rivers as shown in Figure 3. BWDB's hydrometric measurement stations for the Upper Kangsha Basin are also shown in Figure 3.

Malijhee River
The Malijhee originates in the Meghalaya Hills (Tura Range) and has a catchment of 160 km^2 within India. After entering Bangladesh the Malijhee continues southwards where on its right bank, near Surihara, it receives inflow from several channels and the Darong River which virtually double the flows in the Malijhee. The River then passes through a series of beels to the north of Sherpur after which it receives Chillakhali River flow and joins the Bhogai River at Danakusa (below Nalitabari).

No river gauging station has ever been installed on the Malijhee. Neither water level nor discharge data are available.

Chillakhali River
The Chillakhali River also originates in the Tura Range of the Meghalaya Hills and has a catchment of 120 km^2 within India. Within Bangladesh, the Chillakhali continues southward and passes through a series of beels south of Nalitabari before flowing into the Malijhee River.

Water levels in the Chillakhali have been observed by BWDB at Bathkuchi and indicate that the highest level occurred in 1985. Discharges have been observed since 1988; however the observed discharge data are too limited to define the peak flows accurately.

Bhogai River
As with the Malijhee and Chillakhali Rivers, the Bhogai River originates in the Tura Range of the Meghalaya Hills and enters Bangladesh at Nakuagaon. Above Nakuagaon, the River has a catchment area of 430 km^2 within India. Within Bangladesh, the River flows in a southerly course for 20 km from Nakuagaon to its confluence with the Malijhee five kilometres south of Nalitabari.

The River then bifurcates at Tarakanda into two branches, with the north branch continuing on to Sarchapur as the Bhogai River. The south branch is believed to be an ancient channel of the Malijhee River. The south branch/Malijhee River then rejoins the Bhogai River a short distance upstream of Sarchapur Bridge to form the Kangsha River. At this location, a small distributary channel separates from the Malijhee River and rejoins the Kangsha River upstream of the Kharia River outfall.

The Bhogai and Chillakhali Rivers have shallow channels, steep longitudinal slope, substantial transport of sand bed material during floods, and shallow "perched" channels whose banks are well above the main portion of the floodplain. Flood spills do not return to the river but rather they collect in the lower, flatter area of the Malijhee floodplain and in the Malijhee River itself.

Water levels are measured at Nakuagaon and Nalitabari and discharges are measured at Nakuagaon. The 24 years of discharge records indicate a range of daily discharge from 0.6 m^3/sec (1988) to 1240 m^3/sec (1983).

Kangsha River

The Kangsha River originates from the confluence of the Bhogai and Malijhee, just upstream of Sarchapur, from where it follows an easterly course until it joins the Baulai just south of Sukdevpur (east of the Upper Kangsha Basin and not shown in Figure 3). The Kangsha River receives cross-boundary inflows coming from the north via the Malijhee, Chillakhali, Bhogai, Nitai, Someswari, and other hill streams. The River also receives rainfall-runoff from the local area within Bangladesh which is mostly located to the North of the Kangsha.

The River divides into three channels at Thakurakona; Gholamkhali Khal, the Kangsha, and Dhonaikhali Khal. The Kangsha channel below the trifurcation has infilled with sediment which has virtually blocked the original channel, possibly due to:

- an avulsion of the Someswari River into the Shibganj Dhala, which now flows into the Kangsha River above Jaria, in 1963. It is believed that approximately six million cubic metres of predominantly fine sand and silt was eroded during that avulsion and that much of this sediment has been carried into the Kangsha River and deposited downstream of the trifurcation;

- restriction of the flow in the lower reach due to the construction of the Thakurakona-Mohanganj Road along the river's right bank and dykes constructed by local people along the left bank.

These factors combined to force the Kangsha River to shift into an earlier channel, the Gholam Khali khal, which flows to the northeast to eventually join the original Someswari and the Baulai River. Dhonaikhali Khal flows southward to join the Mogra River downstream of Netrokona, and the combined river becomes the Dhanu and eventually joins the Baulai River some 50 km further south. At present, about 70% of the Kangsha River's monsoon flow is conveyed through the Gholam khali khal, 10% through the lower Kangsha, and 20% through the Dhonaikhali khal. However, the entire dry season flow is conveyed by the Dhonaikhali khal.

Water levels in the Kangsha River have been observed by BWDB at Sarchapur, Jaria-Jhanjail and Mohanganj. Discharges have been measured at Sarchapur since 1991 when the peak flow was 300 m^3/s; water level records show the highest previous water level occurred in 1983 and corresponded to an estimated discharge of 350 m^3/s. In the middle reach at Jaria Jhanjail the 25 years of record indicate a range of daily discharges from 0 m^3/s (1979) to 1430 m^3/sec (1989).

Nitai River

The Nitai River originates from the Tura Range of the Meghalaya Hills and enters Bangladesh at Ghosegaon. Above Ghosegaon the River has a catchment area of 365 km^2 within India. Below Ghosegaon the Nitai follows a southeasterly course for 30 km before joining the Kangsha River 10 km upstream of Jaria-Jhanjail.

Water levels and discharges for the River are measured at Ghosegaon. The 24 years of record indicates a range of daily discharge from 0 m^3/sec (1967) to 981 m^3/sec (1991).

Someswari River
The Someswari River originates in the Meghalaya Hills and enters Bangladesh at Bagmara, which is 5 km above Durgapur. Above Bagmara, the River has a catchment area of 2419 km^2 within India.

The Someswari River is very unstable and changes its course frequently. In referencing the Rennell Map (Figure 4) it was noted that in 1768, the Someswari River flowed southwards from its canyon mouth to split into two at Durgapur. One branch flowed southward to the Kangsha River, more-or-less following the present route of the Durgapur-Jaria road, and the other branch flowed eastward into the Baulai system. In 1952 the Someswari River appeared as a single braided channel which turned eastward into the Baulai system, more-or-less following the earlier east branch alignment. Again, in 1963, the River reverted to the west of its earlier position and is presently known as the Shibganj Dhala. The abandoned channel is now called "Old Someswari River". Relic channels of these and earlier channels are still visible in the maps and satellite images in this area.

During the 1988 floods, the River formed a new channel to the east through Atrakhali khal about one kilometre above Durgapur. The Atrakhali channel is further developing with every flood in the Someswari River.

Discharges in the Someswari River have been measured by BWDB at Durgapur and water levels at Bagmara and Durgapur. The 19 years of discharge records for Shibganj Dhala channel indicate a range of daily discharges from 2 m^3/sec (1964) to 2490 m^3/sec (1984).

2.4.2 Flooding

The Kangsha River and its tributaries are the source of flooding in the area. The tributaries attain their peaks almost simultaneously (Figure 5) and overload the Kangsha River. Consequently, the Kangsha River spills over both its banks and damages standing crops, homesteads, roads and other infrastructure. The tributaries also spill out of their respective channels and cause flooding in adjacent areas.

Water Levels and Discharges for Various Return Period
Peak water levels and discharges of the Kangsha River system are presented in Annex A, Tables A-3 through A-5, based on statistical analysis of the historic data. Mean water level profiles for the rivers are shown in Figure 6. The profiles indicate that the highest water levels (24.0 m,PWD) occur on Chillakhali River at Bathkuchi.

2.4.3 Drainage

Basin drainage takes place from the north towards the south and southeast. The Kangsha River is the main drainage outlet for the northern area including cross-boundary inflows. Drainage from the southern area is mainly effected through the Mogra River.

All of the rivers spill over their banks during peak flood conditions. The river channels have raised banks such that the overbank spills generally drain away from the main channels into floodplain drainage channels that are often ancient courses of the main rivers, and return to the main rivers some distance downstream. Spillage from the upper portions of the Bhogai, Chillakali, and Malijhee Rivers collects in the Malijhee floodplain at the Bhogai-Malijhee confluence. The Kangsha River spills over both of its banks onto the floodplain at several locations in the basin.

The Sherpur-Nalitabari floodplain is experiencing drainage congestion because of slow drainage through the Kangsha River.

2.4.4 Water Bodies

Open water bodies
The basin contains approximately 5500 ha of beels and 12,600 ha of rivers and channels. Sitli, Chinakuri, Koilakuri, Omriputi, Rajdhala, Pakish, Hoogla, Mohishaura, Mandharua, Pagli, Raipha, Aspat, Baipha are the major beels in the basin (beel areas by thana are provided in Annex A, Table A.6). Of these beels, Sitli Beel in Durgapur thana is the most prominent. However, this beel is being infilled with sediment from the Someswari River which enters via Shibganj Dhala.

There is a good network of rivers and channels in the area. Kangsha and Someswari are the most prominent rivers.

Closed water bodies
In addition to open water bodies, there are about 15,000 ponds and ditches in the basin used for fish stocking and other household purposes. The ponds cover a total area estimated at 1700 ha. The highest concentration of ponds is in Kalmakanda thana (10 per km^2). The pond area by thana is given in Table A.6.

A general problem for pond aquaculture in this area is that flash floods annually inundate most of the ponds which discourages people from investing in intensive pond aquaculture systems.

2.4.5 Surface Water Availability

The 50% (2-yr), 80% (5-yr) and 90% (10-yr) dependable flow in the Bhogai River at Nakuagaon, Nitai River at Ghosegaon, Someswari River at Durgapur and Kangsha River at Jaria-Jhanjail are given in Table 2.1. The data illustrate that the Kangsha River and its tributaries above the

Table 2.1: Dependable Flow in Lean Months

Station Number, Name, and River	Month/ Decade		Dependable discharge (m^3/sec)		
			2-yr	5-yr	10-yr
34 Nakuagaon, Bhogai River	Feb	I	3.52	2.60	2.29
		II	3.27	2.33	2.00
		III	3.07	2.22	1.91
	Mar	I	2.67	1.92	1.68
		II	2.88	2.02	1.67
		III	3.21	1.93	1.32
314 Ghosegaon, Nitai River	Feb	I	2.75	1.66	1.00
		II	2.52	1.47	0.84
		III	2.39	1.40	0.80
	Mar	I	2.14	1.22	0.88
		II	2.13	1.14	0.94
		III	2.39	1.09	0.44
263 Durgapur, Someswari River	Feb	I	20.45	14.80	12.89
		II	18.55	14.05	12.41
		III	17.12	12.70	11.26
	Mar	I	16.44	11.30	9.24
		II	14.30	9.58	8.41
		III	17.72	10.65	7.28
36 Jaria Jhanjail, Kangsha River	Feb	I	22.44	17.05	15.00
		II	19.96	14.88	11.98
		III	16.83	12.02	9.94
	Mar	I	15.40	11.03	9.02
		II	13.61	8.52	7.05
		III	16.67	8.86	5.79

Someswari confluence have little water for irrigation use. Although there is water in the Someswari River, the channel's instability prevents development of any irrigation system based on its flow. There is, however, ample scope for low lift pump irrigation from the Someswari-Kangsha System.

2.4.6 Ground Water

Usable and available groundwater recharge computed from thana resources which were estimated by WARPO are presented in Table 2.2. The data shows that there is little prospect for increased groundwater abstraction under STW technology.

2.5 Land/Water Interactions

2.5.1 River Morphology (Siltation and Erosion)

Kangsha River
The Kangsha River can be sub-divided into seven reaches that have similar morphologic and sediment transport characteristics. Key information describing these reaches are summarized in Table A.7, Annex A. The following brief comments are intended to highlight changes in channel stability and sedimentation processes along the river.

The Bhogai River, between the Indian border to Nalitabari is a steep piedmont stream (0.28 m/km), that is characterized by an irregularly meandering sand-bed channel that is incised into primarily sandy floodplain bank materials. The Bhogai can probably be considered a "Transport Reach", meaning that over the long-term, the river is neither degrading or aggrading since it can transport all of the incoming sediment load. There is evidence of recent bank erosion and widening, possibly in response to the unusually high floods that have occurred in recent years.

Downstream of Nalitabari, the river's gradient flattens as the channel spills onto the Old Brahmaputra River floodplain and turns eastward. Rennell's map of 1768 shows no major channel in this reach, with the Bhogai River apparently occupying a channel several kilometres north of its present location. This suggests the reach below Nalitabari has formed relatively recently. Maps from 1955 show this reach had a tortuously meandering channel with frequent ox-bows and meander scars. Efforts to channelize the river in recent years have produced a

Table 2.2: Usable and Available Recharge

Usable Recharge (Mm^3)			Available Recharge (Mm^3)			Present Use (Mm^3)		
STW	DSSTW	DTW	STW	DSSTW	DTW	STW	DSSTW	DTW
124	246	822	104	221	665	98	145	243

20

second branch to the south of the 1955 channel[1]. This southern branch is less sinuous and appears to be capturing more of the flow. The banks are much lower in this reach than along the Bhogai, which allows sediments to be stored overbank during spills. This feature, and the reduction in gradient below Nalitabari suggest that this is a natural deposition zone. However, this long-term deposition process may be affected by other factors, particularly if one of these channels is abandoned and the other one becomes the only major flow-carrying channel.

The dimensions of the channel and the tendency to meander increase noticeably just below Sarchapur, near the point where the Kharia River enters the Kangsha. The Kharia River is virtually completely silted-in and is morphologically inactive. However, according to the Rennell's survey, 200 years ago the Kharia was a major distributary channel of the Brahmaputra River. At that time the Kangsha River was a direct continuation of the Kharia River and displayed a similar channel pattern. Therefore, the present Kangsha River is occupying a former distributary spill channel which probably had a substantially different hydrologic regime than the present conditions. The channel is probably still adjusting to this change, and appears to be very slowly reducing its size and slope by point bar accretion. The tortuous meander pattern and active formation of inner levees within a wide active floodplain are signs of this adjustment as the river forms a new channel that is approximately one-half the width of the original channel.

The Someswari River enters the Kangsha River through the Shibganjdhala channel, just upstream of Jaria Janjail. There has been an avulsion on the alluvial fan of the Someswari River during the last 30 years which has resulted in increased discharges and sediment loads along the Kangsha River. Prior to this avulsion, most water and sediment from the Someswari did not enter the Kangsha River system; instead it flowed north of the Kangsha River and entered the Baulai River. This major channel shift has significantly altered the stability of the lower Kangsha River and its two main distributaries - the Ghulamkhali channel and the Dhonakhali channel. Sand deposition at the entrance to the Dhonakhali and lower Kangsha River has virtually blocked off these channels during the dry season and has caused more flow to be diverted into the Ghulamkhali channel. As a result, the Ghulamkhali channel has widened from a minor khal into the dominant river channel. This widening and degradation has added large volumes of sediment to the lower reaches, and this sediment is being deposited in the deeply flooded backwater zone as the Ghulamkhali approaches the Baulai River. This deposition is causing additional channel instability and aggradation near the junction with the Baulai River. These processes illustrate how some morphologic disturbances can propagate along a river system and cause additional channel shifting and sedimentation problems that are far removed from the point of the initial disturbance.

Someswari River

Sedimentation and channel instability associated with the Someswari River alluvial fan constitutes one of the most difficult flood control issues in the project area. Alluvial fans are formed when steep mountain streams exit from their canyons and spread over flatter unconfined lowlands. The decrease in channel gradient and reduction in velocity causes deposition of sand and gravel in the form of a fan shaped conical delta. Alluvial fans are characterized by sudden, irregular channel shifts which result in periodic abandonment of some channels and the creation of new channels

[1] The south branch existed prior to 1955 but was not connected to the Bhogai except through a minor channel. It is identified on topographic maps as the Malijhee River and appears to be a relic channel of the Malijhee. It originally drained Putia Bil and the area south of the Bhogai.

across the fan surface. As a result, channel shifting on alluvial fans is usually unpredictable and erratic.

The alluvial fan of the Someswari River covers an area of approximately 138 km^2. The overall gradient on the fan is relatively low for an alluvial fan; 0.5 m/km between the fan apex at Bagmara and Durgapur and 0.15 m/km downstream of Durgapur. As a result, the land surface has been built up only a few metres (typically less than 3 m) above the surrounding low-lying floodplain and beels. Most land on the active fan lies between an elevation of 9 and 15 m PWD. Consequently, the lower portion of the fan is deeply inundated during the monsoon season by backwater from the Kangsha River (backwater extends upstream to near Durgapur).

Most of the channels on the fan are composed of uniform sand, with a median size ranging between 0.25 and 0.40 mm and maximum sizes ranging between 1 and 2 mm. Unlike other fans in the region there are virtually no gravel or cobble sized materials in the river-beds.

Figure 4 shows past channel changes on the alluvial fan, based on maps from 1768 (Rennells' survey), 1952 (1:40,000 mapping from air photography), and 1989 (SPOT image). In 1768 a single channel of the Someswari River flowed southwards from its canyon mouth to the Kangsha River. East of the Someswari River Rennell's showed a large haor area (marked as "marshy lake" on Figure 4). In 1952 the Someswari River flowed in a single braided channel which turned east into the Baulai River system. This channel is called "Old Someswari River" in this report. The presence of channel scars and abandoned channels on the east and west side of the fan suggests the river probably shifted at least two other times in the interval between 1768 and 1952.

Local inhabitants reported that a landslide occurred in the upper catchment in the early 1960's. The resulting channel deposition on the fan is believed to be responsible for the river shifting back towards the west and excavating a new channel to the Kangsha River in the early 1960's. This new channel is termed the Shibganjdhala channel in this report. Approximately 6 million m^3 of predominantly fine sand and silt sized sediment was eroded during the course of this avulsion. Much of this sediment has been deposited overbank into low lying areas on the fan such as Sitli Beel.

The present-day Shibganj Dhala channel has an incised width at bankfull stage of about 100 m; however, the river spills out of bank in many locations and is depositing lobes of sediment over a 3 km wide zone. These broad sandy deposits extend as far east as the Jaria - Durgapur highway and as far west as the low lying haors near Sitli Beel. These recent sand deposits are visible as lighter-coloured overbank areas in Figure 7.

Two new avulsion paths have opened up since 1988 on the east side of the Someswari River, upstream of Durgapur near the fan apex (Figure 7). Local residents reported the Atrakhali channel developed after the 1988 flood when flow spilled through a minor distributary. Since then the channel has widened to approximately 60 m and has developed a permanent channel which flows eastward, through Rennells' "marshy lake", into a former course of the Old Someswari channel. A second spill channel is evident approximately 1 km upstream of the Atrakhali channel. There is also evidence of recent sand deposition near the west side of the fan apex, which suggests the river may also have spilled towards the Nitai River system. These features suggest that the locus of deposition and channel avulsion may be progressing up the fan.

Information about past rates of channel changes on the fan can be made by interpreting the discharge measurements that were conducted by BWDB at Durgapur. Figure 8 shows "specific gauge" plots for the Shibganjdhala channel and Old Someswari River channel. The graphs illustrate trends in water levels at specific discharges and provide a means for assessing long-term aggradation or degradation processes. It can be seen that there has been a trend of aggradation in the Old Someswari River since 1960; specific gauge heights have risen by as much as two metres with the largest changes occurring in the floods of 1960, 1973, and 1988. During the same period the Shibganjdhala has degraded by approximately one metre, which occurred primarily between 1965 and 1975 probably in response to channel widening and incision following the avulsion. Since 1975 the Shibganjdhala River levels have been relatively stable and may be rising following the flood of 1988. Formation of the Atrakhali channel since 1988 is likely a factor in the recent aggradation in the Someswari and Shibganjdhala channels.

Occasional measurements of suspended sediment concentration have been carried out by BWDB at Durgapur between 1965 and 1985. Using rating curves and published daily flow records, the annual suspended sediment loads were estimated to range between 1 and 6 million tonnes per year and to average about 2 million tonnes/year at Durgapur[1]. Errors induced during sampling and field analysis could be very large - actual sediment loads could be between 2.0 and 0.5 times the estimated values.

Additional sediment transport calculations were carried out to develop a better understanding of sedimentation processes along the fan. These calculations involved estimating the daily bed material loads using the Ackers-White and Engelund-Hansen sediment transport equations, and then summing up the daily loads over the year to arrive at estimates of the annual loads. The calculations were carried out at three locations:

- at the head of the fan, near Bagmara hydrometric station;
- approximately mid-fan on the Shibganj dhala River downstream of Durgapur;
- the Kangsha River at Jaria Janjail, 2 km below the Shibganj dhala confluence.

The calculated loads must be considered as "order of magnitude" estimates.

Estimated annual loads at all three locations are summarized in Table 2.3. The calculations show that the Someswari River transports in the order of 3.6 million tonnes of sand at the head of the fan near Bagmara during a major flood such as in 1988 and 1.3 million tonnes/year at mid-fan below Durgapur, indicating that more than half of the incoming sand load is deposited in this 14 km reach or lost to the Old Someswari River and overbank spills. By comparison, the Kangsha River at Jaria Janjail had the capacity to transport about 0.5 million tonnes of sand in 1988. Therefore, virtually all of the incoming sand load at Bagmara (85 %) is deposited on the fan.

These estimates do not include the finer wash load (silt and sand finer than 0.15 mm) which is flushed through the Shibganj dhala channel into the Kangsha River. It is this finer sediment that

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[1] These samples were taken with instantaneous "trap" samplers. They appear to include the suspended bed material load as well as the "wash load" (finer sediments such as silt and fine sand that are flushed through the channel system and therefore are not found in significant quantities in the bed), but they do not include the coarsest fraction of the bed material load which moves in direct contact with the bed as "bed load". The measurements have not been analyzed previously are of dubious quality; thus the sediment transport estimates have a wide margin for error.

is causing aggradation in the lower Kangsha River.

These features indicate that the pattern of flooding and channel shifting on the fan is very dynamic and is likely to continue in the future. Bed material transport rates are very high. Most of the sand-sized sediments are at present being deposited on the fan, either within the existing channels or overbank in lower areas such as Sitli Beel, while the finer sand and silt are being carried downstream into the lower Kangsha River where they are deposited. These processes must be taken into account in the implementation of any works which are planned to control the flooding, sedimentation, or river avulsions on the fan.

Table 2.3: Estimated Annual Bed Material Loads

Year	Fan Apex	Mid-Fan	Kangsha River
1987	2,600,000	680,000	390,000
1988	3,600,000	1,300,000	510,000
1989	2,210,000	380,000	390,000

2.5.2 Crop Damage

Floods from the tributaries damage boro and aus crops during the pre-monsoon season as well as deepwater and transplanted aman crops during the monsoon season. In response to a survey regarding the extent of crop damage around Phulpur[1], it was noted that significant (more than 50%) damage was reported by more than 50% of the responding households[2] in seven of the nine years between 1983 and 1991. Only in one year (1987) was there no damage reported in any of the three cropping seasons (Kharif I, Kharif II, or winter) and in one year (1986) the damage reported was slight.

In general, throughout the basin, high and late flood water occurs in the deepwater aman and transplanted aman fields when the crops are in their vegetative growth phase. The flash flood may occur more than once in a year damaging the re-transplanted aman. The damage is more severe when the flood occurs so late that farmers have no chance to re-transplant the crop. The aus is damaged by random flooding which can occur either at early or mature phases of the crop. The boro damage usually occurs when the crops are nearly or fully mature.

2.6 Wetlands and Swamp Forest

2.6.1 Natural Wetlands

Since the project is situated in the seasonally flooded area, the wetlands are characteristically seasonally flooded. Most of the wetlands are flat and shallow containing some small deep

[1] The People of Phulpur (Kangsha River Basin); A Monograph Prepared by the Social Anthropology Team, NERP, July 1993.

[2] Boro was damaged in one year, aman was damaged in four years, and aus was damaged in two years.

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pockets (beels) which retain water perennially. The total area of these perennial beels is about 3000 ha, which is a very small fraction of the monsoon wetland.

The ecological characteristics of the wetlands in this area vary according to their location. The entire northern belt is highland and the wetlands located in this area are all seasonal. The larger perennial wetlands are located in the eastern part of the project. Other major perennial wetlands are located at the confluence of Malijhee and Bhogai.

Because the wetlands are flat and shallow, they support a large number of aquatic plants in the monsoon, particularly submerged and rooted floating plants. The most common plants are Hydrilla verticillata, Nymphaea, Aponogeton and Otellia alismoide. Various species of grasses are found in these areas although there are no high grasses such as reeds.

Because the wetlands are small in area, fragmented and have a high level of human activity, the waterfowl concentration is low and other forms of wildlife are not common.

2.6.2 Swamp Forest

The is no swamp forest in the project area.

2.7 Upland Forest

A small section of upland forest exists in the northwestern corner of the project area. It is part of the 6000 ha upland forest which covers the small hilly region under Mymensingh Forest Division. The main species of this forest was originally Shorea robusta (*sal*) with very little undergrowth. However, the forest has mostly been depleted of this natural vegetation and most of the plants now found were planted by the forest department. They mainly planted Tectona grandis and Eucalyptus sp.

3. SETTLEMENT, DEVELOPMENT, AND RESOURCE MANAGEMENT

3.1 Human Resources

3.1.1 Land Use and Settlement Pattern

Land Use
Current land use is summarized in Table 3.1.

Table 3.1: Current Land Use

Use	Area (ha)
Cultivated (F0+F1+F2+F3)	195,740
Homesteads	8,325
Beels	5500
Ponds	1700
River/Channels	12600
Hills	325
Fallow[1]	1000
Infrastructure[2]	8580
Total	**233,770**

[1] Multi-use land, wetlands, grazing lands, village grounds. Includes F4 land.
[2] Government-owned land not appearing elsewhere.

Settlements
Settlements within the basin are mainly found in the form of villages along the levees of the rivers and along various road sides. In the western area of the basin where land elevations are higher, homesteads are also constructed in the fields. In the northern hilly areas, settlements are constructed at the foot of the hills. The river banks and road sides are densely settled, while settlements tend to be more sparsely scattered in the fields and hill sides. Settlements are extremely sparse in the eastern low-lying haor areas where the land elevations are very low.

Flood Damage to Housing
Substantial damage to housing is caused in the basin by flash floods from the Malijhee, Chillakhali, Bhogai, Nitai, Someswari and Kangsha Rivers.

Coping Strategies
In the higher area, homesteads platforms are usually raised by one meter or more to avoid flash floods. However, in low-lying areas, homesteads are raised even higher — as much as 3 or 4 m — to avoid monsoon flooding. In the low areas, necessary measures are taken to protect against erosion of homesteads against monsoon flooding. Generally, this involves constructing a seasonal protection wall around the homesteads with soil, bamboo and locally available grasses.

While flash floods usually recede from the homesteads in the western and northern areas within a week or so, monsoon flood water remains in the low-lying eastern area for a period of about five months starting in early June. If there is severe flooding, villagers generally make platforms inside their houses or shift their belongings to safer places, if available.

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Table 3.2: Population Distribution by Age Group (%)

Sex	Population Age Group (Years)						Total
	0-4	5-9	10-14	15-54	55-59	>60	
Male	16.7	15.9	13.5	45.0	2.1	6.8	100.00
Female	17.6	16.7	12.0	46.5	1.7	5.5	100.00
Total	**17.1**	**16.3**	**12.8**	**45.7**	**1.9**	**6.2**	**100.00**

Source: BBS, 1981 Population Census

3.1.2 Demographic Characteristics

The project area's total population is estimated to be 1,604,431 of whom 786,358 are female. The gender ratio is estimated to be 104 (males to 100 females). The total number of households are estimated to be 320,070 within 1,960 villages. The population increased by 10.3% in Netrokona district, 20.0% in Sherpur district, 30.0% in Mymensingh district, and 23.8% in Sunamganj district between 1981 and 1991.

The cohort distribution for males is: 32.6% below 10 years of age, 45.2% between 15 and 54 years of age, and 6.4% above 60 years of age. The corresponding distribution for females is 34.3%, 46.8%, and 5.0% (see Table 3.2).

The average population density is 686 persons per km^2, with density ranging from a maximum of 1015 persons per km^2 in Sherpur Sadar Thana to 343 persons per km^2 in Madhyanagar Thana. The average household size in the area is estimated to be 5.0 persons.

3.1.3 Quality of Life Indicators

Quality of life is usually determined by several key indicators. Those described here are literacy, access to health, sanitation, and pure drinking water facilities.

Literacy

In the project area the literacy rate are extremely varied[1]. According to the 1981 census, the literacy of the population at 5 years of age and above varied from 13.5% in Dharmapasha Thana to 22.7% in Netrokona Thana. The corresponding figures for females were 8.5% and 16.3% respectively for the same thanas. The rate appears to have increased slightly over the last 10 years. According to the 1991 census, the literacy rate for all people of Sherpur, Netrokona,

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[1] As described in the monograph "The People of Phulpur", the results of an eighty sample survey indicated that in the village of Nogua (a village composed primarily of agriculturalists), 51% of the respondents over 5 years of age (61% for female and 48% for male) were illiterate while in a separate survey in the village of Paikpara (predominately fishermen), 60% of respondents were illiterate (71% female and 48% male).

Mymensingh and Sunamganj districts is recorded as 14.65%, 18.09%, 19.30% and 17.20% respectively for both male and female.

According to the 1981 census, school attendance in the project area for all children five to nine years of age varied from 12.4% in Sherpur Thana to 20.9% in Netrokona Thana[1]. Attendance for females in this age cohort in these two thanas varied from 10.5% to 19.1% respectively. Attendance for all youths between the ages of five and 24 was 12.5% and 19.4% for these thanas while the corresponding attendance for females was 9.2% and 15.7%.

Many villages, especially in the east area, have no primary schools. The average number of primary schools per 10,000 population is estimated to be 3.9, 3.8, and 4.3 for Mymensingh, Sherpur, and Netrokona Districts (BANBEIS, 1990).

Rural Water Supply

Detailed information on access to rural water supply for drinking purposes is not available for the project area. However, for the rural areas of the district of Netrokona, DPHE[2] reports the availability of one working tube well for 108 persons. The corresponding figures are 118 and 122 for Mymensingh and Sherpur Districts. It is noted that most tube wells are located in the houses of the rich. This results in the poor having very limited access to potable water.

DOMESTIC WATER IN NOGUA

Insufficient water for domestic use during the irrigation season is a major problem in Nogua as well as in most of the surrounding areas. For the last six or seven years, following the expansion of irrigation driven by the increased development of shallow tube well technology, domestic tube wells have been yielding very little water in the months from February through April. For example, the winter of 1992 was a very dry year, it was difficult to lift water already in January and most domestic tube wells stopped functioning altogether in March and April. Domestic water was carried from the more distant deep tube wells which were irrigating rice fields. Generally, this results in an increase in women's work load since they are tasked with providing domestic water supplies. However, during periods of crisis, men will help.

It was also noted that when the water table is low, there are numerous accidents involving the handles of the manual tube wells. The amount of force that needs to be applied to the handle increases as the water table recedes. Should the operator slip, the handle will spring back with considerable force and cause injury to teeth, foreheads, or any other part with which it comes in contact. Doctors in Phulpur confirmed that they see many patients involved in such accidents (mainly women) during the months of March and April.

Source: excerpts from "The People of Phulpur" NERP Social Anthropology Team, July 1993

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[1] While school attendance appears to have improved over the past 12 years, surveys ("*People of Phulpur*", NERP, July 1993) suggest that in Nogua still as many as 40% of the children between the ages of 5 and 14 are not attending school and in Paikpara, more than 50% of the children in this age cohort are not attending school.

[2] DPHE, 1991-92

Sanitation
Specific information on sanitation facilities is not available at the project level. During field reconnaissance, it was noted that open space defecation is a common practice in the rural villages, particularly for males. During monsoon months, the low-lying haor inhabitants generally defecate in open running water. Women generally use kutcha latrines or defecate at a fixed spot which is protected by banana leaves or bamboo mats. Sanitary latrines are uncommon in the village environment, except for the very well-off and educated families.

Access to Health Services
The district headquarters of Mymensingh has a medical college and a hospital. Hospital facilities are available at all the other district headquarters within the project area. Similarly, all thanas have hospital facilities located at their headquarters. Access to health services is generally limited for rural villagers and is out of reach of the poor. According to the Directorate General of Health Services (1992), there is one hospital for every 159,208 persons and one doctor for every 21,621 persons in the district of Netrokona. The corresponding figures for Sherpur District are 229,463 and 26,682 and for Mymensingh District; 334,350 and 19,197. Each hospital bed must serve 5877 people in Netrokona District. For Mymensingh and Sherpur Districts, the corresponding figures are 4049 and 6594 respectively. Immunization coverage of children below two years of age is very low for the project area. The rate varies from 10% in Mymensingh Thana to 30% in all the thanas, except for Dharmapasha Thana which is 63% (1990).

3.1.4 Employment and Wage Rates

Village employment opportunities are predominantly related to agricultural activities though there is also fisheries related employment. The major crops are t aman and boro in the west area and boro in the east area. Jute is also grown in the west area. The employment which this provides for men mainly consists of activities such as transplanting and harvesting crops. For boro, transplanting occurs between December and mid-February and harvesting occurs in late April and May. The corresponding times for t aman are July-August and November-December respectively. Seasonal employment is available with well-off farmers, particularly in the eastern haor areas during the winter months for boro cultivation.

The wage rates for male agricultural labourers vary from Tk 30 to 45 with two meals per day during peak agricultural months. During months when there is no agriculture work, the wage rate varies from Tk 20 to 30 with or without meal.

During months when employment opportunities in agriculture are limited, some poor people migrate to Dhaka, Sylhet and Mymensingh Towns to work as rickshaw pullers, as construction workers, or sometimes in household activities. A considerable number of labourers also migrate to Sunamganj and Sylhet Districts to harvest the boro rice.

Employment opportunities for women are limited in the area. However, a few women are reported to be employed in the rice husking mills owned by the rich in the west area and as seasonal labourers, especially in the east area. The tribal women, particularly from Durgapur, Dhobaura, Haluaghat, Nalitabari and Jhenaigati Thanas work for agricultural activities as wage labourers. Their wages vary from Tk. 25 to 35 per day. A few poor women are also employed for the Rural Maintenance Program of CARE and some women migrate to the cities of Mymensingh, Sherpur and Netrokona to work as domestics. Their numbers, however, are very limited. Many villages have no such migrant woman labourers.

3.1.5 Land Ownership Pattern

Land ownership[1] is extremely skewed in the project area. More than 49.0% of the households are landless (with cultivable land less than 0.2 ha). Among the landless, about 2.7% have no homesteads of their own. If the definition of landless includes landholdings up to 0.4 ha, the proportion of households included increases by 9%. Among the others, the small (0.21 - 1.00 ha), medium (1.01 - 3.00 ha) and large farmers (more than 3.00 ha) are 25.5%, 19.4%, and 5.9% respectively.

The basin area has substantial amount of uncultivable land which include hills and pastures. The price of agricultural land varies from Tk 5,000 to Tk 30,000 per ker (0.12 ha) depending on the quality of the land and the intensity with which it can be cropped.

3.1.6 Land Tenure

Owner operation is common in the area. The large land owners, share out their lands to tenants for operation. The share cropping system is that one-half of the produce is retained by the land owners but they provide no inputs. For high yielding varieties of rice, one-half of the input costs are shared by the land owners. The leasing out of land in kind (chukti) is practised, particularly in the eastern area. Leasing out of land with advance payment — in kind or in cash (Rangjama) is common in the low-lying boro growing areas. The usual rate for such arrangements varies from three maunds (or Tk 600) to four maunds (Tk 800) of rice per bigha (0.12 ha) per year. This is paid in advance. Landless people have very little access to land under this tenurial arrangement since they are unable to provide the cash after which they must still purchase agricultural inputs.

3.1.7 Fishermen

Fishing is an important activity in the basin, particularly in the eastern side and in some of the low pockets. Competition over the fish resource is increasing every year. There are an estimated 6,000 to 10,000 traditional fisherman households in the area. Formerly, the large commercial fishing nets were fabricated by the wives of the traditional fishermen but they no longer have a monopoly over this trade. They now share the commercial fishing with the non-traditional fishermen. The only activity that traditional fishermen largely control is the handling of fish in the market place. Within the project area, the livelihood of the traditional fishermen is also being threatened as they come into conflict with agriculturalists over the use of wetlands (see box on following page).

The non-traditional fishermen are mainly an emerging group from the landless and poor agriculturists, especially from the flood plain areas. They fish in open water especially during monsoon months and sell the catch. The numbers of these non-traditional fishermen are increasing and nearly 20-25% of the households, particularly in the eastern area, are reportedly engaged in catching fish. These non-traditional fishermen are increasingly competing with the traditional fishermen for a resource which is shrinking in volume. They catch fish without paying jalmohal rent fees and the fishing techniques they use tend to be more exploitive of the resource.

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[1] It was noted that in Nogua village, women owned less than 2% of the agricultural land. In most cases (80%), women obtained their land from their parents; in the remainder, from their husbands. Women were unable to buy land from their own income.

A CASE STUDY IN CONFLICT:
AGRICULTURALISTS AND FISHERMEN

In 1989, a landless cooperative, the Bittahin Samabai Samiti, composed of 20 members (traditional fishermen) was formed in Paikpara with the support of Phulpur Thana BRDB staff.

The Samiti obtained a Tk 42,000 loan with an annual interest rate of 15% and the members jointly decided to lease the Narayanpatty Andar Duba jalmohal in Rupsi union which was some 8 km from their village. The 2.8 ha fishery was leased for a period of 3 years at a cost of Tk 5800.

During the first year, the fishermen spent Tk 10,000 for fingerlings, tree branches for piles, and a guards salary. During that first year, they harvested and sold fish worth Tk 20,000. Some of the profits were reinvested in the jalmohal.

In the second year, however, neighbouring farmers and non-traditional fishermen started forcibly catching fish from the jalmohal. The fishermen who owned the fishing rights were not strong enough to prevent this incursion into the jalmohal they had legally rented. In a further, deliberate action to weaken the fishermen, the farmers extended their rice plots into the jalmohal. They argued that the wetland should be used for rice cultivation and that the waterbody should serve for irrigation. Lastly, they claimed that in any case the beel could not be a profitable fishery any longer — though the previous year the fishermen had demonstrated that it was possible. The Thana Fishery Officer advised the Samite to file a court case which the fishermen subsequently lost.

The lack of support to traditional fisheries as demonstrated in this case study should serve to indicate that some political will is required if the current negative trends in fish production are to be reversed.

Source: Excerpts from "The People of Phulpur" NERP Social Anthropology Team, July 1993

For example, the non-traditional fishermen do not characteristically practice pile fishing but rather will tend to build dykes or put up fences and drain the water body to extract all the fish.

Another group of people who catch fish but should not be referred to as "fishermen" are the general public. They do not sell fish but catch for consumption by their own families. Sometimes, the rich among them lease the jalmohals to earn a profit from the catch and they may also act as financiers for the fishermen cooperatives.

3.1.8 Situation of Women

Women's role is agricultural production is important. Women's contribution, however, tends to be devalued and under reported. Though women generally do not work in the field, some poor women are reported to be working outside their homes, mainly for the Road Maintenance Program of CARE and activities like gathering wild vegetables and collecting fuel. The village women generally work in the post-harvesting activities of rice crops, especially drying, winnowing, per-boiling and storing of rice. Most women prefer working on homestead gardening and raising poultry/duck in addition to other common household works. However, the tribal women traditionally work outside their home in agricultural activities and such trend is common in the upper border thanas of the area.

3.1.9 People's Perception

General

Local people's perception of their problems were solicited. These were related mainly to water and its impact on their livelihood and their suggestions as to the nature of interventions which could solve these problems. These were collected through personal interviews, group discussions, and meetings with various cross-sections of the people during the relatively short field work in the area. Also, opinions and suggestions were sought in a one-day seminar held in the District Headquarters of Sherpur and Netrokona with the Honourable Members of the Parliament, District and Thana level officials, Union Parishad Chairman, representatives from village level organizations and NGOs. These are described below.

Problems

The major problems that people described were flash flooding, sand deposition and inadequate drainage. Flash floods, both pre- and monsoon, was referred to as the most serious problem in uplands as well as in the haor areas. Pre-monsoon flash floods damage boro crops in the eastern part of the basin which consists of Kalmakanda, Barhatta, and part of Netrokona Thanas. In recent years, damage to the boro crop has been frequent in many of the haors in the eastern area. The flash floods generally enter through open khals or overspill their riverbanks to inundate low-lying boro fields. The intensity of these flash floods are reportedly increasing because the rivers and canals are thought to be filling with sediment and because of increased rainfall in the catchment area.

Transplanted aman and aus are generally not damaged in the western area. Aus, t aman, and t aman seed beds are frequently affected by monsoon flash floods in the western part of the basin. Flood water spills over the banks of the Bhogai, Kangsha, Chillakhali, and Someswari Rivers, damaging standing aus and t aman crops. The water generally remains for 4 to 10 days in the upper areas. The intensity of this damage has reportedly increased in recent years.

Crop damage is also caused by sand deposition in the upland areas, particularly along the Bhogai, Chillakhali, Someswari, and Nitai Rivers. The sand is carried by the floods from the hills and deposited on agricultural lands. As a result, standing crops are damaged and lands remain unsuitable for subsequent cropping.

Drainage congestion in Malijhee-Chillakhali areas delays transplanting t aman rice. In some years, the water logging can be so prolonged as to prevent transplanting at all.

Damage to homesteads by wave action was referenced as a major problem by those villages in the eastern area of the basin. These villages, located in Barhatta, Netrokona, and Kalmakanda Thanas are eroding rapidly from monsoon wave action and their existence is reportedly threatened in some locations.

Suggestions

The following suggestions were made by people from the area during field discussions and seminars held in Netrokona and Sherpur:

- Construct embankments with drainage regulators on both banks of the Bhogai, Chillakhali and Someswari Rivers to stop overbank spilling, and re-excavate them as and where needed;

- Dredge the Baulai/Dhanu River from the outfall of the Kangsha River at Gaglajur Bazar to improve drainage of flash flood water from upland rivers;

- Re-excavate the Kangsha River with necessary loop cuts and river training to stop overbank spilling;

- Develop appropriate measures to stop overland flow of flood waters to reduce crop damage;

- Prevent sand deposition on crop land which are transported through the hilly streams, including the use of a Sabo dam to trap sand, and explore possibilities for removing and better use of deposited sand;

- Develop irrigation facilities in the upper areas of the basin, especially along the foot of the hills of the border thanas (e.g. Jhenaigati, Nalitabari, Haluaghat, Dhobaura, and Durgapur Thanas);

- Take measures to protect erosion of the most vulnerable villages of the east area caused by monsoon waves;

- Lease jalmohal only to local fishermen;

- Allow poor and subsistence fishermen to catch fish in the flood plains;

- Reserve a few jalmohals as fish sanctuaries;

- Take appropriate measures to develop aquaculture in the west area of the project.

- Conserve enough fish habitat for increasing fish production.

- Take afforestation program in the hills to stop erosion as well as to reduce the flow of sands from the upper lands.

3.1.10 Local Initiatives

Information on specific local initiatives to avert flood-related problems in the project area were not collected during the field visit. In general, however, people stated that their traditional practice is to organize local people to counteract crisis which arise as a result of flash floods and drainage congestion. The main activity in which they collectively engage is to construct dams on various localised canals to stop the intrusion of pre-monsoon flash floods. This reduces damage to the boro crop. They also assemble to re-excavate canals for quick drainage.

People also construct earthen cross-dams at several places across upland rivers and streams to irrigate boro fields. These schemes[1] are located on the Maroshi/Malijhee River; the Chillakhali River; the Bhoraghat River; the Bagpara Jhorna and the Gilagora Jhorna; three creeks near the village of Goborchina in Dhokin Maizpara union; the Nitai River; the Dekni creek and include

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[1] "Local Initiatives and Peoples Participation", NERP, July 1993, pp25

the Kodalia cross-dam. This work is generally organized by the more influential people in the locality and carried out on a voluntary basis by the villagers around a particular canal or field. Sometimes, they raise "chanda" to perform the work. More recently the union parishad have also allotted wheat or cash for this purpose.

3.2 Water Resources Development

3.2.1 Flood Control and Drainage.

BWDB has implemented various projects in the area. These projects are summarized in Table 3.3 and their locations are shown in Figure 1. The projects are intended to provide full flood control improvement to a gross area of 19,678 ha and irrigation to 8090 ha.

3.2.2 Irrigation

Surface Water

Two water retention structures have been constructed on the Malijhee and Chillakhali Rivers to provide irrigation to 8090 ha. The Malijhee water retention structure, however, is not in operation. People have been constructing earthen dam in the upstream reaches of the rivers and hilly streams and irrigating land by low lift pumps and traditional methods. According to AST 1991 Irrigation Census, LLPs and traditional technologies irrigated 8970 ha and 19,950 ha respectively of boro rice.

Table 3.3: Existing FCD Projects - Salient Features

Project Name	Type	Gross Area (ha)	Project Component
Malijhee River WRS Sub-Project	Irrigation	6650	A 7 vent (2.44mx2.54m) water retention structure
Chillakhali Sub-Project	Flood Control and Irrigation	1,440	14 km of flood embankment along Chillakhali River; A 23 vent (8-1.5mx3.0m, 15-1.5mx1.5m) water retention structure
Konapara Embankment Project	Flood Control and Drainage	3,480	22 km of flood embankment along the left bank of the Kangsha River from Bahir Shimul to Phutkai. 26 small pipe drainage structures (pipe diameter: 30 cm - 45 cm)
Kangsha River Improvement Project	Flood Control and Drainage	11,600	19 km of full flood control embankment along Kangsha River right bank from Jaria to Baroari village; Drainage regulators of various sizes at seven locations
Thakurakona Sub-Project	Flood Control and Drainage	3,158	13 km of full flood control embankment along the Kangsha River and Dhonaikhali khal Right bank from Baroari to Thakurakona; Three drainage regulators.

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Groundwater
According to the AST 1991 census, about 26,050 ha of land was irrigated by STW and 16,330 ha by DTW in the area.

3.3 Other Infrastructure

Eleven thana centres including two district headquarters are situated in this basin. In addition, there are many village markets and growth centres, schools and colleges in the area.

The area has a reasonably good network of roads. There are more than 1000 km of metalled and unmetalled roads. With the exception of Kalmakanda Thana, all thanas are connected to the district headquarters with metalled roads.

Flash floods from Kangsha River and its tributaries are disruptive. Almost annually, some of this infrastructure is inundated, thus disrupting communication systems.

3.4 Agriculture

The net cultivated area comprises about three-fourths of the total Upper Kangsha Basin. The major crop is rice, which accounts for 87% of the total cropped area. Among the other crops, wheat occupies 1%, jute 5%, pulses and oilseeds 3%, vegetables and spices 2%, and potato and sweet potato 1% of the total cropped area. A very wide range of minor crops, such as millet, cotton, tobacco, sugarcane are grown but in very small proportion to the others. Records indicate that the total cropped area has been reduced over the last ten years. Discussions with farmers and field visits indicate that the reduction is due to aus and deepwater aman being replaced by irrigated modern boro varieties. There has been a substantial increase in the irrigated area over the past years. The main crop which is grown under irrigation is boro whilst smaller areas of wheat, potatoes, and winter vegetables are grown.

The main cropping pattern practised on the permeable high ridges is an aus-early rabi crop rotation.

The general practice on impermeable highlands and medium highlands is an aus/jute-transplanted aman rotation sometimes followed by a rabi crop of pulses, oilseeds or wheat. A single transplanted aman cropping pattern, possibly followed by a rabi crop is also practised on medium highlands. The rabi crop, however, is produced entirely on residual soil moisture. High yielding varieties of aus are cultivated in some rainfed areas, and hyv transplanted aman is widely grown. With irrigation, the crop rotation mainly involves hyv transplanted aman followed by hyv boro.

On medium lowland, transplanted aman is mainly grown, followed by hyv boro with irrigation. In some areas, aus or jute are grown, partly followed by rabi crops.

On lowlands, hyv boro is grown with irrigation. The hyv has replaced many deepwater aman areas in the lowlands. However, deepwater aman, partly followed by rabi crops is still grown on the higher margins. In more recent years, farmers have started inter-cropping to fill the gap during the kharif season. This involves transplanting a deepwater aman into the wet hyv boro fields. Farmers report similar yields from the transplanted deepwater aman as from the normally broadcast deepwater aman. Local boro is cultivated in basin centres and old channels where early flooding is normal.

3.5 Fisheries

3.5.1 Floodplain fishery

More than 50 important seasonal and permanent beels and channels exist within the project area. The most prominent beels are Sitli, Chinakuri, Koilakuri, Omriputi, Rajdhala, Pakish, Hoogla jalmohal, Mohishaura, Mandharua, Pagli, Raipha, Aspat, Baipha, Sibdara, and Japur. In addition, about 120,000 ha of floodplain are inundated to depths exceeding 0.30 m by the monsoon floods. It is noted that during the monsoon, fish are more available in the more shallowly flooded western part of the project area than in the deeply flooded eastern part. This may be because fish move from the eastern deeply flooded area to the shallow region for grazing.

Except for a few jalmohals under the NFMP, most of the large and important jalmohals are leased out to a few rich persons who generally reside outside the area. Profits accrue to the lease holders. Leases are usually for a three year period. This system leads to conflicts with the local fishermen who are deprived of access to the fisheries resources and who have little opportunity to serve even as labourers since fishermen from outside areas are generally hired for the final catch. Sometimes rich people take lease of a jalmohal by showing a "shadow fishermen organization", which can even cause bloodshed between genuine fishermen and the appointed guards.

It was reported that lessees do not permit fishing by either traditional or non-traditional fishermen in the vicinity of the jalmohals even during the monsoon months. This assertion was not cross-checked but it is in agreement with another study in the area (Minkin, 1992). The extent of the jalmohal lessees' control over the area needs to be verified more closely during feasibility since this will have a significant bearing on the operability of any proposed intervention.

3.5.2 Species present in the area

Of the 155 species in the region, about 60-70 species inhabit in the project area. For several reasons, important species like *Mohashoal, Nanid, Pangas, Angrot, and Berkul* are now almost

Table 3.4: Major Fish Species in the Upper Kangsha River Basin

BARAMACH	CHOTOMACH
Catla, Rui, Mrigel, Kalibaus, Ghonia, Boal, Air, Ghagot, Rita, Ghagla, Chital, Gazar, Shoal.	Singi, Magur, Koi, Kholisha, Lati, Cheng, Garua, Tengra, Gulsha, Bajori, Bheda, Fali, Napit, Darkina, Mola, Chata, Dhela, Chela, Tit puti, Puti, Sarputi, Kani pabda, Pabda, Chanda, Boicha, Tatkini, Kanipona, Bashpata, Batashi, Bacha, Rani, Chapila, Keski, Laso, Tara baim, Baim, Gutum, Cirka, Kaikka, Shilon, Chanda, Icha .

extinct in the region (this year some *Mohashoal* which are costly and rare in the region were caught). At present, several other species are becomming very rare. These include *Catla, Mrigel, Ghagla, Bheda*, and *Koi*. The most common species in the area are listed in Table 3.4.

3.5.3 Duar Fishery

Duars, which are an indispensable part of a typical floodplain fishery, act as a refuge for the large brood fish during the winter season. These fish then migrate to a suitable spawning ground for breeding when water levels begin to rise. The Kangsha River has about 20 duars within this basin area. (Annex A, Table A.8). While no carp breeding ground could be identified during the short field visits in the area, a thorough survey is required to determine if these do exist within the system so that proposed interventions do not prove to be disruptive.

3.5.4 Sources of fish and breeding

It is generally understood that early rain, thunder, flooding, temperature, grassy or rocky land all influence spawning habits of fresh water fish. If conditions are favourable, during the pre-monsoon and early monsoon season fish migrate into shallow areas, usually from beels to adjacent grassy areas, to rivers, to canals, and vice-versa. Migration is usually contranatent, that is against the direction of current. When rain is localized on a haor, the haor will drain into beels through khals and water will flow to the river (provided that the river water level is lower). In this case, fish tend to move from the river up to the khal, to the beel and adjacent floodplain.

It is generally considered that perennial water bodies with shallow floodplain containing reeds are the best potential breeding grounds for most species. A number of spawning places of Chotomaach and large catfish exist within the project area. The existence of several deep duars in the Kangsha River makes the area ideal for fish production.

3.5.5 Production trends

According to a NERP study[1], fish abundance is directly related to the flood duration, water depth and access to flooded lands. Fish production in the project area has declined by an estimated 20-30% over the last five years, based on interviews with local fishermen. This decline may be due to:

- Siltation. Beel and river areas have been reduced and the depth and duration of flooding have declined.
- Reduced fish population as a result of overfishing,
- A reduction in reproductive fish stock due to indiscriminate use of some gear (current jal, kona ber jal etc),
- Increased fish mortality as a result of fish disease caused by water pollution in the beels, particularly during the month of December and January,

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[1] Fisheries Specialist Study, April 1993

- Construction of local dikes on spill channels, which reduce fish resource in the area by hampering migration,

- Rapid deforestation (trees and reeds) on the floodplain which causes fish loss by reducing fish food organisms and breeding places,

- Reduced fish habitat as a result of agriculturalists encroaching into fish producing beels,

- Short term leasing and the corresponding lack of security which encourages overfishing through complete de-watering. Previously most of the small beels were kept under villagers' use and as a result part of the overwintered stock were maintained in those beels.

- the absence of a proper extension service for the pond owners to develop culture based fish farming in existing ponds,

- Weak leadership, poor communication facilities, and inadequate infrastructure which prevents the fishing community from adequately defending its interests.

The basin is large (233,770 ha gross) and production varies significantly from its eastern to its western side. There are only limited fish catch data with which to develop estimates of fishery production within the basin; consequently only rough estimates of the fishery potential are possible. Impacts of various interventions were estimated on the basis of these rough estimates and an understanding of the fisheries dynamics and practices.

3.5.6 Fishing practice

Floodplain
Open water fisheries are the major source of fish in the area. Subsistence fishing occurs on the floodplain, mainly during the flood season. Commercial fishing occurs in beels and duars from December to March. Fishing occurs in beels and river duars on an annual basis although a few pile fisheries are harvested on a three year basis.

Katha fishing occurs but is not as widespread or commonplace as in the other parts of the Northeast Region because most water bodies in the project area tend to dry up too early for this method of fish harvesting to be effective. However, some kathas are installed in August and September as flood water recedes and are harvested during late October and early November. Gill netting and cast netting are more common fishing practices.

Closed water
Pond aquaculture is extensive within the basin. Most pond owners stock an uncounted number of fingerling into ponds. These fingerlings are simply caught from open water and no other basic management activities are applied (such as predatory and weed fish eradication, aquatic weed eradication, or regular application of feed and fertilizer). The growth and health of the fish are generally not monitored. Fish are usually harvested during the late winter and dry season.

3.5.7 Present Fisheries Resource Development

All of the fish are supplied to the other parts of the country through rail and trucks. There is no developed fish processing or marketing facility in the project area, partly due to the establishment of rail communication from Jaria Janjail about 150 years ago which transports fish from this area. Since the establishment of the railway, no initiative has been taken to improve local marketing facilities to ensure that a consistent, quality product can be maintained. Two ice plants (3 tonne capacity) in Jaria produce ice for icing fish.

3.6 Navigation

Changes are taking place in the region's river network. Sedimentation has reduced the navigability of all the rivers in the area. Except for the Kangsha River (from Jaria downstream along Dhonaikhali Khal), the rivers are not navigable during the dry season. However, in the monsoon, many areas including Kalmakanda Thana centre are totally dependent on waterway communication. In addition, the waterways provide the only means of communication and transport when the roads are inundated by floods.

3.7 Wetland Resources Utilization and Management

The most important use of the wetlands is for fodder. During the monsoon, water covers almost all grazing land so fodder that has been collected from the wetlands is of primary importance to sustaining livestock. People from areas which are shallowly flooded also depend on the wetlands for green fodder. Plants most commonly used are: Nymphaea sp. (shapla), Nymphoides sp. (*chandmela*), and other available grasses.

Quantification of their real economic value is difficult since most people collect what they need themselves. By necessity, the estimation is based on the replacement value of the fodder and on data collected from other areas. The fodder is mainly produced on the 30,000 ha of F3 land which remains fallow in the summer. The estimated gross total value could reach as high as Tk 1.2 million per year, which corresponds to an annual yield of Tk 40 per ha. The estimated employment in gathering for this is about 0.03 million pd (person-days) per year, which corresponds to an annual rate of 1 pd per ha.

Another important use of these resources is for fuel. Due to the scarcity of fuel around homesteads, people are becoming increasingly dependent on wetland products for fuel. These products include woody shrubs as well as grasses. Saplings of swamp forest trees are badly affected due to this scarcity with the result that degraded swamp forest trees can not be regenerated.

Other uses of the wetlands are:

- Food material. Mostly from Nymphaea sp. (shapla), Aponogeton sp. (*ghachu*), and Ottelia alismoides (*panikola*),
- Bio-fertilizer. From various weeds of the wetland,

- Medicinal plants. Mostly from Polygonum sp (*kukra*) and many others.

These common-property resources are of some importance to the poor, who are the most likely to engage in wetland gathering, to eat wetland food in times of scarcity, to depend on income from wetland products, and so on. Fodder and building materials tend to be collected by men, and food and medicinal materials tend to be collected by women. Information on resource management practices is not available.

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4. PREVIOUS STUDIES

Within this basin, BWDB has proposed various projects and has analyzed them to feasibility level. These projects are described in the following paragraphs and summary information is provided in Table 4.1. The locations of the projects are shown in Figure 1.

Ranjana-Malijhee Sub-Project
The purpose of this project would be to reduce flood damage in the area by constructing embankments to eliminate spill from the Malijhee River upstream of its confluence with the Chillakali (Figure 1).

Table 4.1: BWDB Proposed Projects

Project Name	Gross Area (ha)	Year of Study	Project Component
Ranjana-Malijhee Sub-Project	3,832	1989	Construction of 68.0 km of flood embankment Excavation and re-excavation of 65 km of drainage channel; Construction of four drainage regulators and one flushing sluice Construction of one drop structure
Bhogai-Kangsha Sub-Project	24,430	1989	Construction of 78 km of flood embankment; Re-excavation of 12.0 km of drainage channel Construction of 5 drainage regulators, four pipe sluices and one flushing regulator.
Dampara Sub-Project	11,780	1986	Construction of 30.0 km of flood embankment; Re-excavation of 25.0 km of drainage channels; Construction of two regulators (total: 22 vents); Construction of one-seven vent cross-regulator; Construction of six check structures.
Someswari River Flood Control Project	21,255	1990	116 km of flood embankment along Someswari, Nitai and Kangsha Rivers and 36.0 km along Shibganj Dhala; Re-excavation of 50.0 km of drainage channel; Construction of nine drainage regulators.

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It is considered that the major problem in this area is one of drainage congestion which results from persisting high water levels at the Malijhee/Bhogai confluence which backs up into the Malijhee. The Malijhee River acts as a drainage channel for this area and receives inflows from both banks. Embanking the river in the lower reach of this project would restrict the drainage from the adjacent low-lying areas and will only aggravate the existing problems. Embankments in the upstream reaches of this project may have some benefit in preventing overbank spills and local flooding but will aggravate flooding and sediment deposition in the downstream reaches.

More appropriate development options for this area are described in Chapters 6 and 7.

Bhogai-Kangsha Sub-Project
The Bhogai-Kangsha Flood Control and Drainage Sub-Project Feasibility Report recommended confinement of the Bhogai and Kangsha Rivers from the Malijhee confluence to Phutkai by means of embankments on both banks (Figure 9), and confining the Malijhee upstream of the confluence by means of an embankment on the right bank. The embankments would extend upstream to high ground. The Malijhee River would be kept open to the Bhogai River within the confined area.

Under present conditions, the Bhogai and Kangsha Rivers are backing up the Malijhee at the confluence. Confinement of the Bhogai and Kangsha Rivers would further increase water levels at the Malijhee confluence and will increase the drainage congestion in the Sherpur-Nalitabari floodplains. Further, drainage will be reduced from the low outside of the right bank which presently drains to the river system. As such the proposed intervention may cause more losses by bringing drainage congestion over a larger area than would be protected from flooding. For these reasons, the project is not recommended.

More appropriate development options for this area are described in Chapters 6 and 7.

Dampara Sub-Project
This project is intended to protect the area south of Kangsha River from Meda to Jaria from spills over the right bank by means of an embankment along the right bank. It proposes to use Baola-Meda Road as its western embankment. Internal drainage would be discharged to the Kangsha River through regulators.

NERP supports this project in principle but has two concerns regarding the concept.

Firstly, the Kharia River is a more appropriate western boundary for this intervention. Using the Baola-Meda Road as the western embankment will aggravate drainage problems to the west of the road such as presently occur near Jaria, which could result in people cutting the embankment.

Secondly, this area drains naturally toward the Mogra River. Water levels in the Kangsha will be raised with the implementation of various proposed projects along the Kangsha and Someswari Rivers and, consequently, drainage to the Kangsha River will be further impeded. Therefore, draining of the project area to the south into the Mogra River would be more efficient and a better option than draining it into the Kangsha.

Proposed options for the Dampara project will be discussed further in Chapters 6 and 9.

<u>*(a) Embanking Shibganj Dhala Channel*</u>
A proposal for constructing embankments on both sides of the Shibganj Dhala River from the bifurcation of the old Someswari channel to the Kangsha River confluence was made in 1990 (SMEC/BCL, 1990). The embankments would have been set back 100 m from the channel so as to prevent overbank spills into the low lying beel area on the west side of the fan (Figure 21). It was reported that the embankments would have increased flood discharges and increased water levels along the Kangsha River by about 0.8 m at Jaria. No assessment was made of impacts from future sedimentation.

The following comments indicate our assessment of the most likely outcome of this scheme:

- **channel widening:** The Shibganj Dhala channel appears to be widening at present. Embankments would effectively confine more flow to the channel, so that bank erosion processes would be greatly accelerated. Regime calculations suggest an equilibrium bankfull width that would be three times greater than the present. This erosion would reduce the proposed setback to zero in a few years and as a result the embankments would be subjected to high velocity river flows, direct bank attack, and scour.

- **channel instability:** Increased bank erosion and higher sediment loads carried by the embanked channel would cause the river to develop a more braided, laterally unstable channel. If the embankments were not protected with a stone revetment, the project would be at very high risk from breaching.

- **channel aggradation within embanked channel:** It is noted that the Someswari River transports about 2.5 million tonnes of sediment annually. Embankments would shift the locus of sand deposition towards the bottom of the fan near the confluence with the Kangsha River. It would not be possible to flush the coarser sand out of the system since the Kangsha River has the capacity to transport only 10 to 15 per cent of the sand load from the Someswari River. As a result, channel aggradation would progress upstream from the Kangsha/Someswari confluence. This aggradation would lead to increased channel shifting and attack against the unprotected embankments and possibly to increased flood levels. Continuous dredging operations in the order of 1-2 million m^3 per year would be required to maintain the conveyance of the channel. All of this material would have to be disposed on land outside of the active channel.

- **channel aggradation in the Kangsha River:** Finer sand and silt sediments which would be flushed through the embanked channel would deposit in the Kangsha River, particularly in its lower reaches. The aggradation would eventually lead to higher water levels along the Kangsha River, which would lead to a higher tailwater condition on the Shibganj Dhala River and would further aggravate conditions within the reach.

Confining the river in a narrow channel with high embankments would not be practical unless a major continuous dredging operation was carried out to preserve the channel's conveyance. The embankments would also require stone protection to prevent erosion during channel shifting and channel widening. Such a development would also produce major sediment impacts downstream and would also be susceptible to failure because a channel shift further upstream could cause the scheme to be completely by-passed. Therefore, the scheme proposed by SMEC does not appear to be appropriate for a highly unstable aggrading river such as the Someswari.

(b) Closure of Shibganj Dhala Channel and Rehabilitation of Old Someswari River

BWDB has made two unsuccessful attempts to close the Shibganjdhala channel and to divert the river back into the Old Someswari channel. SMEC's 1990 feasibility study evaluated a proposal for closing the Shibganj dhala channel and re-diverting the river back into the Old Someswari channel. An embankment was proposed along the right bank of the Old Someswari channel, and existing distributary channels (Kamarbari Dhala and Kagjur Dhala) would also be closed. The Someswari River would flow back into the Kangsha River about 10 km downstream of Jaria. Therefore, the scheme would not reduce discharges in the lower Kangsha River.

It was indicated that serious geotechnical problems would be encountered in any attempt to construct a permanent closure dyke across the Shibganj dhala channel, and that there would be a high risk of catastrophic failure. A second problem, not addressed by SMEC/BCL is that a substantial amount of ongoing maintenance dredging would be required at the entrance to the Old Someswari River to ensure that sedimentation did not trigger a new avulsion path. If this was not carried out, it is likely that the channel entrance would be abandoned again during future flood events as has happened before. Finally, it is unlikely that an unprotected embankment along the Old Someswari channel would be able to survive the future channel shifting and erosion that could be anticipated after the diversion was completed. Instead, there would be a high probability that the river would shift its course either south-west towards the Balos River or eastward towards the Baulai system.

Downstream impacts from the project would include greatly increased flooding and sedimentation problems along the lower Someswari/Gunai/Baulai River systems. Based on these considerations, the scheme does not appear to be very desirable or beneficial.

5. WITHOUT-PROJECT TRENDS (NULL OPTION)

The purpose of this chapter is to characterize the future of the project area with no intervention. It focuses on important trends and briefly describes the likely future scenario if these trends continue through 2015 as described in the following paragraphs.

Net population growth
The population is projected to grow at an annual rate of about 2.02% per year up to the year 2000 and 1.5 % per year up to 2015. This is above the national average but below the growth rate of the past ten years. With this growth rate, there are expected to be 1,920,830 people in the area by the year 2000 and 2,412,150 people by the year 2015.

Food grain production growth
A slight increase in overall production is expected due to increased cropping intensity and improved crop management. Without intervention, flash floods which occur more than once in a year would continue to damage aus and aman crops forcing farmers to shift to boro. The result will be more abstraction of surface and ground water for irrigation. This will be at the expense of other users (eg domestic, fisheries) and may cause longer term environmental problems.

The current land types would remain much the same though drainage conditions could be aggravated because of sedimentation. Current cropping practices and rotations are expected to remain stable with little change expected apart from that described above.

Openwater fisheries production
Observations of past fish production indicate that it is declining by 1-3% per year overall. Conversely there is great potential for increase in fish production if steps are taken to improve management of biological fisheries management. Lacking any way to decide between these two scenarios, it is assumed that future production will be equal to present production in the absence of project interventions.

River Course Changes
Malijhee, Chillakhali, Bhogai, and Nitai appear to be relatively stable although they have local erosion and siltation problems. The Kangsha River above the trifurcation has been stable between 1952 and 1990 (Figure 4), but downstream of the trifurcation the River is shifting towards Gulamkhali Khal. Gulamkhali Khal has been developing since 1963 in concert with the siltation of the Kangsha River. It is expected that the Gulamkhali Khal will continue to develop as the major outlet from the basin in the future since the present topography shows a bias in this direction.

The Someswari system appears to be the most critical in the area. Future channel instability can be expected during the next five to ten years on the Someswari fan. The Atrakhali River, which is one of the avulsed channels of the Someswari system, appears to be rapidly becoming the dominant low flow channel in the system. As this process continues in the future, the loss of flow on the Shibganj Dhala will cause sediment deposition rates to increase near Durgapur since the locus of sediment deposition will shift further upstream. This will lead to increased channel instability near Durgapur but may reduce the rate of siltation on the lower end of the fan.

Channel widening on the Atrakhali River channel will lead to further diversion of flows from the Someswari, increased flooding, channel erosion, and sedimentation on the eastern side of the fan.

These changes will threaten infrastructure, villages, crop lands, and fisheries habitat. A complete avulsion down the Atrakhali channel is possible and would seriously affect roughly 38 km^2 of land on the fan. It is likely that this increased instability will persist for at least 20 to 30 years.

The Old Someswari River will continue to carry less flow at high flood stages in the near future due to ongoing aggradation at the channel entrance.

In the long-term (10 to 20 years) there is a high probability of new flow paths and avulsions developing across the fan. Probable sites are shown in Figure 7.

The Shibganj Dhala channel which is the present course of the Someswari is in the process of developing a wider, shallower channel. The active channel and floodplain zone will extend over a width of about 3000 m. This zone will be subject to high velocity overbank spills, bank erosion, and sand deposition.

6. DEVELOPMENT OPTIONS

6.1 Problems

Through field visits, public consultations, meetings, seminars, reports and hydrological analysis, Northeast Regional Project identifies the following problems in the basin:

- Drainage congestion in Malijhee Basin;
- Kangsha River flooding;
- Someswari River flooding, erosion, sediment deposition, and channel avulsion.

6.2 Drainage Congestion in the Malijhee River Basin

6.2.1 Description of the Problem

Flooding occurs in the Malijhee basin where the steep border rivers (the Bhogai, Chillakhali, Malijhee, and Darong) converge and spill onto the Old Brahmaputra Floodplain. Simply stated, the runoff peaks are greater than the capacity of the outlet channel - the Kangsha River - to carry them, and the excess runoff spills onto the low-lying lands of the Malijhee floodplain. Contributing factors are:

- the large area of local runoff downstream of the border which also drains to this location;
- the relatively low elevation of the Malijhee floodplain relative to the Kangsha channel which was formed by an entirely different hydrological regime as was discussed in Chapter 2.

The outline of the drainage basin is provided in Figure 10. The total area of the catchment is approximately 1,700 km^2, of which approximately one-half is located in India. The upper basin is steep and flood peaks from this part of the basin are flashy in nature as shown for Nakuagaon in Figure 11. Several flood peaks occur in the upper watershed during a typical monsoon season, each lasting only a few days at a time. At Sarchapur, which is located downstream, the peak flows are considerably lower and persist for longer periods.

Figure 12 shows the total inflow and outflow hydrographs in the project area for the 1991 water year. Total inflows were re-constructed by adding the gauged flows in the Bhogai and Chillakhali Rivers to model-generated flows in the ungauged portion of the catchment (the Malijhee, the Darong, and the local area downstream of the international border). Total outflows include the discharges in the Kangsha River at Sarchapur plus two floodplain spills. As can be seen in Figure 12 the peak inflow was approximately two times as high as the peak outflow, with the difference being stored on the floodplain. It follows that completely eliminating the flooding in the project area would require or result in a doubling of the outflows, which would be difficult to accomplish. A more realistic expectation may be to reduce the flooding to an acceptable level.

Figure 13 shows the extent and depth of flooding in the project area in 1991. There are two primary areas of flooding, the first being located near the Malijhee/Bhogai confluence and the second being located along the Malijhee (south branch) where the Bhogai splits into two and crosses a low, wide floodplain.

6.2.2 Development Options

NERP has studied four options and a number of variants to solve the drainage problems of the Malijhee basin as will be described below. The analysis was made with a computer model of the Kangsha basin which has been developed by the Surface Water Modelling Center (SWMC) and the Northeast Regional Project (NERP). It includes a runoff model (NAM) for simulation of discharges from rainfall and evaporation as well as a hydrodynamic (HD) river model, MIKE11, which simulates the flows and water levels in the river system.

All simulations which are reported herein were conducted for the 1991 water year which was the basis for calibration of the model. It is noted that the 1991 peak had approximately a 1:2 return period in the Kangsha basin.

An index plan showing the existing projects in the basin and two development options in the Malijhee basin (Options 1 as 2 as described below) is provided in Figure 14.

Option 1: Embankment along the Malijhee River
This option considers embankment from the international border to the Malijhee/Chillakhali/Bhogai confluence to prevent the flash floods from spilling over the banks.

While embanking the upper portions of the Malijhee, Chillakhali, and Bhogai Rivers to prevent overbank spills may be helpful in reducing local flooding along the upper rivers, it would have little benefit in reducing flooding near their confluence and could possibly make matters worse by cutting off areas of overbank storage and spillage out of the project area. The lower Malijhee River receives drainage from both sides from the low areas of the floodplain, as discussed previously. This drainage, from approximately one-half of the drainage basin, contributes a substantial portion of the flow during flood conditions and these embankments would only be possible if alternate drainage routes are provided. Thus embankments within the Malijhee floodplain, by themselves, would only further restrict the local drainage without reducing the flood peaks and are not recommended.

Option 2: Full embankment of the Bhogai River to isolate it from the Malijhee
This scheme considers isolation of the Bhogai River from the Malijhee by confining it within embankments from the international border to Sarchapur. The purpose in doing so would be to prevent overbank spills from the Bhogai into the Malijhee floodplain from contributing to the flooding there. The left embankment would close off the Gangina-Ramkhali channel and other left bank spills. The south (Malijhee) branch would be reserved for draining the Malijhee River and the Chillakhali River independently of the Bhogai.

Modelling of this option indicates that it would cause higher peak flood levels in both the Bhogai River and the Malijhee. Flood levels would rise by about 0.8 m at Sarchapur and at the Malijhee/Bhogai confluence which would further impede the drainage of the Malijhee floodplain. Flood levels would be raised by 1.5 to 2 m within the embankments during flash floods which would need to be accommodated in the design of these embankments.

Thus it is concluded that the scheme to confine and isolate the Bhogai from the Malijhee floodplain is not technically feasible and is therefore not recommended.

Option 3: Bhogai, Malijhee, and Kangsha River channel improvements
This scheme considers improvements to the channels of the Bhogai and the Kangsha Rivers so as to lower the water levels upstream of Sarchapur. The channel improvements would consist of a number of loop cuts in the lower Bhogai River (the north branch), in the Malijhee River (the south branch), and in the Kangsha River downstream of Sarchapur as shown in Figure 15. The purpose of this work is to increase the carrying capacity of the river channel and thus to lower the water levels within the project area.

Modelling of this scheme indicates that the water levels could be lowered by 0.2 to 0.3 m within the project area. Although the reduction in flood level is relatively small the change would benefit a large area. Other improvements may be possible through channel excavation upstream of the Bhogai/Malijhee confluence and should be considered in the feasibility stage of the project.

Option 4. Diversion to the Mogra River Basin
Further improvements are possible by diverting a portion of the peak flows into the Mogra basin. A diversion channel would be constructed to connect from Sarchapur to the Mogra River or to the Saiduli River, which falls to the Mogra approximately 10 km downstream of Netrokona. Elements of this scheme are shown in Figure 10.

Modelling this scheme with a peak diversion rate of 100 m^3/s indicates the peak water levels could be reduced by 0.8m at Sarchapur and 0.2m in the Malijhee. This diversion would have the effect of increasing peak discharges in the Mogra and would tend to raise the water levels there unless additional measures are taken. Therefore two variants of this scheme were studied:

Variant 1: Several loop cuts would be made in the Mogra River from Netrokona to approximately 20 km downstream so as to lower the downstream flood water levels. This variant was tested with the model and was found to give water levels in the Mogra that were virtually unchanged from the present, which would mitigate the impact of the increased discharges. There is little benefit to extending the loop cuts further downstream since the downstream water levels are controlled by backwater from the deeply flooded area of the Baulai River and by overbank spills.

Variant 2: The alternative would be to direct the diversion flow via the Saiduli River into the Mogra approximately ten km downstream of Netrokona, thus reducing the peak discharges and water levels at Netrokona. The diversion route would follow a re-excavation of the Bismai River, which appears to be an ancient channel of the Mogra, toward the southeast and would intercept the runoff from the upper Mogra basin. Thus the discharges at Netrokona would be reduced below the present levels and the diversion flow would be split between the Dhanu and the Saiduli downstream of Netrokona. Modelling of this alternative indicates that the peak water levels at Netrokona could be lowered by as much as 0.4m below the present levels and, therefore, the scheme could result in an improvement in flood levels in the Mogra as well as improving the drainage conditions in the Malijhee River. Further improvements are possible by construction of loop cuts in the Mogra River as in Variant 1 described above.

6.2.3 Recommended Option

The recommended plan for developing the Malijhee floodplain drainage is shown in Figure 15 and consists of the following:

1. Construction of loop cuts in the Bhogai and Malijhee Rivers from their confluence to Sarchapur, and in the Kangsha River from Sarchapur to approximately 40 km downstream,

2. Diversion of peak flows to the Mogra River at a rate of approximately 100 m^3/s to the upper Mogra River upstream of Netrokona,

3. Re-excavation of the Bismai River to intercept the runoff from the upper Mogra basin into the Saiduli River and thence into the Mogra River downstream of Netrokona,

4. Improvement of the Mogra channel for a distance of approximately 20 km downstream of Netrokona by means of loop cutting to increase the discharge capacity and reduce water levels at Netrokona.

Modelled water levels in the Malijhee floodplain and at Sarchapur are shown in Figure 16, and discharges and water levels in the Mogra River at Netrokona are shown in Figure 17. As shown in these Figures the proposed works will reduce the peak water levels throughout the improved reaches of the Malijhee, Bhogai, and Kangsha Rivers, by as much as 0.8 m at Sarchapur and 0.3 m in the Malijhee floodplain. Discharges in the Mogra will be slightly increased at Netrokona but flood water levels will be maintained more-or-less at their present levels by means of channel improvements downstream of Netrokona.

The analysis assumed that the Dampara project would be drained to the Mogra River as will be discussed in subsequent sections of this Chapter. The possibility exists to improve flood conditions in the upper Mogra by connecting the Kangsha overflow diversion channel to the re-excavated Bismai River, which should be further investigated during the feasibility studies.

Further details and analysis of this scheme are provided in Chapter 7.

6.3 Kangsha River Flooding

The Kangsha River receives inflows from the several hilly streams (the Malijhee, Chillakhali, Bhogai, Nitai, Someswari, and others) as well as from the local drainage area downstream of the border. As was discussed previously these streams attain peak almost simultaneously (Figure 5) and load the Kangsha all at the same time.

The carrying capacity of different reaches of Kangsha River is given in Table 6.1 along with the approximate average annual peak inflows to the respective reaches. The figures indicate that the potential inflows greatly exceed the carrying capacity of the river in all reaches. To eliminate river spill, the following actions are proposed for different reaches of Kangsha River.

6.3.1 International Border to Sarchapur Bridge

Right Bank
There exists a road-cum-embankment on the right bank of the Bhogai River from the international border to the Malijhee confluence which prevents the Bhogai from spilling to the right bank area. No further works are planned.

Left Bank
There is an embankment (constructed by local bodies) from the international border to the Malijhee confluence, and another embankment from Bahirshimul to Phutkai (constructed by BWDB as the 'Konapara Embankment' - Figure 1). There is a gap between the Malijhee confluence and Bahirshimul through which the Bhogai River floodwater spills and damages crops outside the left bank.

Table 6.1: Carrying Capacity of Kangsha at Bankful Stage

Reach	Average Annual Peak Inflow (m^3/sec)[a]	Carrying Capacity at Bankful (m^2/sec)
International border to Sarchapur bridge	720	280
Sarchapur bridge to Someswari confluence	1050	400
Someswari confluence to Kangsha split	2550	750

[a] Sum of cross-boundary inflows only.

The gap is intended to be plugged by embankment under the proposed project 'Extension of Konapara Embankment' as shown in Figure 18, the details of which are furnished in Chapter 8. The drainage of the left bank area will be effected through Gangina and Ramkhali channels which drain to the Kangsha River at Phutkai. The connection at Phutkai will remain open.

NERP has included it in the basin development plan. However it is noted that this embankment will increase the flows in the Bhogai and Malijhee Rivers and will partly negate the benefits of the Malijhee River drainage improvements. The computer model indicates that this embankment could raise the flood levels at the Malijhee confluence by as much as 0.5 m. The model results are based on several assumptions which need to be confirmed through field investigation before this scheme is implemented.

6.3.2 Sarchapur Bridge to Jaria Janjail

Right Bank
This area generally lies within the proposed Greater Dampara Project area as shown in Figure 19. The Greater Dampara Project has been studied by BWDB in 1986 as the Dampara Sub-Project.

The Kangsha River spills over its right bank in this reach during high floods. The average annual flood level within the Kangsha River in this reach is about 12.2 m,PWD while the average ground level outside the right bank is about 10.5 m. The rate of spill is thought to be relatively small compared with the Kangsha inflows but it is sufficient to flood more than 35 percent of the project area outside the right bank to a depth of 0.9 m or more under annual flooding conditions.

The flooding situation in this area has worsened after completion in 1990 of the Kangsha River Improvement Project, which is located to the east of the Greater Dampara Project. The Lauari

River, which served as a drainage outlet from overbank area into the Mogra River, was closed and as a result the drainage of this area is forced to discharge to the Kangsha River. During high Kangsha water levels the drainage is impeded. People of the area have cut open the road-cum-embankment during floods, thus damaging crops and infrastructure within the Kangsha project area and cutting the vital road link to Durgapur and Jaria. These problems are expected to become more severe as the Kangsha River flood levels are raised by other projects in the basin.

The purpose of the Greater Dampara Project is to construct an embankment along the right bank to prevent the overbank spills from flooding the project area. The embankment would extend from the Kharia River to the existing Kangsha River Project embankment at Jaria.

It is proposed to route the drainage from this area to the Mogra River, to correct the restricted drainage from this area that has been discussed above. Since the overbank spills would be cut off by the embankment the drainage flows would be only local runoff and could be accommodated in the Mogra River. The existing regulator which discharges to the Kangsha River near Jaria would be retained to supplement the drainage of the project area during low Kangsha stages.

The BWDB feasibility report proposed to use the Baola-Meda Road (Figure 1) as its western embankment. However this embankment would cut off the drainage from the area lying west of the Baola-Meda Road and east of the Kharia River, such as has been done to the Laurai River drainage in the Kangsha Project. Northeast Regional Project feels that the project boundary should follow the hydrological boundary and thus make the project safe from external drainage. It is recommended that the Kharia River would be made the western boundary of the project area (Figure 19) instead of the Baola-Meda Road.

With these two modifications, the area is proposed to be developed under the 'Greater Dampara Project' (Figure 19), the details of which are provided in Chapter 9.

Left Bank
There exists a BWDB embankment up to the Gangina-Ramkhali channel outfall at Phutkai (Figure 18). It is not practical to extend the embankment downstream of Phutkai as the northern area has no alternate drainage route.

6.3.3 Jaria to Kangsha River Split

Right Bank
A BWDB flood control embankment exists from Jaria to Thakurakona (the Kangsha River Improvement Project - Figure 1). No further protective measure is required for the area although the embankment heights are to be reviewed as part of the Someswari River Improvement Project which will increase the discharges in the Kangsha River.

Left Bank
With the upstream development, including protection against Someswari River floods as will be discussed below, it is expected that the discharge in this reach of the Kangsha River will increase substantially. As a result, there may be more lateral erosion of the left bank. Field observation indicates that there are several locations where the river is eroding its left bank at the present time. Furthermore, construction of embankments on this side would cause higher water levels

by further confining the flow. It would be best to wait for the river to adjust to the upstream changes before doing anything for this area.

6.4 Someswari River Flooding, Erosion, Sediment Deposition, and Channel Avulsion.

6.4.1 Description of the Problem

The major problems in the Someswari River Basin are river flooding, erosion, sediment deposition, and channel avulsion. More than 55 percent of the area goes under water for a depth exceeding 0.90 m under average flooding conditions.

The river flow spills to the left overbank area through the newly avulsed Atrakhali channel, the Old Someswari River, and five bridge openings and over the Jaria-Durgapur Road. Flood water also spills to the right overbank area; to Sitli Beel and to the Nitai floodplain. Discharge hydrographs for the Someswari River at Bagmara/Bijoypur and the Kangsha River at Jaria (Figure 20) indicate that as much as two-thirds of the Someswari flow is spilled overbank or temporarily lost to floodplain storage during floods.

Sedimentation is another big problem in the area. As was discussed in Chapter 2 virtually all of the incoming sand load at Bagmara is deposited in the channel and floodplain between Bagmara and Jaria and in the areas subjected to overbank spills. The deposition turns the croplands unsuitable for cultivation and destabilizes the channel course. The wash load which is composed of fine sand and silt is carried further downstream and tends to deposit in the lower Kangsha.

Another major problem in this area is the periodic channel erosion during avulsion and channel shifting. After an avulsion occurs, land adjacent to the newly formed channel will experience erosion as the new channel widens to accommodate the high velocity flows from upstream spills and overland flows. Large amounts of coarse sand will also be deposited overbank during subsequent floods over a zone of several kilometres in width as the river spills out of bank.

Any work that is proposed on the Someswari fan must take into account the high rates of sediment transport, the channel instability, and the possibility of forcing more flow and sediment downstream.

6.4.2 Development Options

Potential measures for controlling future flooding and sedimentation on the Someswari fan range from providing upstream sediment control to constructing full flood control embankments along the major channels. Non-structural measures such as hazard zoning and sediment management methods have also been considered. It should be noted that some options have been included for completeness, even though it was considered unlikely that they would prove feasible. The alternatives are summarized in Table 6.2.

The following options have been studied by the Northeast Regional Project:

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Table 6.2: River Control Alternatives

Option	Purpose	Feasibility	Comments
Sediment trap	Reduce Sediment Inflows	Not Feasible	No Suitable Sites
Dredging	Increase Channel Capacity	Not Feasible	Annual Dredging Required
Fully Embank Shibganj Dhala	Channelize & Confine River	Not Feasible	Severe Downstream Impacts
Close Shibganj Dhala	Restore Old Someswari Channel	Questionable	Severe Downstream Impacts
Old Someswari Floodway	Reduce flows in Shibganj Dhala	Probably Feasible	Minor Impact on Flooding
Shibganj Dhala Floodway	Protect East & North Side of Fan	Probably Feasible	
Zoning & Fan Management	Reduce future damages	Probably Feasible	Non-Structural Option

Option 1: Sediment Basin

Suggestions have been made that the Someswari River could be stabilized by constructing a debris basin near the head of the fan, upstream of Durgapur. The purpose of the basin would be to reduce channel aggradation and sand deposition on the fan and to reduce the chances of future channel avulsions. Stabilizing the channel would be a prerequisite to constructing full flood control embankments to contain overbank flooding.

Given the fine nature of the sediment (typically 0.3 mm sand), huge flow volumes (flood inflows in the order of 3,000 m^3/s), and very high sand loads (2 - 4 million tonnes/year), an effective sand trap would require an extremely large reservoir to maintain sufficiently low velocities to promote settling. Settling basin and trap efficiency calculations indicate the sediment trap would have to be in the order of 1000 m long, 500 m wide and <u>at least</u> 30 m deep in order to significantly reduce the downstream sand loads. The basin would have to be cleaned out every year and the sand would be stockpiled on the floodplain.

Apart from other considerations, there are no suitable sites for providing a storage reservoir of this size within the study region. Therefore, this approach is not considered feasible.

Option 2: Dredging

The cross sectional area of the Shibganj Dhala channel is approximately 400 m^2 at bankful stage. Dredging the channel to provide a cross sectional area of 600 m^2 would require removing approximately 2 million m^3 of sand. This would lower flow levels by approximately 0.5 m at the upstream end of the dredged reach but there would be no impact on water levels at the lower end of the dredged reach.

Given the high sand loads on the river, the dredged channel could be completely infilled in a single flood event so that dredging would have to be carried out virtually every year. Furthermore, since the basin can be subjected to more than one extreme flood in the monsoon season, the channel could even be infilled before the end of the flood season. Based on these considerations, dredging should not be considered as a practical option for controlling flooding on the fan.

Periodic smaller scale dredging operations may be useful for assisting in river training and channel maintenance work. For example, dredging could be conducted to control the local channel alignment upstream of Durgapur to prevent bank attack and further shifting down the Atrakhali channel. The amount of material involved in this work would be in the order of 300,000 m^3 per year.

Option 3: Improvement of Old Someswari Channel Floodway

The Old Someswari Channel carries up to 25 per cent of the total flow during flood conditions. Local dredging at the entrance to the Old Someswari channel could allow more of the flood flows to pass down the channel and reduce flood magnitudes on the Shibganj Dhala channel. This approach could divide the inflows more or less equally between the Old Someswari and Shibganj Dhala channels. Approximately 1.5 million m^3 of sediment would have to be dredged over a 3 km length downstream of the channel entrance to accomplish this. It is expected that ongoing dredging (every three to five years) would be required to maintain the entrance.

This modification would reduce, but not eliminate flooding along the Shibganj Dhala channel. Since flows would be diverted to the Baulai River system there would be some reduction in flood levels along the Kangsha River as well. It is estimated that the flow diversion would lower water levels near Jaria by about 0.6 m during a high flood and would have virtually no impact on levels at Sarchapur, 60 km upstream. Therefore, the overall benefits from this approach appears to be minor.

Option 4: Protect East Side of Fan

Risks to flooding and avulsions could be reduced on the eastern half of the fan by raising the existing Jaria-Durgapur Road to act as a set-back dyke and by constructing river training structures (spurs and closure dykes) to prevent avulsions and spills from occurring upstream of Durgapur.

The Shibganj Dhala channel would be allowed to flow in a wide floodway and the haor area west of the channel would be left as a storage basin for overflowing water and sediment. Provision of a designated storage basin area on the fan is considered critical for regulating downstream flood flows and for reducing sediment impacts. Approximately 13 million m^3 of sediment could be stored in this area, which suggests the low-lying basins would be filled in about 20 years. If no sediment removal was carried out, the channels would probably begin to spill further westward into other low lying land. In the long-term, it might be necessary to utilize other areas on the fan for sediment storage once this basin becomes filled.

The main components of the scheme would include:

- raising and strengthening the existing road between Jaria and Durgapur to contain overflows from the Shibganj Dhala channel and Someswari River (upstream);

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- closing off Atrakhali channel;

- keeping open the Old Someswari Channel to allow overspills during high floods to the lower Someswari River/ Kamarbari Dhala/ Gunai/ Baulai River system. During high floods, the old Someswari River receives about 10 to 25 percent of Someswari flow. It is considered that the Old Someswari River can carry this flow at bankful;

- constructing river training spurs upstream of Durgapur to deflect flow away from the Atrakhali Channel and to prevent further development of an avulsion;

- closing off entrances to other potential avulsion paths on the east side of the river between Durgapur and the fan apex at Bagmara.

Option 5. Hazard Zoning & Hazard Management
A hazard zoning approach involves identifying the level of risk from flooding, erosion and sedimentation on the fan and attempting to guide future developments towards lower risk areas. Future developments in high risk areas would be discouraged. Efforts would be made to encourage people living in high risk areas to re-settle to safer sites. This approach emphasises non-structural measures at sites where structural flood control works are not feasible or economical.

High risk areas on the Someswari fan encompass the active channel of Shibganj Dhala (land west of the Jaria - Durgapur road) and lands in the path of the presently developing avulsions north of Durgapur. At the present, lower risk areas are located east of the Durgapur - Jaria road, and adjacent to the Old Someswari Channel.

Accompanying zoning, attention would be focused on implementing channel maintenance operations and local river training works to prevent undesirable channel shifts from developing. For example, if a new avulsion path began to open up, then remedial works would be carried out to prevent the channel from enlarging and capturing more of the channel's flow. Emphasis would be given to diagnosing channel pattern changes and implementing maintenance such as limited dredging or river training before the channel changes have developed into serious problems that require major structural works. Such actions would be limited in scope and would not attempt to provide complete protection during extreme flood events. Therefore, this approach represents a minimum level of intervention.

6.4.3 Recommended Option

From a river engineering point of view, protecting the eastern area (Option 4) by raising the existing Jaria-Durgapur Road and by preventing spills down Atrakhali channel appears to be the most viable option. An outline of the proposed work is shown in Figure 22. A detailed analysis for this option has been provided in chapter 10 under proposed 'Someswari River Project'.

7. PROPOSED PROJECT
MALIJHEE RIVER IMPROVEMENT PROJECT

7.1 General Information

BWDB Division:	Tangail O&M
District:	Mymensingh and Sherpur
Thana(s):	Sherpur, Nalitabari, Jhenaigati, Nakhla and Phulpur
Project Type:	Drainage Improvement
Gross Area:	34,280 ha
Net Area:	27,190 ha
Population:	280,500 (1991), 286,100 (1993), 319,700 (2000), 399,800 (2015)

Current land use is summarized in Table 7.1. The project area and proposed engineering works are shown in Figure 15.

7.2 Rationale

The project area has one of the highest distress levels in the region.

More than eighty five percent of the people of the area live on agriculture. They suffer repeated heavy damage of their crops by the flooding from the Bhogai, Malijhee, and Chillakhali Rivers. Flash floods occur in these rivers more than once per year and spill over a large portion of the project area. Standing crops are damaged as well as crops which have been re-transplanted following an earlier flood.

The flash floods also damage homesteads, developments, and infrastructure. The Jhenaigati-Sherpur Road and Nalitabari-Sherpur Road which are the only access roads into the area are disrupted by flash floods. Economic activity is brought to a halt and even emergency food and medical supplies cannot be brought into the area during floods.

Flash floods discourage the use of intensive pond aquaculture in the area.

Continued flood damage to the monsoon crop will force the farmers to shift to dry season boro. The resulting increase in abstraction of surface water and groundwater for irrigation will cause damage to wetlands and the environment during the dry season.

Table 7.1: Current Land Use

Use	Area (ha)
Cultivated (F0+F1+F2+F3)	27,190
Homesteads	1,720
Beels	1,570
Ponds	800
River Channels	1,500
Hills	-
Fallow[1]	500
Infrastructure[2]	1000
Total	**34,280**

People's distress and suffering will be reduced if the flooding can be controlled.

7.3 Objectives

The objectives of the project area are:

- to improve drainage from an area of about 34,280 ha;
- to protect crops, homesteads, roads, and other infrastructure;
- to manage ground water and surface water resources on a sustainable basis;
- to promote pond aquaculture.

7.4 Description

The project area is low-lying and poorly drained. As stated in Chapter 6, the main problem is drainage congestion caused by flash floods in the border tributaries, low elevations of the floodplain relative to its outlet, the Kangsha River, and the somewhat restrictive capacity of the Kangsha River. To improve the drainage of the area generally, it is proposed to increase the outlet capacity by cutting a number of meander loops on the Bhogai, Kangsha, and Malijhee Rivers. To further reduce the water levels during flood peaks, it is also proposed to construct a high-level diversion to direct a limited quantity of flood discharge (approximately 100 m^3/sec) through a re-excavated channel to the Mogra River.

To reduce the impact of diversion on the Mogra and on flood levels near Netrokona, it is proposed to straighten the Mogra River by means of loop cutting between Netrokona and Atpara. Further, to reduce discharges in the Mogra, it is suggested to re-excavate the Bismai River (Upper Saiduli) to intercept the local run-off that is presently draining to the Mogra River in the upper watershed. The details of the scheme are provided below and are shown in Figure 15.

7.4.1 Loopcuts

About 6.93 km of loopcuts are proposed at eleven locations on the Bhogai River and 2.77 km at four locations on the Malijhee River between the Bhogai-Malijhee confluence and Sarchapur. Another 6.92 km of loopcuts are recommended on Kangsha River downstream of Sarchapur. Loopcuts are proposed on Mogra River below Netrokona for a total length of 5.77 km.

To avoid deposition downstream of the cuts and to encourage the formation of the new channel, it is proposed that the new channel would be excavated to seventy percent of the existing section of the river in that reach.

7.4.2 Diversion Channel

The work includes excavation or re-excavation of a 35.0 km diversion channel from near the Sarchapur Bridge to the upper Mogra River. Wherever possible this diversion will follow the course of old channel alignments to minimize the disruption to residents. It is proposed to divert about 100 m³/sec of discharge from the project area. In addition, about 20.0 km of the Bismai Channel would be re-excavated to intercept the local drainage that is now draining to the Mogra River and to take this drainage to the Saiduli River. The final routing of these channels is to be selected during feasibility study.

7.4.3 Structures

Road Bridge
It is anticipated that the proposed 35 km of channel re-excavation will dislocate the main roads in at least two locations. Provision has been made in the project cost for construction of two 50-m span road bridges (provisional item).

Table 7.2: Pre-monsoon Depth of Flooding (by 1:2 Year Flood before 15 May)

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	27,190	27,190
0.30-0.90	-	-
0.90-1.80	-	-
>1.80	-	-
Total	27,190	27,190

[a] These figures do not reflect cultivable land acquired for loopcuts and re-excavation of drainage channels. Production impacts of land acquisition are documented in the Evaluation section.

Impact on Flooding
As a result of the proposed drainage improvements, the depth and extent of flooding will be reduced and the area of flood-free land will be increased as shown in Tables 7.2 and 7.3. In addition the duration of flooding will be reduced. The details are given in Appendix B.

7.4.4 Expected Benefits

The expected benefits of the project relate mainly to increased crop production resulting from protection of agriculture. Agricultural crops are damaged almost every year in the project area by Bhogai-Malijhee-Chillakhali flooding.

The present cropping patterns and crop production are given in Tables 7.4 and 7.5 respectively. These data were based on field visits and information which was collected by interviewing farmers in the project area with respect to average yields under damage-free conditions, types of crops which are damaged, percent of the crop area which is damaged annually, the reduced yields of crops after flood damage, and other factors. These data were analyzed to obtain the total production which is presented in Table 7.5.

Table 7.3: Monsoon Depth of Flooding (by 1:2 Year Max Annual Flood)

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	16000	19,200
0.30-0.90	6620	5,730
0.90-1.80	3770	2,100
>1.80	800	160
Total	27,190	27,190

[a] These figures do not reflect cultivable land acquired for loopcuts and re-excavation of drainage channels. Production impacts of land acquisition are documented in the Evaluation section.

Table 7.4: Present Cropping Patterns (ha)

Crop Pattern	F0	F1	F2	F3	Total
b aman				16 (2)	16
l boro				160 (20)	160
hyv boro			452 (12)	520 (65)	972
l aus-lt aman	1120 (7)	331 (5)	189 (5)		1640
l aus-rabi	800(5)				800
l aus-lt aman-wheat		132 (2)			132
l aus-lt aman-rabi	960 (6)	331 (5)			1291
l aus-hyv aman	640 (4)	265 (4)			905
l aus-hyv aman-potato		132 (2)			132
l aus-hyv aman-rabi	800 (5)	199 (3)			999
jute-hyv aman		662 (10)	75 (2)		737
jute-hyv aman-potato		265 (4)			265
jute-hyv aman-rabi		331 (5)	151 (4)		482
hyv aus-lt aman	1600 (10)	331 (5)			1931
hyv aus-hyv aman	1120 (7)	199 (3)			1319
lt aman	1600 (10)	794 (12)	377 (10)		2771
lt aman-rabi	2080 (13)	331 (5)	189 (5)		2600
lt aman-hyv boro	1280 (8)	1324 (20)	1772 (47)		4376
hyv aman-hyv boro	3520 (22)	662 (10)	565 (15)		4747
b aman-hyv boro				64 (8)	64
hyv aman-wheat	480(3)	331(5)			811
b aman-rabi				40(5)	40
TOTAL	**16000**	**6620**	**3770**	**800**	**27190**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

Table 7.5: Present Crop Production

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
l aus	5293	1.3	6881	606	1.04	630	7511
hyv aus	3087	3.0	9261	163	2.4	391	9652
b aman	64	1.5	96	56	1.2	67	163
lt aman	7371	1.8	13268	7370	1.44	10613	23881
hyv aman	7798	2.4	18715	2599	1.92	4990	23705
l boro	160	2.2	352				352
hyv boro	10160	4.0	40640				40640
wheat	943	2.0	1886				1886
jute	1484	1.65	2449				2449
potato	397	11	4367				4367
pulses	932	0.9	839				839
oilseeds	3105	0.8	2484				2484
spices	311	2.5	778				778
vegetables	1863	4.0	7452				7452

Source: NERP estimates.

Table 7.6: Projected Crop Pattern-Future Without Project (ha).

Crop Pattern	F0	F1	F2	F3	Total
b aman				8 (1)	8
l boro				152 (19)	152
hyv boro			452 (12)	520 (65)	972
l aus-lt aman	960 (6)	331 (5)	189 (5)		1480
l aus-lt aman-wheat		132 (2)			132
l aus-lt aman-rabi	960 (6)	265 (4)			1225
l aus-hyv aman	800 (5)	265 (4)			1065
l aus-rabi	800 (5)				800
l aus-hyv aman-potato		132 (2)			132
l aus-hyv aman-rabi	800 (5)	265 (4)			1065
jute-hyv aman		596 (9)	38 (1)		634
jute-hyv aman-potato		265 (4)			265
jute-hyv aman-rabi		397 (6)	189 (5)		586
hyv aus-lt aman	1440 (9)	265 (4)			1705
hyv aus-hyv aman	1280 (8)	265 (4)			1545
lt aman	1600 (10)	662 (10)	301 (8)		2563
hyv aman-wheat	480 (3)	397 (6)			877
lt aman-rabi	2080 (13)	397 (6)	226 (6)		2703
lt aman-hyv boro	1280 (8)	1324 (20)	1734 (46)		4338
hyv aman-hyv boro	3520 (22)	662 (10)	641 (17)		4823
b aman-rabi				40 (5)	40
b aman-hyv boro				80 (10)	80
TOTAL	**16000**	**6620**	**3770**	**800**	**27190**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

Table 7.7: Crop Production - Future Without Project

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
l aus	5293	1.3	6881	606	1.04	630	7511
hyv aus	3087	3.0	9261	163	2.4	391	9652
b aman	68	1.5	102	60	1.2	72	174
lt aman	7074	1.8	12733	7073	1.44	10185	22918
hyv aman	8243	2.4	19783	2748	1.92	5276	25059
l boro	152	2.2	334				334
hyv boro	10214	4.0	40856				40856
wheat	1010	2	2020				2020
jute	1484	1.65	2449				2449
potato	397	11	4367				4367
pulses	963	0.9	867				867
oilseeds	3209	0.8	2567				2567
spices	321	2.5	803				803
vegetables	1926	4.0	7704				7704

Source: NERP estimates.

Table 7.8: Projected Crop Pattern-Future With Project (ha)

Crop Pattern	F0	F1	F2	F3	Total
l boro				51 (32)	51
hyv boro			252 (12)	90 (56)	342
l aus-rabi	800 (4)				800
l aus-lt aman	960 (5)	115 (2)			1075
l aus-lt aman-wheat		172 (3)			172
l aus-lt aman-rabi	960 (5)	229 (4)			1189
l aus-hyv aman	960 (5)	172 (3)			1132
l aus-hyv aman-potato		172 (3)			172
l aus-hyv aman-rabi	960 (5)	286 (5)			1246
jute-hyv aman		573 (10)	42 (2)		615
jute-hyv aman-potato		286 (5)			286
jute-hyv aman-rabi		401 (7)	189 (9)		590
hyv aus-hyv aman-rabi		115 (2)			115
hyv aus-lt aman	1562 (8)	172 (3)			1734
hyv aus-hyv aman	1344 (7)	172 (3)			1516
lt aman	1536 (8)	172 (3)	105 (5)		1813
hyv aman-wheat	576 (3)	344 (6)			920
lt aman-hyv boro	3014 (16)	1031 (18)	1050 (50)		5095
hyv aman	576 (3)	172 (3)			748
hyv aman-rabi	192 (1)	115 (2)			307
hyv aman-hyv boro	3840 (20)	859 (15)	315 (15)		5014
lt aman-rabi	1920 (10)	172 (3)	147 (7)		2239
b aman-rabi				19 (12)	19
TOTAL	**19200**	**5730**	**2100**	**160**	**27190**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

The future cropping pattern and crop production without intervention (FWO) are given in Tables 7.6 and 7.7. Without intervention it is expected that Bhogai-Malijhee-Chillakhali flash floods would continue to damage aus and aman crops. The cropping pattern, yield, and total production would remain much the same as at present.

With the project (FW) it is expected that the cropping pattern will change as a result of the changes in the flood regime, and yields will increase as the flood damages are reduced. The changed cropping pattern is shown in Table 7.8 and the revised yields and total crop production are shown in Table 7.9.

Annual cereal production is expected to increase by about 15,979 tonnes from 108,525 tonnes (FWO) to 124,504 tonnes (FW) as a result of the project, an increase of 14%. Non-cereal production would increase by about 845 tonnes or 5%. This increase in non-cereal crops is mainly due to an increase in the area of oilseeds and vegetables.

The increase in cereal production implies a per person increase in cereal availability from 409 gm per person per day (FWO) to 469 gm per person per day (FW), an increase of +15% (Table 7.10). Current Bangladesh average consumption is 440 gm per person per day.

Table 7.9: Crop Production - Future With Project

Crop	Area (ha)	Yield (t/ha)	Total (t)
l aus	5786	1.3	7522
hyv aus	3364	3.2	10765
b aman	19	1.5	29
lt aman	13317	2.0	26634
hyv aman	12661	2.8	35451
l boro	51	2.2	112
hyv boro	10452	4.0	41808
wheat	1092	2.0	2184
jute	1492	1.65	2462
potato	458	11	5038
pulses	976	0.9	878
oilseeds	3253	0.8	2602
spices	325	2.5	813
vegetables	1952	4.0	7808

Source: NERP estimates.

7.4.5 Mitigation Measures Incorporated

No mitigation measures were incorporated into the project design. From past experience, it has been observed that with the high rainfall encountered through the region, improved drainage on some hydraulic regimes can secure agriculture production system without a significant loss in fisheries and wetlands and their associated bio-diversity.

Table 7.10: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2015)	FWO (2015)
Cereals	568	469	409
Non-Cereals	176	134	128

7.5 Project Operation and Maintenance

Under this development plan, operation and maintenance requirements would be minimal. They would be mostly limited periodic cleaning of drainage channels. In the long term some rehabilitation of the improved drainage channels may be required, depending on future patterns of siltation, but these cannot be properly anticipated now.

7.6 Organization and Management

During the early part of the feasibility study process, client groups would need to be organized to oversee project development. These client groups would be composed of representatives from the local farming and fishing communities and relevant thana-level technical officers. The groups would ensure that the problems of the area are clearly understood and adequately reflected in the feasibility work and that the technical solutions which are proposed address the problems in an acceptable manner. They would be continually briefed as the feasibility work was carried out and would need to confirm the conclusions of the exercise. They would also be informed as to details of designs being proposed by BWDB design engineers. The client groups would also monitor the construction program which would be carried out by BWDB.

BWDB would be responsible for undertaking technical work related to implementation of the project in accordance with current practice and would be responsive to the client group described above. The general tasks include completion of final designs, preparation of tenders, pre-qualification of contractors, awarding of contracts, and supervision of construction. The general management of BWDB activities would be under the Executive Engineer stationed in Netrokona. Construction supervision would be carried out by sub-divisional field staff.

The Department of Agricultural Extension (DAE) is responsible for the provision of extension services to the farmers within the project.

The Bangladesh Rural Development Board (BRDB) is responsible for assisting with farmer training and by organization into cooperatives which will then have access to short term crop production loans. Medium term credits are available to these cooperatives from all nationalized banks.

The supply of all agricultural inputs has been deregulated and the distribution placed into the hands of the private sector.

In summary, the organization and management of this project have a high dependency on central government for key inputs. The extent to which project targets are realized will be determined by how effectively it serves people's needs and how actively the local community participates in all stages of project development.

7.7 Cost Estimates

Total project costs are Tk 518.1 million.

The estimates of physical works are based on preliminary designs and lay-out plans prepared using four inch to one mile topographic maps and historic hydrological data.

Land costs reflect the current prices obtained from field interviews:

> single cropped - Tk. 120,000/ha;
>
> double cropped - Tk. 300,000/ha;
>
> suitable for homesteads and gardens (including high ridges along the river) - Tk. 500,000/ha.

Earthwork costs are based on BWDB's Schedule of Rates for Mymensingh O&M circle indexed to June 1991 prices. Structure costs are based on parametric costs developed for the Region, also indexed to June 1991 prices in accordance with the FPCO Guidelines for Project Assessment.

A summary of total costs is presented in Table 7.11 and details are provided in Annex C.

Table 7.11: Capital Cost Summary

Item	('000 Tk)
Structures	-
Embankments	-
Channels/Loopcuts	234,418
Bridges	56,100
Buildings	-
Land Acquisition	69,900
BASE COST	360,418
Physical Contingencies (25%)	90,105
SUBTOTAL	450,523
Study Costs[1] (15% of Subtotal)	67,578
TOTAL	**518,101**
Net Area (ha)	27,190
Unit Cost (Tk/ha)	19,055

[1]Includes preparation of EIA and Environmental Management Plan.

7.8 Project Phasing and Disbursement Period

Four years are required to implement the project. Feasibility studies and field surveys will be carried out in one year (year zero). Preparation of detail designs should start in year zero and should be completed in the second year. Land acquisition should be started in year zero and should be completed in phases prior to the start of construction. Construction activities should start in year one and should be completed in year three. An itemized implementation schedule is shown in Table 7.12.

7.9 Evaluation

7.9.1 Environmental

The key areas of environmental impact for this project are described briefly below. Additional information is given in Annex E, Initial Environmental Evaluation.

Land Use

Land use changes are summarized in Table 7.13. A total of 233 ha of land (about 0.7% of the project gross area) will be required for construction of loopcuts and diversion channels. This land will be taken from cultivated area. Assuming that this area is under rice production and has an average yields of 2.4 tonnes/ha, this corresponds to foregone cereal production of about 560 tonnes per year or about 3.5% of total incremental cereal production.

Agriculture
Increased crop production is documented in Section 7.4.4, Expected Benefits. Briefly, the project is expected to increase the production of cereal crops by about 16,000 tonnes per year and to increase the production of non-cereal crops by 845 tonnes per year. Cereal food availability would increase by 15% from 744 gm per person per day (FWO) to 853 gm per person per day (FW). Availability of non-cereals would increase by 5%, from 128 gm per person per day to 134 gm per person per day.

Openwater fisheries production
Generally three types of impacts are considered to be important. These are:

- reduced flood plain fisheries resulting from reduced grazing areas;
- reduced beel fisheries resulting from drainage and destruction of water links between beels and rivers;
- impacts on spawning resulting from destruction of water links between spawning grounds and rivers.

Table 7.12: Implementation Schedule

Activity	Year (% Completion)			
	0	1	2	3
Preconstruction Activities				
Feasibility Study	100			
Engineering Investigation	100			
Detail Designs	80	20		
Land Acquisition	50	50		
Construction Activities				
Construction of Embankments	-	-	-	-
Excavation of Channels/Loop cuts		20	30	50
Construction of Structures	-	-	-	-
Construction of Bridges		10	40	50

The flood control infrastructure will reduce the seasonally flooded area within the project by about 29% (Table 7.15).

Impacts on production were assessed using a simplified model reflecting the current understanding of the system. The details of the model are given in Annex D. Values of various parameters which were used in the model to calculate future production with and without the project are also furnished in Annex D. Where standard values for the region or for a particular project type were used, these are noted.

Table 7.13: Change in Land Use

Use	Change in area (ha)
Cultivated	233
Homesteads	-
Beels	-
Ponds	-
Channels	-
Hills	-
Fallow[1]	-
Infrastructure[2]	-

As was discussed in Chapter 5, it is assumed that fish production will remain unchanged without the project, at 722 tonnes.

The openwater fisheries production will be reduced by 96 tonnes per year as a result of the project implementation, which is 13% of the FWO annual production. This implies a decrease in fish availability from openwater sources, due to the project, from 4.9 gm per person per day (FWO) to 4.3 gm per person per day (FW) as shown in Table 7.14. This Table includes data for food grains which were presented in an earlier section.

Table 7.14: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	568	587	469	409
Non-cereals	176	168	134	128
Open Water Fish	6.9	5.4	4.3	4.9
Pond	4.6	5.5	4.4	3.3

[1] Multi-use land, wetlands, grazing lands, village grounds.
[2] Government-owned land not appearing elsewhere.

This area does not contain a "mother fishery" so there are no regional effects on fisheries as a result of implementation of this project.

Aquaculture production
The impact on aquaculture production will be an increase of 160 tonnes per year, which is 33% of the FWO annual production of 480 tonnes per year. This implies an increase in fish availability, due to the project, from 3.3 gm per person per day (FWO) to 4.4 gm per person per day (FW).

Table 7.15: Fish Production Indicators

Regime	FWO (2015)		FW (2015)		
	Area (ha)	Production (t)	Area (ha)	Production (t)	Production Impact ('000 kg)
Flood Plain (F1+F2+F3)	11,190	336	7990	240	-96
Beels	1,570	236	1570	236	0
Channels/River	1,500	150	1500	150	0
Sub-total	14,260	722	11,060	626	-96
Pond	800	480	800	640	160
Total	15,060	1202	11,860	1266	64

Homestead flooding
Homestead flood damage would be significantly reduced. Due to the lack of historical data on flood damage costs, a simple model was used to estimate future costs assuming that there are about 66,225 homesteads in the area, the average plinth level is at about the 1:5 year flood level, and that about 25% of homesteads are affected by flooding of 10-20 cm in the 1:10 and 1:25 year floods. The estimated annualized economic value of reduced flood damage is Tk 6.0 million.

Wetland Habitats and Grazing Area
Impacts on wetlands are difficult to quantify, but a general impression is given by Table 7.16, which shows the impact on:

- **'Winter grazing area'**; defined as F0, F1, and F2 lands that lie fallow in the dry season (winter), plus any perennially-fallow highlands. This land has limited residual moisture. Although animals do graze on such areas the productivity per unit area is not known.

- **'Winter wetland'**; F3 land that lies fallow in the dry season, plus any perennially-fallow lowland (F4), beel, and channel areas. This land would likely have considerable residual moisture and could support a range of wetland plant communities.

- **'Summer wetland'**; F1, F2, and F3 land that lies fallow in the summer, plus perennially-fallow lowland (F4 area), beel, and perennial channel areas. This land would be inundated to a depth greater than 0.3 m and would support submerged, free-floating, rooted floating, and sedge/meadow plant communities.

The impact of the project would be to decrease winter grazing area by 10%, decrease winter wetland area by 1%, and decrease summer wetland area by 16%.

Economic and employment impacts of the project on wetland plant and animal production can be only roughly estimated. Assuming an annual economic production of Tk 100 per hectare for both summer and winter wetland areas gives a total annual loss of Tk 74 thousand per year.

Table 7.16: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	6080	6362	282	
sc/wf F1	2384	1548	-836	
sc/wf F2	528	147	-381	
Fallow Highland	150	150	0	
Total	9142	8207	-935	-10

Land Type	Winter Wetland			
sc/wf F3	8	0	-8	
F4, Beel, Channel	3420	3420	0	
Total	3428	3420	-8	0

Land Type	Summer Wetland			
wc/sf F1	0	0	0	
wc/sf F2	452	252	-200	
wc/sf F3	672	141	-531	
F4, Beel, Channel	3420	3420	0	
Total	4544	3813	-731	-16

FW areas shown here do not reflect cultivable land acquired for infrastructure (see Land Use, Section 7.8.1). 'sc' - summer cultivated. 'wc' - winter cultivated. 'sf' - summer fallow. 'wf' - winter fallow.

Assuming 1.0 pd/ha/yr is spent in harvesting, the impact on employment would be minimal (a loss of 739 person-days per year).

Transportation/navigation
The total length of existing roads in the project is 300 km of which 75 km are inundated every year. The project would make 75 km of these roads flood-free up to the 1:25 year flood. Assuming a capital cost of Tk 190,000/km and damage of 15% during floods, the annual benefit of flood protection is Tk 1.5 million.

The loopcuts will improve navigation by straightening and shortening the river. The economic benefit of this change has not been estimated.

Flood levels
Kangsha River flood levels would decrease by 0.8 m at Sarchapur due to downstream cut-offs without changing flood levels at Jaria Janjail. The effect of diversion on the water level in the Mogra River at Netrokona will be minimized by the downstream loopcuts and by diverting the upper watershed into the Saiduli River. However, improved understanding of these impacts is required through more detailed modelling and feasibility studies.

7.9.2 Social

The key areas of social impact by this project are described below. Additional information is given in Annex E, Initial Environmental Evaluation.

Employment
There will be an overall increase in employment of 0.050 million person-days per year. This is composed of:

- an increase in owner-labour employment of 0.125 million pd/yr, of which very roughly 20% is post-harvest processing activities traditionally done by women of the household.

- a net decrease in employment opportunities for landless people of 0.075 million pd/yr, composed of changes in the following areas:

    - Agricultural hired labour: increase of 0.100 million pd/yr, of which about 10% is for post-harvest processing traditionally done by women;

    - Fishing labour: decrease of 0.174 million pd/yr, in addition to a corresponding loss in support activities such as net-making and post-catch processing (mainly drying), much of which is done by women;

    - Wetland labour (gathering wetland products): decrease of 0.0007 million pd/yr. Fodder and building material are gathered mainly by men; food, fuel, and medicine are gathered mainly by women.

Displacement impacts due to land use changes
In this study, it is assumed that the loop cuts and diversion channel will detour any homesteads. However at the time of implementation, it is likely that a few houses may require to be displaced and acquired by the project, for suitable cash compensation.

Households whose homestead land is acquired by the project may have difficulty relocating. This is because suitable homestead lands are so scarce that replacement land may not be available for purchase.

The experience of BWDB in resettling landless people on embankments in the Cyclone Protection Project may be relevant to the requirements of this project area. Two mitigation options bear consideration. Embankments could be constructed with berms at strategic locations to support homesteads. Alternatively, raised housing platforms could be constructed to facilitate relocation.

Conflicts
Although steps have been taken to mitigate the increased flows and to prevent raising water levels along the diversion route, these changes may be far removed and their effects may not be evident to local residents. Therefore a perception may develop that these areas will be flooded by the proposed diversion; in such a situation, the people of that area may resist the diversion. Thus the entire scope of the project should be clearly communicated and should be understood by the local population.

Equity
The net equity impact would appear to be *regressive* in that the benefits tend to accrue to the more wealthy. Who benefits?

- Landowners, in proportion to landholdings, benefit directly from investment in agriculture production. This is the main benefit (95% in economic terms) of the project and its distribution is quite *regressive*.

Who loses?

- Families dependent upon fishing labour. These families are mainly landless and tend to be poorer than average. *Regressive*.

- Families involved in gathering wetland products. These families are mainly landless and tend to be very poor. *Regressive*.

- Families displaced from their homesteads by project land acquisition. Insofar as more wealthy families can influence infrastructure siting/alignment, this is *regressive*.

Gender Equity
The net impact on gender equity would appear to be somewhat *progressive* in that employment opportunities for women will increase in all categories except wetland gathering. Reduced homestead flood damage will favour women, given that most women still spend most of their lives within the homestead.

Table 7.17: Qualitative Impact Scoring

		True=1 False=0					
Qualitative Impact	Impact Sign	Sensitive	Magnitude	Immediate	Sustainable Pos Impact/ Irreversible Neg Impact	No Mitigation Required/ Possible	Score
Ecological Character of Kangsha Basin	-1	0	0	0	0	1	-1
Regional Biodiversity	-1	0	0	0	0	1	-1
Road Transportation	1	1	1	1	1	1	+5
Navigation	-1	0	0	0	0	0	0
Flood Levels Outside Project Area	-1	0	0	0	0	0	0
Conflicts	-1	1	1	0	0	1	-3
Socioeconomic Equity	-1	0	0	0	0	1	-1
Gender Equity	0	1	0	0	1	1	+2

Qualitative Impact Scoring

Impacts of the project are scored qualitatively in Table 7.17 on an 11-level scale ranging from -5 to +5. The scoring procedure is analogous to that used in the FAP 19 EIA case studies, but was simplified to eliminate half-point scores (1.5, 2.5, 3.5, etc). Here, each score sums across five equally weighted logical (true/false) criteria, with each 'true' counting for a value of one and each 'false' for zero. The sign reflects whether the impact is positive or negative.

7.9.3 Economic

A summary of salient data is provided in Table 7.18.

The project has an economic rate of return of 28%, which is favourable compared with the required rate of 12% as prescribed by government. It is a relatively high investment project, at Tk 518 million or Tk 19,055 per hectare, and it covers a large geographic area (34,280 ha gross). The rate of return is somewhat sensitive to the timing of the benefits, and a delay in benefits by two years would reduce the ERR to 19%. The other sensitive variable is the capital costs - a 20% increase in capital costs would decrease the rate of return to 24%. A 20% reduction in fish benefit (20% increase in fish losses) would decrease the ERR to 24%.

The foreign costs component of the project is fairly small, at 6% (excluding FFW contributions).

Almost all of the benefits of the project relate to increased agricultural production, mostly resulting from shifts to hyvs and non-cereal production. Average crop yields would increase as a result of reduced flood damage. Cropping intensity would increase by 8%. Non-cereal production would increase by 5%. About 5% of project benefits would result from reduced homestead flooding.

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Floodplain fish production would decrease by about 13%. The value of the lost fisheries output amounts to about 2% of the value of increased agricultural output. A small amount of disbenefit would result from loss of food, shelter, and tree products that are currently harvested from the seasonal wetlands.

It is anticipated that the established crop marketing system will handle incremental crop production without any reduction in prevailing average price levels. Assuming that the current annual growth in the demand for grain remains about 3%, the increased cereal production is unlikely to present any marketing difficulties.

A significant caution is that the economic benefits depend in part on assumed shifts in cropping patterns, and if this did not occur the viability of the project would be reduced. Lessons of the past have shown that producers have not always responded as predicted, and this case warrants special efforts in predicting producer responses.

7.9.4 Summary Analysis

From a multi-criteria perspective (Table 7.19), some aspects of the project are not attractive. Negative aspects include:

- Fisheries and wetlands would be reduced.
- Employment opportunities for hired labourers would be reduced, primarily in floodplain fisheries.
- A number of households would lose their homestead land to project land acquisition.
- Conflicts between the benefitted and affected families may increase.
- The project has a high dependency on central government for implementation.

The positive aspects of the project include:

- Rate of return is attractive.
- Increase in rice production will be substantial.
- Net employment will be increased.
- Flood damage to homesteads, roads, and aquaculture will be decreased.
- Kangsha River levels will be generally lowered.
- Non-cereal production will be increased substantially.
- Gender equity of impacts will be somewhat progressive.
- The project responds to expressed public concerns.

Table 7.18: Summary of Salient Data

Economic Rate of Return (ERR)	28%			
Capital Investment (Tk million)	518			
Maximum O+M (Tk million/yr)	12			
Capital Investment (Tk/ha)	19,055			
Foreign Cost Component	6			
Net Project Area (ha)	27190			
Land Acquisition Required (ha)	233			

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (Tk million / yr)	100.59			
Cropping Intensity		2.0	2.0	2.0
Average Yield (tonnes/ha)		2.3	2.4	2.6
Average Gross Margins (Tk/ha)		11605	11588	13395
Owner Labour (md/ha)		121	121	121
Hired Labour (md/ha)		33	33	34
Irrigation (ha)		12402	12518	12753
Incremental Cereal Prod'n (' 000 tonnes / yr)	16			
Incremental Non-Cereal (' 000 tonnes / yr)	1			
Incremental Owner Labour (' 000 pd / yr)	125			
Incremental Hired Labour (' 000 pd / yr)	100			

FISHERIES IMPACTS		Flood plain	Beels	River/ Channel	Pond
Incremental Net Econ Output (Tk million / yr)	-2.15	-2.15	0	0	-
Area (FWO) - ha		11190	1570	1500	800
Area (FW) - ha		7990	1570	1500	800
Average Gross Margins (Tk/ha)		1050	7500	5000	-
Remaining Production %		71	100	100	133
Incremental Fish Production (tonnes / year)		(-)96	0	0	160
Incremental Labour ('000 pd / yr)		(-)192	0	0	18

FLOOD DAMAGE BENEFITS				
Households Affected		16,556		
Reduced Econ Damage Households (Tk M / yr)	6.02			
Roads/Embankments Affected -km		75		
Reduced Econ Damage Roads (Tk M / yr)	1.5			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	0.07			
Wetland Incremental Labour ('000 pd / yr)	0.74			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	3.5			
Persons Displaced by Homestead Acquisition	0			

Table 7.19: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	28
EIRR, Increase Capital Costs by 20%	per cent	24
EIRR, Delay Benefits by Two Years	per cent	
EIRR, increase Fisheries losses by 20%	Percent	24
Net Present Value	Tk	312,882

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	15979	15
Incremental Non-Cereal Production	tonnes	845	5
Incremental floodplain Fish Production	tonnes	(-)96	(-)13
Change in Floodplain Wetland/Fisheries Habitat	ha	3200	29
Homesteads Displaced Due to Project Land Acquisition	homesteads	0	0
Homesteads Protected From Floods	homesteads	16556	25
Roads Protected From Floods	km	75	25
Kangsha River Levels	m PWD	-	-
Incremental Owner Employment	million pd/yr	0.125	2
Incremental Hired Employment (Agri+Fishing+Wetland)	million pd/yr	(-)0.075	(-)3

Qualitative Impacts (ranked from -5 ...0... +5)	
Impact	**Rank**
Regional Biodiversity	-1
Road Transportation	+5
Navigation	0
Flood Levels Outside Project Area	0
Conflicts	-3
Socioeconomic Equity	-1
Gender Equity	+2
Decentralized Organization and Management	-2
Responds to Public Concerns	+3
Conformity to Regional Strategy	+4

[1] Percent changes are calculated relative to future-without-project values of: total production of cereal, non-cereal, and fisheries; total floodplain area; total number of homesteads (for displacement due to land acquisition); flood-affected homesteads; flood-affected roads; Kushiyara water level; and total employment for owners and hired labourers.

[2] Includes incremental production foregone due to acquisition of cultivated land.

8. PROPOSED PROJECT
EXTENSION OF KONAPARA EMBANKMENT

8.1 General Information

BWDB Division:	Tangail O&M
District:	Mymensingh and Sherpur
Thana(s):	Phulpur, Haluaghat and Nalitabari
Project Type:	Full Flood Control (bottom open)
Gross Area:	7,000 ha
Net Area:	5990 ha
Population:	50,100 (1991), 52,400 (1993), 57,200 (2000), 72,600 (2015)

Current land use is summarized in Table 8.1 and a project area map with proposed works is shown in Figure 18.

8.2 Rationale

The BWDB's Konapara Embankment is ended abruptly at its upper end at Bahirshimul without connecting to high ground. Thus there is spill from Bhogai-Kangsha River to its left bank area upstream of the Konapara Embankment which reduces the effectiveness of this project.

Agriculture is the main profession for more than eighty five percent of the project people. The crops of the area are damaged almost annually by Bhogai River spills. To support farmers and to maintain rice self-sufficiency with the expected population growth, it is necessary that crops be saved from flooding.

In the last two decades, many roads, village markets, and growth centres have developed in the area. Flooding causes extensive damage to this infrastructure.

The project expects to eliminate flooding on 530 ha of land, to reduce the flood depth in the remaining area, and to protect infrastructure.

Table 8.1: Current Land Use

Use	Area (ha)
Cultivated (F0+F1+F2+F3)	5990
Homesteads	300
Beels	180
Ponds	280
River/Channels	120
Hills	-
Fallow[1]	30
Infrastructure[2]	100
Total	**7000**

[1]Multi-use land, wetlands, grazing lands, village-grounds. Include F4 land.
[2]Government owned land not appearing elsewhere.

8.3 Objectives

The objectives of the project are:

- to provide the full potential benefit of the Konapara Embankment project;
- to protect crops, homesteads, and infrastructure from Bhogai River flooding.

8.4 Description

The project is proposed to extend the existing BWDB's Konapara Embankment upstream from Bahirshimul for a length of 20.00 km to the Malijhee confluence. Local bodies' embankments already exist from the Malijhee confluence to the international border. Thus the proposed project will provide continuous embankment along the Bhogai River left bank from the international border to Phutkai (Figure 18).

Table 8.2: Design Embankment Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Malijhee Confluence	0.00	16.75
Bahirshimul	20.00	15.56

No embankments are planned on the north side of the project area along the Gangina-Ramkhali channel so as to facilitate drainage and fish migration.

The other engineering works include construction of one flushing regulator at the offtake of Kodalia khal.

An outline of the proposed work is shown in Figure 18.

8.4.1 Flood Protection

Embankments
The flood protection of the area will be effected with embankments designed for a 20-year return period (annual) flood, along the left bank of the Bhogai River.

To minimize land acquisition and earthwork volume, it is proposed that the project will utilize all existing roads and local bodies' dykes provided there is sufficient setback distance. However, to be conservative in the cost estimate this pre-feasibility study assumes a new embankment for the entire reach. The required height of the new embankment along the Kangsha River is about 3.0 m. The proposed cross section of the embankment has a crest width of 4.27 m and side slopes of 2:1 on the country (protected) side and 3:1 on the river side.

Design embankment crest elevations are shown in Table 8.2. Details are provided in Annex C.

Impact on Flooding
As a result of the flood protection measures, the depth of flooding will be reduced and the area of flood-free land will be increased as shown in Tables 8.3 and 8.4.

Table 8.3: Pre-Monsoon Depth of Flooding (by 1:2 Year Flood before 15 May)

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	5990	5915
0.30-0.90	-	-
0.90-1.80	-	-
>1.80	-	-
Total	**5990**	**5915**

[a] These figures reflect cultivable land acquired for embankment. Production impacts of land acquisition are documented in the Evaluation section.

8.4.2 Drainage

The area land slopes away from the Bhogai River towards the north to Gangina khal. Thus the embankment construction along the Bhogai River will create no drainage problem for the area.

Following completion of the project, the drainage requirements of the area will be greatly reduced since the present flood spills from the Bhogai River will be decreased, and consequently the outflow discharge will be smaller.

The existing natural drainage system of khals and beels will be used for drainage of the project area. The Gangina-Ramkhali channel, which drains to the Kangsha River at Phutkai, is the main outlet from the project area.

Table 8.4: Monsoon Depth of Flooding (by 1:2 Year Max Annual Flood)

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	2480	3009
0.30-0.90	1840	1764
0.90-1.80	1240	1041
>1.80	430	101
Total	5990	5915

[a] These figures reflect cultivable land acquired for embankment. Production impacts of land acquisition are documented in the Evaluation section.

8.4.3 Structures

A one-vent (1.52 m x 1.83 m) flushing regulator is proposed at the offtake of Kodalia khal to supply river water to the project area as required.

8.4.4 Expected Benefits

The expected benefits of the project relate mainly to increased crop production resulting from protection of agriculture. Agricultural crops are presently damaged almost every year in the project area by floods from the Bhogai River.

Changes in crop production were estimated as follows:

1. The existing cropping pattern was estimated for each flood depth class based on information gained from field visits and farmer interviews (Table 8.5), supplemented with secondary data regarding typical crop distributions for various flood depth classes;

2. Annual yields which are presently obtained for each type of crop from flood-damaged land and non-damaged land were estimated, as well as the percentage of the crop area that is annually damaged by floods, from field visits and farm interviews (Table 8.6);

3. The present annual production of each crop was calculated as the sum of area times yield for both damage-free and flood-damaged areas (Table 8.6);

4. The future cropping pattern (Table 8.7) and yields (Table 8.8) were estimated *without* the proposed project, for year 2015, allowing for anticipated changes in the hydrologic regime (primarily on-going siltation), increased use of irrigation, improvements in cultural practices, improvements in drainage, shift to higher-yield varieties, and other factors. The future

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Table 8.5: Present Cropping Patterns (ha)

Crop Pattern	F0	F1	F2	F3	Total
b aman				13 (3)	13
l boro				52 (12)	52
hyv boro				322 (75)	322
b aus-lt aman	495 (20)	184 (10)	62 (5)		741
b aus-lt aman-rabi	149 (6)	92 (5)			241
b aus-hyv aman	248 (10)	184 (10)			432
b aus-hyv aman-potato		37 (2)			37
b aus-hyv aman-rabi	99 (4)	37 (2)			136
jute-hyv aman	248 (10)	184 (10)			432
hyv aus-lt aman	298 (12)	147 (8)			445
hyv aus-hyv aman	149 (6)	92 (5)			241
lt aman	174 (7)	55 (3)	62 (5)		291
lt aman-wheat	50 (2)				50
lt aman-rabi	248 (10)	92 (5)	124 (10)		464
lt aman-hyv boro		276 (15)	682 (55)	43 (10)	1001
hyv aman	74 (3)				74
hyv aman-rabi	248 (10)				248
hyv aman-hyv boro		460 (25)	310 (25)		770
TOTAL	**2480**	**1840**	**1240**	**430**	**5990**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

Table 8.6: Present Crop Production

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	1429	1.4	2001	159	1.0	159	2159
hyv aus	583	3.2	1866	103	2.50	257	2121
b aman	8	1.6	13	5	1.25	6	19
lt aman	2586	2	5172	647	1.50	970	6142
hyv aman	2133	3.3	7039	237	2.6	616	7655
l boro	52	2	104				104
hyv boro	2094	4.2	8795				8795
wheat	50	2	100				100
jute	432	1.65	713				713
potato	37	11	407				407
pulses	163	0.9	147				147
oilseeds	544	0.8	435				435
spices	54	2.5	135				135
vegetables	327	4.0	1308				1308

Source: NERP estimates.

Table 8.7: Projected Crop Pattern-Future Without Project (ha).

Crop Pattern	F0	F1	F2	F3	Total
b aman				21 (10)	21
l boro				43 (10)	43
hyv boro				323 (75)	323
b aus-lt aman	372 (15)	110 (6)	62 (5)		544
b aus-lt aman-rabi	149 (6)	92 (5)			241
b aus-hyv aman	372 (15)	221 (12)			593
b aus-hyv aman-potato		55 (3)			55
b aus-hyv aman-rabi	124 (5)	55 (3)			179
jute-hyv aman	248 (10)	184 (10)			432
hyv aus-lt aman	248 (10)	129 (7)			377
hyv aus-hyv aman	198 (8)	110 (6)			308
lt aman	149 (6)	37 (2)	62 (5)		248
lt aman-wheat	50 (2)				50
lt aman-rabi	149 (6)	110 (6)	124 (10)		383
lt aman-hyv boro		240 (13)	682 (55)	43 (10)	965
hyv aman	124 (5)				124
hyv aman-rabi	297 (12)				297
hyv aman-hyv boro		497 (27)	310 (25)		807
TOTAL	**2480**	**1840**	**1240**	430	**5990**

Note: *Numbers in parenthesis indicate percent of cultivated area under the relevant land type.*

Table 8.8: Crop Production - Future Without Project

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	1451	1.4	2031	161	1.0	161	2193
hyv aus	583	3.2	1866	103	2.5	257	2121
b aman	13	1.6	21	9	1.25	11	32
lt aman	2245	2	4490	561	1.5	842	5332
hyv aman	2517	3.3	8306	279	2.6	725	9032
l boro	43	2	86				86
hyv boro	2094	4.2	8795				8795
jute	432	1.65	713				713
wheat	50	2	100				100
potato	55	11	605				605
pulses	165	0.9	149				149
oilseeds	550	0.8	440				440
spices	55	2.5	138				138
vegetables	330	4.0	1320				1320

Source: NERP estimates.

X80

Table 8.9: Projected Crop Pattern-Future With Project (ha)

Crop Pattern	F0	F1	F2	F3	Total
b aman				5 (5)	5
l boro				10 (10)	10
hyv boro				86 (85)	86
b aus-lt aman	361 (12)	35 (2)			396
b aus-lt aman-rabi	151 (5)	88 (5)			239
b aus-hyv aman	361 (12)	53 (3)			414
b aus-hyv aman-potato		71 (4)			71
b aus-hyv aman-rabi	151 (5)	88 (5)			239
jute-hyv aman	241 (8)	194 (11)			435
hyv aus-lt aman	241 (8)	123 (7)			364
hyv aus-hyv aman	270 (9)	176 (10)			446
lt aman	120 (4)				120
lt aman-wheat	90 (3)				90
lt aman-rabi	241 (8)	53 (3)	31 (5)		325
lt aman-hyv boro	120 (4)	266 (15)	229 (22)		615
hyv aman	151 (5)				151
hyv aman-rabi	421 (14)		52 (5)		473
hyv aman-hyv boro	90 (3)	617 (35)	729 (70)		1436
TOTAL	**3009**	**1764**	**1041**	**101**	**5915**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

Table 8.10: Crop Production-Future With Project

Crop	Area (ha)	Yield (t/ha)	Production (t)
b aus	1358	1.4	1901
hyv aus	811	3.2	2595
b aman	5	1.6	8
lt aman	2149	2	4298
hyv aman	3665	3.3	12095
l boro	10	2	20
hyv boro	2136	4.2	8971
wheat	90	2	180
jute	435	1.65	718
potato	71	11	781
pulses	191	0.9	172
oilseeds	638	0.8	510
spices	64	2.5	160
vegetables	383	4.0	1532

Source: NERP estimates.

cropping pattern and yields were used to calculate total crop production without the project as in Step 3 (Table 8.8);

5. Future cropping patterns (Table 8.9) and yields (Table 8.10) were estimated *with* the proposed project, based on anticipated changes in the annual flooding regime as provided in Tables 8.3 and 8.4 as well as the other factors which are mentioned in Step 4 above. Resulting annual crop production estimates are provided in Table 8.10.

In the future without the project, flash floods will continue to damage aus and aman crops. It is considered that the current land type will remain much the same, and that cropping patterns and yield will change only slightly.

With the project, changes are expected to occur in the cropping pattern in response to the changed flooding regime. Protection from floods (both flash floods and seasonal floods) would reduce the damage to different types of rice. Yields in areas free of damage are considered to remain much the same as at present.

Annual cereal production is expected to increase from 27691 tonnes (FWO) to 30068 tonnes with the project (FW), an increase of 8.6% or 2377 tonnes. Non-cereal production is expected to increase from 3364 tonnes (FWO) to 3873 tonnes (FW), an increase of 15% or 509 tonnes.

A summary of food availability in the projects area, expressed in units of grams of food available per person per day, is provided in Table 8.11 for each of the three scenarios which were analyzed. The calculation allowed losses of 10% as seed, feed, and waste and 35% in the conversion of paddy to rice.

The availability of cereal grains will increase from 575 gm per person per day (FWO) to 624 gm per person per day (FW), an increase of +8.6%. Current Bangladesh average consumption is 440 gm per person per day and therefore the area is and will continue to be self-sufficient in cereal grain production.

Table 8.11 implies an increase in the availability of non-cereals from 127 to 146 gms per person per day.

8.4.5 Mitigation Measures Incorporated

The main source of broodstock fish in the project area is from the Bhogai and Kangsha Rivers. As described in section 8.4.1 the project area will be protected from the Bhogai floods from the south but will leave open the Gangina-Ramkhali channel on the north. The Gangina-Ramkhali channel is connected with Kangsha River further downstream; however the embankment will cut off the direct spill and migration of fish to/from the Bhogai River.

Table 8.11: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	779	792	624	575
Non-Cereals	164	186	146	127

A flushing regulator is proposed over Kodalia khal to induce spawning during the early monsoon period and to maintain a supply of water from the Bhogai River.

8.5 Project Operation and Maintenance

Under this development plan, requirements for operation and maintenance would be minimal. They would be limited primarily to repair of raincuts in the embankment and to maintenance and operation of the gates.

8.6 Organization and Management

A client group would need to be organized to oversee project development. This client group and other organisation and management aspects would be similar to that for the Malijhee River Improvement Project (see Section 7.6).

8.7 Cost Estimates

Total project costs are Tk 66.7 million.

The land costs, earthwork, and structure costs are indexed to June 1991 prices. The unit prices and cost estimating procedures are similar to that used for the Malijhee River Improvement Project (see Section 7.7).

The summary of total costs is presented in Table 8.12 and details are provided in Annex C.

Table 8.12: Capital Cost Summary

Item	('000 Tk)
Structures	2,200
Embankments	14,190
Channels/Loopcuts	-
Land Acquisition	30,000
BASE COST	46,390
Physical Contingencies (25%)	11,600
SUBTOTAL	57,990
Study Costs[1] (15% of Subtotal)	8,700
TOTAL	**66,690**
Net Area (ha)	5,990
Unit Cost (Tk/ha)	11,134

[1]Includes preparation of EIA and Environmental Management Plan.

8.8 Project Phasing and Disbursement Period

Three years are required to implement the project. Feasibility studies and field surveys would be carried out in year zero. Preparation of detail designs should start in year zero and should be completed in the same year. Land acquisition should be started in year zero and completed in year one before the start of construction. Construction activities should be started in year one and completed in year two. An itemized implementation schedule is shown in Table 8.13.

8.9 Evaluation

8.9.1 Environmental

The key areas of environmental impact for this project are described briefly below. Additional information is given in Annex E, Initial Environmental Evaluation.

Land Use
Land use changes are summarized in Table 8.14. A total of 100 ha of land (about 1.4% of the project gross area) will be required for embankment construction. Of this:

- 75 ha will be taken from cultivated area. This loss corresponds to foregone cereal production of about 210 tonnes per year or about 0.7% of total incremental cereal production.
- 25 ha will be taken from fallow area.

Table 8.13: Implementation Schedule

Activity	Year (% Completion)		
	0	1	2
Preconstruction Activities			
Feasibility Study	100		
Engineering Investigation	100		
Detail Designs	100		
Land Acquisition	80	20	
Construction Activities			
Construction of Embankments		50	50
Closure			100

Agriculture
Increased crop production is documented in detail in Section 8.4.4, Expected Benefits. Briefly, the project is expected to increase cereal production by more than 2000 tonnes per year and is expected to increase non-cereal production by 500 tonnes per year. The benefits are largely economic in that the additional rice production can be marketed outside of the project area.

Openwater fisheries production
Generally three types of impacts are considered to be important. These are:

- reduced flood plain fisheries resulting from reduced grazing areas;
- reduced beel fisheries resulting from drainage and destruction of water links between beels and rivers;
- impacts on spawning resulting from destruction of water links between spawning grounds and rivers.

The flood control infrastructure will reduce the seasonally flooded area of the project by about 17%.

Table 8.14: Changes in Land Use

Use	Change in area (ha)
Cultivated	(-) 75
Homesteads	-
Beels	-
Ponds	-
Channels	-
Hills	-
Fallow	(-) 25
Infrastructure	-

Impacts on production were assessed using a simplified model reflecting the current understanding of the system. The details of the model are given in Annex D. Values of various parameters which were used in the model to calculate future production with and without the project are also furnished in Annex D. Where standard values for the region or for a particular project type were used, these are noted.

The fish production indicators are given in Table 8.15.

As discussed in Chapter 5, it is assumed that the fish production will be remain unchanged without the project, at 144 tonnes per year.

The openwater fisheries production will be reduced by 50 tonnes per year as a result of the project implementation, which is 35% of the FWO annual production. This implies a decrease in fish availability from openwater sources due to the project from 5.4 gm per person per day (FWO) to 3.5 gm per person per day (FW) as shown in Table 8.16. This Table includes data for food grains which were presented in an earlier section.

This area does not contain a "mother fishery" so there will be no regional impacts on fisheries as a result of implementation of this project.

Aquaculture production
The impact on aquaculture will be an increase in production of 56 tonnes per year, which is 33% of the FWO annual production of 168 tonnes per year. This implies an increase in fish availability per person from 1.54 gm per person per day (FWO) to 2.05 gm per person per day (FW).

Homestead flooding
Homestead flood damage would be significantly reduced. Due to the lack of historical data on flood damage costs, a simple model was used to estimate future costs assuming that there are about 9985 homesteads in the area, the average plinth level is at about the 1:5 year flood level, and about 10% of homesteads are affected by flooding of 10 to 20 cm in the 1:10 and 1:25 year floods. The estimated annualized economic value of reduced flood damage is Tk 0.39 million.

Table 8.15: Fish Production Indicators

Regime	FWO (2015)		FW (2015)		
	Area (ha)	Production (t)	Area (ha)	Production (t)	Production Impact ('000 kg)
Flood Plain (F1+F2+F3)	3510	105	2906	69	-36
Beels	100	27	100	17	-10
Channels/River	100	12	100	8	-4
Sub-total		144		94	-50
Pond	280	168	280	224	56
Total		312		318	16

Wetland Habitats and Grazing Area
Impacts are difficult to quantify, but a general impression is given by Table 8.17, which shows the impact on:

- **'Winter grazing area'**; defined as F0, F1, and F2 lands that lie fallow in the dry season (winter), plus any perennially-fallow highlands. This land would have limited residual moisture. Although animals do graze on such areas the productivity per unit area is not known.

- **'Winter wetland'**; F3 land that lies fallow in the dry season, plus any perennially-fallow lowland (F4), beel, and channel areas. This land would likely have considerable residual moisture and could support a range of wetland plant communities.

- **'Summer wetland'**; F1, F2, and F3 land that lies fallow in the summer, plus perennially-fallow lowland (F4 area), beel, and perennial channel areas. This land would be inundated to a depth greater than 0.3 m and would support submerged, free-floating, rooted floating, and sedge/meadow plant communities.

The impact of the project would be to increase winter grazing area by 11%, decrease winter wetland area by 12%, and decrease summer wetland area by 43%.

Economic and employment impacts of the project on wetland plant and animal production can be only roughly estimated. Assuming an annual economic production of Tk 100 per hectare for both summer and winter wetland areas gives a total

Table 8.16: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	779	792	624	575
Non-Cereals	164	186	146	127
Open Water Fish	7.5	4.5	3.5	5.4
Pond	2.15	2.56	2.05	1.54

Table 8.17: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	1711	1745	34	
sc/wf F1	791	581	-210	
sc/wf F2	124	0	-124	
Fallow Highland	0	0	0	
Total	2626	2326	-300	11
Land Type	**Winter Wetland**			
sc/wf F3	21	5	-16	
F4, Beel, Channel	330	305	-25	
Total	351	310	-41	-12
Land Type	**Summer Wetland**			
wc/sf F1	0	0	0	
wc/sf F2	0	0	0	
wc/sf F3	366	95	-271	
F4, Beel, Channel	330	305	-25	
Total	696	400	-296	-43

FW areas shown here do not reflect cultivable land acquired for infrastructure (see Land Use, Section 7.8.1). 'sc' - summer cultivated. 'wc' - winter cultivated. 'sf' - summer fallow. 'wf' - winter fallow.

annual loss of Tk 33 thousand per year. Assuming 1.0 pd/ha/yr is spent in harvesting, the impact on employment would be minimal (a loss of 337 person-days per year)

Transportation/navigation
From field interviews and field observa-tion, it is seen that there is limited river traffic in the area. Transportation in the area is primarily based on the road system.

The total length of existing roads in the project is 100 km of which approximately 10 km are inundated every year. The project would make 10 km of these roads flood-free up to the 1:25 year flood. Assuming a capital cost of Tk 190,000/km and damage of 15% during floods, the annual benefit of flood protection is Tk 0.2 million.

Higher Kangsha River flood levels
River modelling which is described in Chapter 6 suggests that flood levels could increase by as much as 0.50 m in the Bhogai River. This estimate is considered preliminary, subject to review with more detailed modelling which is under way as a part of NERP. This could affect areas outside the project, most likely the right bank area and the Malijhee floodplain.

8.9.2 Social

The key areas of social impact by this project are described below. Additional information is given in Annex E, Initial Environmental Evaluation.

Employment
There will be an overall increase in employment of 0.0843 million person-days per year. This is composed of:

- an increase in owner-labour employment of 0.036 million pd/yr, of which very roughly 20% is post-harvest processing activities traditionally done by women of the household.

- a net increase in employment opportunities for landless people of 0.0483 million pd/yr, composed of changes in the following areas:

  - Agricultural hired labour: increase of 0.117 million pd/yr, of which about 10% is for post-harvest processing traditionally done by women;

  - Fishing labour: decrease of 0.0684 million pd/yr, in addition to a corresponding loss in support activities such as net-making and post-catch processing (mainly drying), much of which is done by women;

  - Wetland labour (gathering wetland products): decrease of 0.0003 million pd/yr. Fodder and building material are gathered mainly by men; food, fuel, and medicine are gathered mainly by women.

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Displacement impacts due to land use changes
In this study, it is assumed that the embankment will detour any homesteads. However at the time of implementation, it is likely that a few houses may require to be displaced and acquired by the project, for suitable cash compensation.

Households whose homestead land is acquired by the project may have difficulty relocating. This is because suitable homestead lands are so scarce that replacement land may not be available for purchase.

The experience of BWDB in resettling landless people on embankments in the Cyclone Protection Project may be relevant to the requirements of this project area. Two mitigation options bear consideration. Embankments could be constructed with berms at strategic locations to support homesteads. Alternatively, raised housing platforms could be constructed to facilitate relocation.

Conflicts
Leaving households outside the embankment can be a source of conflict. When water levels are high, river side residents may cut the embankment in an attempt to relieve flooding in their area. Detailed settlement surveys will be required to assess the magnitude of this problem in this area.

Equity
The net equity impact would appear to be *regressive*. Who benefits?

- Landowners, in proportion to landholdings, benefit directly from investment in agriculture production. This is the main benefit of the project and its distribution is quite *regressive*.

Who loses?

- Families dependent upon fishing labour. These families are mainly landless and tend to be poorer than average. *Regressive*.

- Families involved in gathering wetland products. These families are mainly landless and tend to be very poor. *Regressive*.

- Families displaced from their homesteads by project land acquisition. Insofar as more wealthy families can influence infrastructure siting/alignment, this is *regressive*.

Gender Equity
The net equity impact would appear to be somewhat *progressive*. Employment opportunities for women will increase in all categories except wetland gathering. Reduced homestead flood damage will favour women, given that most women still spend most of their lives within the homestead.

Qualitative Impact Scoring
Impacts of the project are scored qualitatively in Table 8.18 on an 11-level scale ranging from -5 to +5. The scoring procedure is analogous to that used in the FAP 19 EIA case studies, but simplified to eliminate half-point scores (1.5, 2.5, 3.5, etc). Here, each score sums across five equally weighted logical (true/false) criteria, with each 'true' counting for a value of one and each 'false' for zero. The sign reflects whether the impact is positive or negative.

Table 8.18: Qualitative Impact Scoring

		True=1 False=0					
Qualitative Impact	Impact Sign	Sensitive	Magnitude	Immediate	Sustainable Pos Impact/ Irreversible Neg Impact	No Mitigation Required/ Possible	Score
Ecological Character	-1	0	0	0	0	1	-1
Regional Biodiversity	-1	0	0	0	0	1	-1
Road Transportation	1	1	1	1	1	1	5
Navigation	-1	0	0	0	0	1	-1
Flood Levels Outside Project Area	-1	0	1	1	0	0	-2
Conflicts	-1	1	1	1	0	0	-3
Socioeconomic Equity	-1	0	0	0	0	1	-1
Gender Equity	1	1	0	0	1	1	3

8.9.3 Economic

A summary of salient data in provided in Table 8.19.

The project has an economic rate of return of 15%, which is above the required rate of 12% prescribed by government. It is a relatively low investment project, at Tk 66.7 million or Tk 11,133 per hectare, and it covers a large geographic area (7000 ha gross). The rate of return, however, is quite sensitive to the timing of the benefits, and a delay in benefits by two years would reduce the ERR to 10.9%. The other sensitive variable is the increase in capital costs; a 20% increase in capital cost would reduce the rate of return to 12.2%. A 20% reduction in fish benefit (20% increase in fish losses) would decrease the ERR to 13%.

At 4% of total cost (excluding FFW contributions) the foreign cost component is relatively small.

Almost all of the benefits of the project relate to increased agricultural production, mostly resulting from shifts to hyvs and non-cereal production. Average crop yields would increase as a result of reduced flood damage. Cropping intensity would increase by 7%. Non-cereal production would increase by 15%. About 9% of project benefits would result from reduced homestead flooding.

Floodplain fish production would decrease by about 35%. The value of the lost fisheries output amounts to about 22% of the value of the increased agricultural output. A small amount of disbenefits would result from loss of food, shelter, and tree products that are currently harvested from the seasonal wetlands.

It is anticipated that the established crop marketing system will handle incremental crop production without any reduction in prevailing average price levels. Assuming that the current annual growth in the demand for grain remains about 3%, the increased cereal production is unlikely to present any marketing difficulties.

A significant caution is that the economic benefits are based largely on assumed shifts in cropping patterns, and if this did not occur, the project would not be viable. Lessons of the past have shown that producers have not always responded as predicted, and this case warrants special efforts in predicting producer responses.

8.9.4 Summary Analysis

From a multi-criteria perspective (Table 8.20), some aspects of the project are not attractive.

Negative aspects would be:

- Fisheries and wetlands would be reduced.
- A number of households would lose their homestead land to project land acquisition.
- Kangsha River flood levels would increase slightly.
- Conflicts between families living within and outside the embankment would increase.

The positive aspects of the project would be:

- Rate of return is acceptable.
- The net employment impact is positive, and is composed of a large gain in employment for owners and hired labourers.
- Increase in rice production is substantial.
- Economic returns to land owners are increased.
- Flood damage to homesteads and roads are reduced.
- Non-cereal production is increased.
- Gender equity of impacts is somewhat progressive.
- The project responds to public concerns.
- The project has a low dependency on central government for implementation.

Table 8.19: Summary of Salient Data

Economic Rate of Return (ERR)	15			
Capital Investment (Tk million)	66.7			
Maximum O+M (Tk million/yr)	1			
Capital Investment (Tk/ha)	11,133			
Foreign Cost Component	4			
Net Project Area (ha)	5990			
Land Acquisition Required (ha)	100			

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (Tk million / yr)	4.88			
Cropping Intensity		1.9	2.0	2.0
Average Yield (tonnes/ha)		2.6	2.7	2.8
Average Gross Margins (Tk/ha)		13960	14119	14372
Owner Labour (md/ha)		124	123	123
Hired Labour (md/ha)		39	41	50
Irrigation (ha)		2562	2584	2744
Incremental Cereal Prod'n (' 000 tonnes / yr)	2			
Incremental Non-Cereal (' 000 tonnes / yr)	1			
Incremental Owner Labour (' 000 pd / yr)	36			
Incremental Hired Labour (' 000 pd / yr)	117			

FISHERIES IMPACTS		Flood plain	Beels	River/ Channel	Pond
Incremental Net Econ Output (Tk million / yr)	-1.06	-0.8	(-)0.15	(-)0.11	-
Area (FWO) - ha		3510	180	120	280
Area (FW) - ha		2906	180	120	280
Average Gross Margins (Tk/ha)		1050	7500	5000	-
Remaining Production %		66%	63%	67	133
Incremental Fish Production (tonnes / year)		(-)36	(-)10	(-)4	56
Incremental Labour ('000 pd / yr)		(-)72	(-)1.25	(-)1.333	6.222

FLOOD DAMAGE BENEFITS				
Households Affected		1000		
Reduced Econ Damage Households (Tk M / yr)	0.39			
Roads/Embankments Affected -km		10		
Reduced Econ Damage Roads (Tk M / yr)	0.20			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	0.03			
Wetland Incremental Labour ('000 pd / yr)	0.033			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	0.36			
Persons Displaced by Homestead Acquisition	0			

Table 8.20: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	15
EIRR, Increase Capital Costs by 20%	per cent	12
EIRR, Delay Benefits by Two Years	per cent	11
EIRR, increase Fisheries losses by 20%	Percent	13
Net Present Value	Tk	3,974

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	2377	8.6
Incremental Non-Cereal Production	tonnes	509	15
Incremental Fish Production	tonnes	6	2
Change in Floodplain Wetland/Fisheries Habitat	ha	604	21
Homesteads Displaced Due to Project Land Acquisition	homesteads	0	0
Homesteads Protected From Floods	homesteads	1000	10
Roads Protected From Floods	km	10	10
Bhogai River Levels	m	+0.5	-
Incremental Owner Employment	million pd/yr	0.036	3
Incremental Hired Employment (Agri+Fishing+Wetland)	million pd/yr	0.0483	7

Qualitative Impacts (ranked from -5 ...0... +5)	
Impact	**Rank**
Regional Biodiversity	-1
Road Transportation	+5
Navigation	-1
Flood Levels Outside Project Area	-2
Conflicts	-3
Socioeconomic Equity	-1
Gender Equity	+3
Decentralized Organization and Management	-1
Responds to Public Concerns	+3
Conformity to Regional Strategy	+4

[1] Percent changes are calculated relative to future-without-project values of: total production of cereal, non-cereal, and fisheries; total floodplain area; total number of homesteads (for displacement due to land acquisition); flood-affected homesteads; flood-affected roads; Kushiyara water level; and total employment for owners and hired labourers.

[2] Includes incremental production foregone due to acquisition of cultivated land.

9. PROPOSED PROJECT
GREATER DAMPARA PROJECT

9.1 General Information

BWDB Division:	Netrokona WD
District:	Netrokona
Thana(s):	Purbadhala, Phulpur
Project Type:	Full Flood Control
Gross Area:	15,300 ha
Net Area:	12,470 ha
Population:	113,000 (1991), 118,700 (1993), 134,500 (2000) and 170,600 (2015)

Current land use is summarized in Table 9.1 and a project area map with proposed engineering works is shown in Figure 19.

9.2 Rationale

Agriculture is the main occupation for more than eighty five percent of the project people. However the crops of the area are damaged almost annually by spills which overtop the right bank of the Kangsha River and flood some 8,000 ha of land.

Moreover, the flooding situation in the area has worsened with the development of the Kangsha River Project. When the Kangsha overtops its banks the spilled water is trapped by the Netrokona-Durgapur Road which serves as the Kangsha Project's western embankment. People living in the flooded area, when in distress, cut open the road and the sudden rush of water causes heavy damage in the Kangsha River Project's crops and infrastructure. The town of Netrokona is also threatened. The vital road communication between Netrokona and Durgapur is disrupted due to the cuts.

Thus the above circumstances put the area in a desperate position for preventing floods from the Kangsha River.

The project will make more than 1150 ha additional land free of flood and will reduce the depth of flooding on the remaining flooded area.

Table 9.1: Current Land Use

Use	Area (ha)
Cultivated (F0+F1+F2+F3)	12470
Homesteads	620
Beels	230
Ponds	370
River/Channels	400
Hills	-
Fallow[1]	250
Infrastructure[2]	960
Total	**15,300**

[1] Multi-use land, wetlands, grazing lands, village-grounds. Includes F4 land.
[2] Government owned land not appearing elsewhere.

9.3 Objectives

The objectives of the project are:

- to protect crops, homesteads, and infrastructure from Kangsha River flooding;
- to protect the vital Netrokona-Jaria-Durgapur Road;
- to provide protection to Netrokona Town;
- to make the Kangsha River Project fully functional.

9.4 Description

The 15,300 ha (gross) right overbank area of the Kangsha River is intended to be protected from floods by constructing embankments from the outfall of the Kharia River to Jaria, where it would connect to the existing BWDB Kangsha Project embankment. The main components of the scheme would include:

- construction of 35.0 km of full flood embankment along the Kangsha River right bank from Banastala to Jaria to provide monsoon flood protection;
- provision of two drainage regulators;
- construction of twenty LLP inlet structures.

The existing roads along the southern and western sides of the project and the high bank of the Kharia River will act as flood embankments.

The project is intended to be kept open on the south towards the Mogra River provided that it is confirmed that there is no spill from that River.

An outline of the proposed work is shown in Figure 19 and a more detailed description of the proposed works is given in Sections 9.4.1 through 9.4.3.

9.4.1 Flood Protection

Embankments
The flood protection of the area will be effected with 35.0 km of full flood embankment from Banestala to Jaria, along the right bank of the Kangsha River. The embankment would be designed to give protection against monsoon floods of 20-year return period.

In order to minimize land acquisition and earthwork volume, it is proposed to utilize all existing local bodies' dykes and village roads as flood embankment provided that these are located at a safe distance from the River. However, to be conservative this pre-feasibility study assumes a new embankment will be constructed along the entire reach. The required height of the new embankment will range from 0 to 3.0 m. The embankment would have a crest width of 4.27 m and side slopes of 2:1 on the country (protected) side and 3:1 on the river side.

The proposed embankment would connect to the existing BWDB embankment at Jaria.

Preliminary embankment crest elevations are shown in Table 9.2. Details are provided in Annex C.

Impact on Flooding
As a result of the flood protection measures, the depth of flooding will be reduced and the area of flood-free land will be increased as shown in Tables 9.3 and 9.4.

Table 9.2: Design Embankment Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Banastala (Sarchapur Bridge)	0.00	15.06
Jaria	35.0	12.33

9.4.2 Drainage

Following completion of the project, the drainage requirements of the area will be greatly reduced since the present flood spills from the Kangsha River will be decreased. Consequently the outflow discharge will be smaller.

The existing natural drainage system of khals and beels, with minor improvement, will be used for drainage of the project area. The existing khals are assumed to be capable of carrying the local runoff once the Kangsha overbank spills are eliminated. However, a quantity of 400,000 m^3 of channel re-excavation has been kept in the project work as was proposed in BWDB's 1986 'Dampara Feasibility Report'.

It is proposed to drain the outflow from the project area through Kalihar and Balia/Lauri khals to the Mogra River as was discussed in Chapters 4 and 6.

Table 9.3: Pre-Monsoon Depth of Flooding (by 1:2 Year Flood before 15 May)

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	12,470	12,370
0.30-0.90	-	-
0.90-1.80	-	-
>1.80	-	-
Total	**12,470**	**12,370**

Table 9.4: Monsoon Depth of Flooding (by 1:2 Year Max Annual Flood)

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	4620	5670
0.30-0.90	3460	3650
0.90-1.80	2760	1950
>1.80	1630	1100
Total	12470	12370

[a] These figures do not reflect cultivable land acquired for embankment. Production impacts of land acquisition are documented in the Evaluation section.

9.4.3 Structures

Regulators
Two drainage regulators exist in the project area, both in good condition: a five-vent (1.52 m x 1.83 m) regulator on Dharamula khal and a ten-vent (1.52 m x 1.83 m) regulator on Balia khal.

Two new regulators are proposed as a provisional item, one on Kalihar khal (2-1.52

200

m x 1.83 m vents) and the other on Lauri khal (7-1.52 m x 1.83 m vents). These regulators may be required to prevent reverse flows from the Mogra River to the project area, subject to more detailed study. At present the water level data and field information are not sufficient to determine whether there will be backflow under post-project conditions.

9.4.4 Expected Benefits

The benefits expected from the project relate mainly to increased crop production resulting from protection of agriculture. Agricultural crops are damaged almost every year by flooding within the project area.

The present cropping patterns and crop production are given in Tables 9.5 and 9.6. These data were based on information which was gained from field visits and farmer interviews in the project area with respect to average yields under damage-free conditions, types of crops which are damaged, percent of the crop area which is damaged annually, the reduced yield of crops after flood damage, and other factors. These data were analyzed to obtain estimates of the total production which are presented in Table 9.6.

The future cropping pattern and crop production without intervention (FWO) are given in Tables 9.7 and 9.8. Without intervention it is expected that flash floods would continue to damage aus and aman crops. The cropping pattern, yield, and total production would remain much the same as at present.

With the project (FW) it is expected that the cropping pattern will change as a result of the changes in the flood regime, and yields will increase as the flood damages are reduced. The changed cropping pattern is shown in Table 9.9 and the increased yields and total crop production are shown in Table 9.10.

Annual cereal production is expected to increase by about 9,300 tonnes from 49,473 tonnes (FWO) to 58,742 tonnes (FW) as a result of the project, an increase of 19%. Non-cereal production would increase by about 1,500 tonnes or 25%. This increase in non-cereal crops is mainly due to an increase in the area of oilseeds and vegetables.

The increase in cereal production implies an increase in cereal availability from 437 gm per person per day (FWO) to 519 gm per person per day (FW), an increase of +15% (Table 9.11). The current Bangladesh average consumption is 440 gm per person per day.

Table 9.5: Present Cropping Patterns (ha)

Crop Pattern	F0	F1	F2	F3	Total
b aman			221 (8)		221
l boro				489 (30)	489
hyv boro			2070 (75)	1141 (70)	3211
b aus-rabi	462 (10)				462
b aus-lt aman	1155 (25)	346 (10)			1501
b aus-lt aman-rabi	92 (2)	35 (1)			127
b aus-hyv aman	924 (20)	277 (8)			1201
b aus-hyv aman-rabi	46 (1)	69 (2)			115
jute-lt aman		138 (4)			138
jute-rabi		277 (8)			277
jute-hyv aman	139 (3)				139
jute-hyv aman-rabi	139 (3)				139
hyv aus-lt aman	831 (18)	173 (5)			1004
lt aman	139 (3)	104 (3)	276 (10)		519
lt aman-wheat		17 (<1)			17
lt aman-rabi	139 (3)	104 (3)			243
lt aman-hyv boro		1038 (30)			1038
hyv aman	277 (6)				277
hyv aman-potato		121 (4)			121
hyv aman-rabi	277 (6)	69 (2)			346
hyv aman-hyv boro		692 (20)			692
b aman-rabi			55 (2)		55
b aman-hyv boro			138 (5)		138
TOTAL	**4620**	**3460**	**2760**	**1630**	**12470**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

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Table 9.6: Present Crop Production

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	2555	1.4	3577	852	1.12	954	4531
hyv aus	804	3.2	2573	201	2.56	515	3087
b aman	207	1.6	331	207	1.28	265	596
lt aman	3440	2.1	7224	1147	1.68	1927	9151
hyv aman	2313	3.3	7633	578	2.64	1526	9159
l boro	489	2	978				978
hyv boro	4825	4.2	20265	254	3.36	853	21118
jute	485	1.65	800	208	0.99	206	1006
wheat	17	2	34				34
potato	121	11	1331				1331
pulses	265	0.9	239				239
oilseeds	882	0.8	706				706
spices	88	2.5	220				220
vegetables	529	4.0	2116				2116

Source: NERP estimates.

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Table 9.7: Projected Crop Pattern-Future Without Project (ha).

Crop Pattern	F0	F1	F2	F3	Total
b aman			248 (9)		248
l boro				489 (30)	489
hyv boro			2070 (75)	1141 (70)	3211
b aus-rabi	462 (10)				462
b aus-lt aman	693 (15)	277 (8)			970
b aus-lt aman-rabi	92 (2)	35 (1)			127
b aus-hyv aman	1155 (25)	277 (8)			1432
b aus-hyv aman-rabi	46 (1)	138 (4)			184
jute-lt aman-fallow		138 (4)			138
jute-rabi		277 (8)			277
jute-hyv aman	139 (3)				139
jute-hyv aman-rabi	139 (3)				139
hyv aus-lt aman	1062 (23)	173 (5)			1235
lt aman	139 (3)	104 (3)	193 (7)		436
lt aman-wheat		17 (<1)			17
lt aman-rabi	139 (3)	104 (3)			243
lt aman-hyv boro		1038 (30)			1038
hyv aman	277 (6)				277
hyv aman-potato		121 (4)			121
hyv aman-rabi	277 (6)	69 (2)			346
hyv aman-hyv boro		692 (20)			692
b aman-rabi			83 (3)		83
b aman-hyv boro			166 (6)		166
TOTAL	**4620**	**3460**	**2760**	**1630**	**12470**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

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Table 9.8: Crop Production - Future Without Project

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	2381	1.4	3333	794	1.12	889	4223
hyv aus	989	3.2	3165	247	2.56	632	3797
b aman	248	1.6	397	248	1.28	317	714
lt aman	3153	2.1	6621	1051	1.68	1766	8387
hyv aman	2553	3.3	8425	638	2.64	1684	10109
l boro	489	2	978				978
hyv boro	4851	4.2	20374	255	3.36	857	21231
jute	485	1.65	800	208	0.99	206	1006
wheat	17	2	34				34
potato	121	11	1331				1331
pulses	279	0.9	251				251
oilseeds	930	0.8	744				744
spices	93	2.5	233				233
vegetables	558	4.0	2232				2232

Source: NERP estimates.

Table 9.9: Projected Crop Pattern-Future With Project (ha)

Crop Pattern	F0	F1	F2	F3	Total
b aman			39 (2)		39
l boro				55 (5)	55
hyv boro			1365 (70)	1045 (95)	2410
b aus-rabi	454 (8)				454
b aus-lt aman	454 (8)	109 (3)			563
b aus-lt aman-rabi	113 (2)	73 (2)			186
b aus-hyv aman	1134 (20)	183 (5)			1317
b aus-hyv aman-potato	113 (2)				113
b aus-hyv aman-rabi	170 (3)	183 (5)			353
jute-hyv aman	57 (1)				57
jute-hyv aman-wheat	113 (2)	146 (4)			259
jute-hyv aman-rabi		365 (10)			365
hyv aus-lt aman	851 (15)				851
hyv aus-hyv aman	851 (15)	365 (10)			1216
lt aman	113 (2)				113
lt aman-wheat	57 (1)	36 (1)			93
lt aman-rabi	227 (4)				227
lt aman-hyv boro	340 (6)	657 (18)	195 (10)		1192
hyv aman	227 (4)	73 (2)			300
hyv aman-potato		73 (2)			73
hyv aman-rabi	283 (5)	292 (8)			575
hyv aman-hyv boro	113 (2)	1095 (30)	98 (5)		1306
b aman-rabi			39 (2)		39
b aman-hyv boro			214 (11)		214
TOTAL	**5670**	**3650**	**1950**	**1100**	**12370**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

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Table 9.10: Crop Production-Future With Project

Crop	Area (ha)	Yield (t/ha)	Total (t)
b aus	2986	1.4	4180
hyv aus	2066	3.2	6611
b aman	293	1.6	469
lt aman	3226	2.1	6775
hyv aman	5568	3.3	18374
l boro	55	2	110
hyv boro	5123	4.2	21517
jute	681	1.65	1124
wheat	353	2	706
potato	186	11	2046
pulses	330	0.9	297
oilseeds	1099	0.8	879
spices	110	2.5	275
vegetables	660	4.0	2640

Source: NERP estimates.

Table 9.11: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	618	658	519	437
Non-Cereals	130	148	117	93

9.4.5 Mitigation Measures Incorporated

To minimize the negative impacts on fisheries, fish-friendly regulating structures will be constructed. Improvement to current designs would need to be incorporated to ensure the functionality of these regulators for the intended purpose.

9.5 Project Operation and Maintenance

Under this development plan, operation and maintenance requirements would be minimal and would be limited to repairing of raincuts in the embankment and to operation and maintenance of gates.

9.6 Organization and Management

Client groups would need to be organized to oversee project development. These client groups and other organization and management aspects would be similar to that for the Malijhee River Improvement Project (see Section 7.6).

9.7 Cost Estimates

Total project costs are estimated to be Tk 146.5 million.

Land costs, earthwork, and structure costs are indexed to June 1991 prices. The unit rates and cost estimating procedures are similar to that used for the Malijhee River Improvement Project (see Section 7.7).

A summary of total costs is presented in Table 9.12 and details are provided in Annex C.

Table 9.12: Capital Cost Summary

Item	('000 Tk)
Structures	17,100
Embankments	24,836
Channels	6,000
Land Acquisition	54,000
BASE COST	101,936
Physical Contingencies (25%)	25,484
SUBTOTAL	127,420
Study Costs[1] (15% of Subtotal)	19,113
TOTAL	**146,533**
Net Area (ha)	12,470
Unit Cost (Tk/ha)	11,750

[1] Includes preparation of EIA and Environmental Management Plan.

9.8 Project Phasing and Disbursement Period

Four years are required to implement the project. Feasibility studies and field surveys will be carried out in one year (year zero). Preparation of detailed designs should start in year one and should be completed in the same year. Land acquisition should be started in year one and should be completed in phases prior to the start of construction. Construction activities should start in year one and should be completed in year three. An itemized implementation schedule is shown in Table 9.13.

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9.9 Evaluation

9.9.1 Environmental

The key areas of environmental impact for this project are described briefly below. Additional information is given in Annex E, Initial Environmental Evaluation.

Land Use

Land use changes are summarized in Table 9.14. A total of 150 ha of land (about 1% of the gross project area) will be required for embankment construction. Of this:

- 100 ha will be taken from cultivated area. Assuming that this area is under rice production and has average yields, this loss corresponds to foregone cereal production of about 290 tonnes per year or about 3% of total incremental cereal production. The production from this land has been discounted in the calculation of total incremental cereal production in Table 9.10.

- 50 ha will be taken from fallow area.

Agriculture

Increased cereal production is documented in Section 9.4.4, Expected Benefits. Briefly, the project is expected to increase the production of cereal crops by 9,300 tonnes per year and to increase the production of non-cereal crops by 1,500 tonnes per year. Cereal food availability would increase from by 19% from 795 gm per person per day (FWO) to 943 gm per person per day (FW). Availability of non-cereals would increase by 25%, from 93 gm per person per day to 117 gm per person per day.

Openwater fisheries production

Generally three types of impacts are considered to be important. These are:

- reduced flood plain fisheries resulting from reduced grazing areas;

- reduced beel fisheries resulting from drainage and destruction of water links between beels and rivers;

Table 9.13: Implementation Schedule

Activity	Year (% Completion)			
	0	1	2	3
Preconstruction Activities				
Feasibility Study	100			
Engineering Investigation	100			
Detail Designs		100		
Land Acquisition		80	20	
Construction Activities				
Construction of Embankments		20	50	30
Excavation of Channels			50	50
Construction of Structures		10	60	30

Table 9.14: Changes in Land Use

Use	Change in area (ha)
Cultivated	(-) 100
Homesteads	-
Beels	-
Ponds	-
Channels	-
Hills	-
Fallow	(-) 50
Infrastructure	-

- impacts on spawning resulting from destruction of water links between spawning grounds and rivers.

The flood control infrastructure will reduce the seasonally flooded area within the project by about 15% (Table 9.16).

Impacts on production were assessed using a simplified model reflecting the current understanding of the system. The details of the model are given in Annex D. Values of various parameters which were used in the model to calculate future production with and without the project are also furnished in Annex D. Where standard values for the region or for a particular project type were used, these are noted.

Table 9.15: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	618	658	519	437
Non-Cereals	130	148	117	93
Open Water Fish	9.3	1.8	1.4	6.4
Aqua-culture	5.12	6.1	4.8	3.6

As was discussed in Chapter 5, it is assumed that fish production will remain unchanged without the project, at 401 tonnes.

The openwater fisheries production will be reduced by 311 tonnes per year as a result of the project implementation, which is 78% of the FWO annual production. This implies a decrease in fish availability from openwater sources, due to the project, from 6.4 gm per person per day (FWO) to 1.4 gm per person per day (FW) as shown in Table 9.15. This Table includes data for food grains which were presented in an earlier section.

Table 9.16: Fish Production Indicators

Regime	FWO (2015)		FW (2015)		
	Area (ha)	Production (t)	Area (ha)	Production (t)	Production Impact ('000 kg)
Flood Plain (F1+F2+F3)	7850	275	6700	71	-204
Beels	230	46	230	7	-39
Channels/River	400	80	400	12	-68
Sub-total	8480	401	7330	90	(-)311
Pond	370	222	370	296	74

Aquaculture production
Aquaculture production will be increased by 74 tonnes per year, which is 33% of the FWO annual production of 222 tonnes (included in Table 9.16). This implies an increase in pond fish availability, due to the project, from 3.6 gm per person per day (FWO) to 4.8 gm per person per day (FW) (Table 9.15).

Homestead flooding
Homestead flood damage would be significantly reduced. Due to the lack of historical data on flood damage costs, a simple model was used to estimate future costs assuming that there are about 22,139 homesteads in the area, the average plinth level is at about the 1:5 year flood level and about 5% of homesteads are affected by flooding of 10-20 cm in the 1:10 and 1:25 year floods. The estimated annualized economic value of reduced flood damage is Tk 0.66 million.

Wetland Habitats and Grazing Area
Impacts are difficult to quantify, but a general impression is given by Table 9.17, which shows the impact on:

- **'Winter grazing area'**; defined as F0, F1, and F2 lands that lie fallow in the dry season (winter), plus any perennially-fallow highlands. This land has limited residual moisture. Although animals do graze on such areas the productivity per unit area is not known.

- **'Winter wetland'**; F3 land that lies fallow in the dry season, plus any perennially-fallow lowland (F4), beel, and channel areas. This land would likely have considerable residual moisture and could support a range of wetland plant communities.

- **'Summer wetland'**; F1, F2, and F3 land that lies fallow in the summer, plus perennially-fallow lowland (F4 area), beel, and perennial channel areas. This land would be inundated to a depth greater than 0.3 m and would support submerged, free-floating, rooted floating, and sedge/meadow plant communities.

The impact of the project would be to increase winter grazing area by 9%, to

Table 9.17: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	3465	3687	222	
sc/wf F1	969	730	-239	
sc/wf F2	441	39	-402	
Fallow Highland	100	50	50	
Total	4975	4506	-469	-9

Land Type	Winter Wetland			
sc/wf F3	0	5	0	
F4, Beel, Channel	780	780	0	
Total	780	780	0	0

Land Type	Summer Wetland			
wc/sf F1	0	0	0	
wc/sf F2	2070	1365	-705	
wc/sf F3	1630	1100	-530	
F4, Beel, Channel	780	780	0	
Total	4480	3245	-1235	-28

FW areas shown here do not reflect cultivable land acquired for infrastructure (see Land Use, Section 7.8.1). 'sc' - summer cultivated. 'wc' - winter cultivated. 'sf' - summer fallow. 'wf' - winter fallow.

cause no change in winter wetland area, and to decrease summer wetland area by 28%.

Economic and employment impacts of the project on wetland plant and animal production can be only roughly estimated. Assuming an annual economic production of Tk 100 per hectare for both summer and winter wetland areas gives a total annual loss of Tk 123 thousand per year. Assuming 1.0 pd/ha/yr is spent in harvesting, the impact on employment would be minimal (a loss of 1235 pd per year).

Transportation/navigation
The total length of existing roads in the project is 120 km of which approximately 12 km are inundated every year. The project would make 12 km of these roads flood-free (up to the 1:25 year flood). Assuming a capital cost of Tk 190,000/km and damage during floods of 15%, the annual benefit of flood protection is Tk 0.24 million.

Higher Kangsha flood levels
Kangsha River flood levels could increase by a few centimetres. This could affect areas outside the project, most likely on the left bank area. Improved understanding of this impact requires regional flooding analysis, which is ongoing as a part of NERP.

9.9.2 Social

The key areas of social impact by this project are described below. Additional information is given in Annex E, Initial Environmental Evaluation.

Employment
There will be an overall increase in employment of 0.134 million person-days per year. This is composed of:

- an increase in owner-labour employment of 0.252 million pd/yr, of which roughly 20% is post-harvest processing activities traditionally done by women of the household.

- a net decrease in employment opportunities for landless people of 0.118 million pd/yr, composed of changes in the following areas:

  - Agricultural hired labour: increase of 0.310 million pd/yr, of which about 10% is for post-harvest processing traditionally done by women;

  - Fishing labour: decrease of 0.427 million pd/yr in addition to a corresponding loss in support activities such as net-making and post-catch processing (mainly drying), much of which is done by women.

  - Wetland labour (gathering wetland products): decrease of 0.001 million pd/yr. Fodder and building material are gathered mainly by men. Food, fuel, and medicine are gathered mainly by women.

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Displacement impacts due to land use changes
In this study, it is assumed that the embankment will detour any homesteads. However at the time of implementation, it is likely that a few houses may require to be displaced and acquired by the project, for suitable cash compensation.

Households whose homestead land is acquired by the project may have difficulty relocating. This is because suitable homestead lands are so scarce that replacement land may not be available for purchase.

The experience of BWDB in resettling landless people on embankments in the Cyclone Protection Project may be relevant to the requirements of this project area. Two mitigation options bear consideration. Embankments could be constructed with berms at strategic locations to support homesteads. Alternatively, raised housing platforms could be constructed to facilitate relocation.

Conflicts
Leaving households outside the embankment can be a source of conflict. When water levels are high, river side residents may cut the embankment in an attempt to relieve flooding in their area. Detailed settlement surveys will be required to assess the magnitude of this problem in this area.

Equity
The net equity impact would appear to be *regressive*. Who benefits?

- Landowners, in proportion to landholdings, benefit directly from investment in agriculture production. This is the main benefit of the project and its distribution is quite *regressive*.

Who loses?

- Families dependent upon fishing labour. These families are mainly landless and tend to be poorer than average. *Regressive*.

- Families involved in gathering wetland products. These families are mainly landless and tend to be very poor. *Regressive*.

- Families displaced from their homesteads by project land acquisition. In sofar as more wealthy families can influence infrastructure siting/alignment, this is *regressive*.

Gender Equity
The net equity impact would appear to be somewhat *progressive*. Employment opportunities for women will increase in all categories except wetland gathering. Reduced homestead flood damage will favour women, given that most women still spend most of their lives within the homestead.

Qualitative Impact Scoring
Impacts of the project are scored qualitatively in Table 9.18 on an 11-level scale ranging from -5 to +5. The scoring procedure is analogous to that used in the FAP 19 EIA case studies, but was simplified to eliminate half-point scores (1.5, 2.5, 3.5, etc). Here, each score sums across five equally weighted logical (true/false) criteria, with each 'true' counting for a value of one and each 'false' for zero. The sign reflects whether the impact is positive or negative.

Table 9.18: Qualitative Impact Scoring

		True=1 False=0					
Qualitative Impact	Impact Sign	Sensitive	Magnitude	Immediate	Sustainable Pos Impact/ Irreversible Neg Impact	No Mitigation Required/ Possible	Score
Ecological Character	-1	0	0	0	0	1	-1
Regional Biodiversity	-1	0	0	0	0	1	-1
Road Transportation	1	1	1	1	1	1	5
Navigation	-1	0	0	0	0	1	-1
Flood Levels Outside Project Area	-1	0	0	1	0	1	-2
Conflicts	-1	0	1	0	0	0	-1
Socioeconomic Equity	-1	0	0	0	0	1	-1
Gender Equity	1	0	0	0	1	1	2

9.9.3 Economic

A summary of salient data is provided in Table 9.19.

The project has an economic rate of return of 41%, which compares well to the required rate of 12% as prescribed by government. It is a relatively low investment project, at Tk 147 million or Tk 11,750 per hectare, and it covers a large geographic area (15,300 ha gross). The rate of return, however, is quite sensitive to the timing of the benefits, and a delay in benefits by two years would reduce the ERR to 24%, which would still be favourable. The other sensitive variable is capital costs; a 20% increase in capital costs would reduce the rate of return to 33%. A 20% reduction in fish benefit (20% increase in fish losses) would reduce the ERR is to 32%.

The foreign costs associated with the project are low, at 5% (excluding FFW contributions).

Almost all of the benefits of the project relate to increased rice production, mostly resulting from shifts to hyvs and non-cereal production. Average crop yields would increase as a result of reduced flood damage. Cropping intensity would increase by 5%. Non-cereal production would increase by 25%. About 3% of project benefits would result from reduced homestead flooding.

Floodplain fish production would decrease by about 78%. The value of the lost fisheries output amounts to about 28% of the value of the increased agricultural output. A small amount of disbenefit would result from loss of food, shelter, and tree products that are currently harvested from the seasonal wetlands.

It is anticipated that the established crop marketing system will handle increased crop production without any reduction in prevailing average price levels. Assuming the current annual growth in the demand for grain remains about 3%, the increased cereal production is unlikely to present

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any marketing difficulties.

A significant caution is that the economic benefits are dependent on assumed shifts in cropping patterns, and if this did not occur, the project might not be viable. Lessons of the past have shown that producers have not always responded as predicted, and this case warrants special efforts in predicting producer responses.

9.9.4 Summary Analysis

From a multi-criteria perspective (Table 9.20), some aspects of the project are not attractive.

Negative aspects include:

- Fisheries and wetlands would be reduced.
- Employment opportunities for hired labourers would be reduced as a result of the reduced floodplain fishery.
- A number of households would lose their homestead land to project land acquisition.
- Kangsha River flood levels would increase slightly.
- Conflicts between families living within and outside the embankment could increase.

The positive aspects of the project would be:

- Rate of return is attractive.
- Rice production would be increased substantially.
- Economic returns to land owners would be increased.
- Net employment would be increased.
- Flood damage to homesteads and roads would be reduced.
- Non-cereal production would be increased substantially.
- Gender equity of impacts is somewhat progressive.
- Project responds to expressed public concerns.
- The project has a low dependency on central government for implementation.

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Table 9.19: Summary of Salient Data

Economic Rate of Return (ERR)	41			
Capital Investment (Tk million)	147			
Maximum O+M (Tk million/yr)	3			
Capital Investment (Tk/ha)	11,750			
Foreign Cost Component	5			
Net Project Area (ha)	12,470			
Land Acquisition Required (ha)	150			

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (Tk million / yr)	32.32			
Cropping Intensity		1.6	1.7	1.8
Average Yield (tonnes/ha)		2.7	2.7	2.9
Average Gross Margins (Tk/ha)		13784	13866	14276
Owner Labour (md/ha)		124	124	123
Hired Labour (md/ha)		42	43	52
Irrigation (ha)		5834	5895	6432
Incremental Cereal Prod'n (' 000 tonnes / yr)	9			
Incremental Non-Cereal (' 000 tonnes / yr)	1			
Incremental Owner Labour (' 000 pd / yr)	252			
Incremental Hired Labour (' 000 pd / yr)	310			

FISHERIES IMPACTS		Flood plain	Beels	River/ Channel	Pond
Incremental Net Econ Output (Tk million / yr)	-9.07	-4.64	-1.34	-3.09	-
Area (FWO) - ha		7850	230	400	370
Area (FW) - ha		6700	230	400	370
Average Gross Margins (Tk/ha)		1225	14000	14000	-
Remaining Production %		26	15	15	133
Incremental Fish Production (tonnes / year)		(-)204	(-)39	(-)68	74
Incremental Labour ('000 pd / yr)		(-)408	(-)5	(-)23	8

FLOOD DAMAGE BENEFITS				
Households Affected		1107		
Reduced Econ Damage Households (Tk M / yr)	0.66			
Roads/Embankments Affected -km		10		
Reduced Econ Damage Roads (Tk M / yr)	0.3			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	0.12			
Wetland Incremental Labour ('000 pd / yr)	1.2			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	1.34			
Persons Displaced by Homestead Acquisition	-	-		

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Table 9.20: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	41
EIRR, Increase Capital Costs by 20%	per cent	33
EIRR, Delay Benefits by Two Years	per cent	24
EIRR, increase Fisheries losses by 20%	Percent	32
Net Present Value	Tk	94,333

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	9269	19
Incremental Non-Cereal Production	tonnes	1464	25
Incremental Fish Production	tonnes	(-)237	(-)38
Change in Floodplain Wetland/Fisheries Habitat	ha	1150	15
Homesteads Displaced Due to Project Land Acquisition	homesteads	0	0
Homesteads Protected From Floods	homesteads	1107	5
Roads Protected From Floods	km	10	5
Kangsha River Levels	m PWD	few cms	-
Owner Employment	million pd/yr	0.252	10
Hired Employment (Agri+Fishing+Wetland)	million pd/yr	-0118	8

Qualitative Impacts (ranked from -5 ...0... +5)	
Impact	**Rank**
Regional Biodiversity	-1
Road Transportation	+5
Navigation	-1
Flood Levels Outside Project Area	-2
Conflicts	-1
Socioeconomic Equity	-1
Gender Equity	2
Decentralized Organization and Management	-1
Responds to Public Concerns	+4
Conformity to Regional Strategy	+3

[1] Percent changes are calculated relative to future-without-project values of: total production of cereal, non-cereal, and fisheries; total floodplain area; total number of homesteads (for displacement due to land acquisition); flood-affected homesteads; flood-affected roads; Kushiyara water level; and total employment for owners and hired labourers.

[2] Includes incremental production foregone due to acquisition of cultivated land.

10. PROPOSED PROJECT
SOMESWARI RIVER PROJECT

10.1 General Information

BWDB Division:	Netrokona WD
District:	Netrokona
Thana(s):	Durgapur, Kalmakanda, Purbadhala, Netrokona and Barhatta
Project Type:	Full Flood Control (two sides open)
Gross Area:	30,620 ha
Net Area:	22, 515 ha
Population:	169,900 (1991), 176,700 (1993), 200,300 (2000), 254,100 (2015)

Current land use is summarized in Table 10.1. The project area and proposed works are shown in Figure 22.

10.2 Rationale

The Someswari River is located on a high-hazard alluvial fan which is subject to flooding, erosion, deposition, and channel shifting.

The project will provide a measure of security against channel shifting and flooding in the project area and will help to increase rice production which is essential as the main food source.

10.3 Objectives

The objectives of the project area are:

- to protect crops, farmlands, and beels in the Someswari River left bank area;
- to protect Jaria-Durgapur Road, homesteads, and other infrastructure;
- to provide security against future avulsions;
- to promote pond aquaculture;
- to arrest further damage by Atrakhali channel.

Table 10.1: Current Land Use

Use	Area (ha)
Cultivated (F0+F1+F2+F3)	22,515
Homesteads	1,020
Beels	1,200
Ponds	300
River Channels	4,000
Hills	-
Fallow	1,000
Infrastructure	585
Total	**30,620**

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10.4 Description

As stated in Chapter 6, protecting the Someswari left bank area by raising the existing Jaria-Durgapur Road and by preventing the spills down Atrakhali khal appears to be the most viable option.

The main components of the scheme would include:

- raising, strengthening, and paving the existing road between Jaria and Durgapur, and extending this road to the high ground north of Durgapur, to prevent overflows from the Shibganjdhala/Someswari River and to reduce the risk of an avulsion forming toward the east;

- closing Atrakhali channel to prevent further development of this channel from causing further damage to the east;

- closing five bridge openings on the Jaria-Durgapur Road to reduce spills to the east;

- constructing river training works (described in Section 10.5, Operation and Maintenance) to prevent further avulsion and spills.

The project provides limited intervention that will reduce flood depth by as much as 1.5 m. This limited intervention is proposed in consideration that the area is situated on a high-hazard alluvial fan.

The Durgapur-Kalmakanda Road on the northeast of the project area will act as a flood embankment against the northern hilly streams. The area north of the road will be drained through Tongai River and will be kept open on the south and east for fish migration and drainage requirements.

The Old Someswari River is proposed to be kept open of the following two reasons:

- the River does not receive any flow except at high floods when the Someswari level exceeds approximately 11.5 m,PWD at Durgapur. During flood time, it receives less than one-third of Someswari flow. It is considered that the Old Someswari River is able to contain this flow within its banks, at least as far eastward as the annual monsoon flooding of the Sylhet Trough.

- any future avulsion will be induced to take place through this existing channel instead of forming a new channel.

Closing Atrakhali will require considerable effort as the channel is rapidly becoming the main channel of the Someswari River. If the proposed works are not implemented quickly and the channel continues to grow as expected it may become impossible to close the channel at all and the entire project concept would need to be reviewed at that time.

An outline of the proposed work is shown in Figure 22 and a more detailed description of the proposed works is given in Sections 10.4.1 through 10.4.3.

10.4.1 Flood Protection

Embankments
The flood protection of the area will be effected with full flood embankments along the left bank of the Someswari River designed for a flood of 20-year return period.

The project embankment works include the following:

- upgrading the 20.0 km Jaria-Durgapur Road connecting to high ground north of Durgapur;
- paving the Jaria-Durgapur Road for 18.00 km from Jhanjail to the Old Someswari River.

Use of the existing Jaria-Durgapur Road as a flood embankment will minimize land acquisition and earthwork volume. The existing road will need to be raised, on average, by about 1.5 m to an average height of 4.5 m. The finished roadway-cum-embankment would have a crest width of 7.32 m, paved width of 6.1 m, and side slopes of 2:1 on both sides.

Flood levels will be raised by approximately 0.4 m at Jaria in the Kangsha River, as a result of closing the Atrakhali channel and closing the bridges in the Jaria-Durgapur Road, as shown in Figure 23. The Kangsha embankments will need to be raised, with the greatest change being 0.4m at Jaria.

Preliminary embankment crest elevations are shown in Table 10.2. Details are provided in Annex C.

Closures and Structures for Flood Control
Atrakhali khal will be closed along with five bridge openings in the Jaria-Durgapur Road. Only the Old Someswari River and Shibganjdhala River will be left open. Additional information on structures is provided in Section 10.4.3.

The Kaghria and Bilas Rivers, which spill from the Shibganjdhala River through the Jaria-Durgapur Road into the Kangsha floodplain, will be left open. Although their spills contribute to flooding and damaging of crops in the project area they also reduce the flows in the Kangsha. Preliminary modelling indicates that closing these two channels would raise flood levels by 0.4 m at Jaria as shown in Figure 23 and that the water would return to the left floodplain a short distance downstream. Closing of these two bridges should be considered in the future together with Kangsha left embankments as was discussed in Chapter 6.

Impact on Flooding
As a result of the flood protection measures, the depth and extent of flooding within the project area will be reduced as shown in Tables 10.3 and 10.4. In addition the possibility of further avulsion of the river and the resulting flooding will be reduced.

Flood levels will be raised by 0.4 m in the Kangsha River at Jaria. This estimate was derived from modelling with coarse data; hence the results should be treated as preliminary. During feasibility studies, this impact will be assessed further and will be refined using more detailed model data.

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10.4.2 Drainage

No channel improvement work is proposed in this project.

Following completion of the project, the drainage requirements of the area will be greatly reduced since the present flood spills from the Someswari River will be decreased. Consequently the outflow discharge will be smaller.

The existing natural drainage system of khals and beels will be used for drainage of the project area. The project basin's internal runoff will be evacuated mainly through the Old Someswari River and its distributaries.

Table 10.2: Preliminary Embankment Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Bagmara	0.00	19.06
Jaria	18.00	12.33

10.4.3 Structures

River Training Structures

Several spur dikes will be required along the Jaria-Durgapur road to prevent the formation of a major channel along the roadway and local armouring may be required in places to protect the roadway against erosion. In addition spur dikes and a temporary embankment may be required at the Atrakhali offtake in order to divert the river flow and to facilitate construction of the permanent closure.

Table 10.3: Pre-Monsoon Depth of Flooding (by 1:2 Year Flood before 15 May)

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	22,515	22,515
0.30-0.90	-	-
0.90-1.80	-	-
>1.80	-	-
Total	22,515	22,515

10.4.4 Expected Benefits

The expected benefits of the project relate mainly to increased crop production resulting from protection of agriculture. Agricultural crops are damaged almost every year in the project area by floods and sand deposition.

The present cropping patterns and crop production are given in Tables 10.5 and 10.6 respectively. These data were based on field visits and information which was collected by interviewing farmers in the project area with

Table 10.4: Monsoon Depth of Flooding (by 1:2 Year Max Annual Flood)

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	5440	5740
0.30-0.90	4210	4580
0.90-1.80	5635	9925
>1.80	7230	2270
Total	22515	22515

[a] These figures do not reflect cultivable land acquired for embankment. Production impacts of land acquisition are documented in the Evaluation section.

Table 10.5: Present Cropping Patterns (ha)

Crop Pattern	F0	F1	F2	F3	Total
b aman			845 (15)	1807 (25)	2652
l boro			113 (2)	4338 (60)	4451
hyv boro			169 (3)	1085 (15)	1254
b aus-rabi	1088 (20)	126 (3)	113 (2)		1327
b aus-lt aman	1088 (20)	632 (15)	563 (10)		2283
b aus-lt aman-rabi	109 (2)	211 (5)			320
b aus-hyv aman	435 (8)	211 (5)			646
b aus-hyv aman-rabi	109 (2)	126 (3)			235
jute-lt aman-potato		84 (2)			84
jute-hyv aman-wheat	109 (2)	168 (4)			277
jute-hyv aman-potato		84 (2)			84
hyv aus-rabi	272 (5)	84 (2)			356
hyv aus-lt aman	816 (15)	253 (6)			1069
hyv aus-hyv aman	544 (10)	211 (5)			755
lt aman	381 (7)	842 (20)	1127 (20)		2350
lt aman-wheat		84 (2)	113 (2)		197
lt aman-potato			169 (3)		169
lt aman-rabi		126 (3)	169 (3)		295
lt aman-hyv boro		337 (8)	1409 (25)		1746
hyv aman	217 (4)	337 (8)			554
hyv aman-hyv boro	272 (5)	294 (7)			566
b aman-rabi			282 (5)		282
b aman-hyv boro			563 (10)		563
TOTAL	**5440**	**4210**	**5635**	**7230**	**22515**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

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Table 10.6: Present Crop Production

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	3127	1.3	4065	1684	1.04	1750	5815
hyv aus	1852	3.2	5926	327	2.56	837	6764
b aman	1749	1.6	2798	1749	1.28	2239	5037
lt aman	5107	2	10214	3405	1.6	5448	15662
hyv aman	2027	3.1	6284	1091	2.48	2706	8989
l boro	4006	2.2	8813	445	1.54	685	9499
hyv boro	3716	4.3	15979	413	3.01	1243	17222
wheat	474	2.2	1043				1043
jute	446	1.65	736				736
potato	337	9	3033				3033
pulses	422	0.7	295				295
oilseeds	1407	0.65	915				915
spices	141	2.4	338				338
vegetables	844	4.0	3376				3376

Source: NERP estimates.

Table 10.7: Projected Crop Pattern-Future Without Project (ha).

Crop Pattern	F0	F1	F2	F3	Total
b aman			733 (13)	2169 (30)	2902
l boro			56 (1)	3976 (55)	4032
hyv boro			225 (4)	1085 (15)	1310
b aus-rabi	1088 (20)	126 (3)	113 (2)		1327
b aus-lt aman	1088 (20)	505 (12)	564 (10)		2157
b aus-lt aman-rabi	109 (2)	253 (6)			362
b aus-hyv aman	435 (8)	253 (6)			688
b aus-hyv aman-rabi	109 (2)	168 (4)			277
jute-lt aman-potato		84 (2)			84
jute-hyv aman-wheat	109 (2)	168 (4)			277
jute-hyv aman-potato		84 (2)			84
hyv aus-rabi	272 (5)	84 (2)			356
hyv aus-lt aman	816 (15)	253 (6)			1069
hyv aus-hyv aman	544 (10)	211 (5)			755
lt aman	381 (7)	758 (18)	1127 (20)		2266
lt aman-wheat		84 (2)	113 (2)		197
lt aman-potato			169 (3)		169
lt aman-rabi		126 (3)	169 (3)		295
lt aman-hyv boro		337 (8)	1521 (27)		1858
hyv aman	217 (4)	421 (10)			638
hyv aman-hyv boro	272 (5)	295 (7)			567
b aman-rabi			282 (5)		282
b aman-hyv boro			563 (10)		563
TOTAL	**5440**	**4210**	**5635**	**7230**	**22515**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

Table 10.8: Crop Production - Future Without Project

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	3127	1.3	4065	1684	1.04	1515	5816
hyv aus	1852	3.2	5926	327	2.56	1085	6763
b aman	1874	1.6	2998	1873	1.28	2542	5396
lt aman	5074	2	10148	3382	1.6	5090	15559
hyv aman	2136	3.1	6622	1150	2.48	3093	9473
l boro	3630	2.2	7986	403	1.54	596	8607
hyv boro	3869	4.3	16637	430	3.01	1484	17931
wheat	474	2.2	1042				1042
jute	446	1.65	736				736
potato	338	9	3042				3042
pulses	435	0.7	305				305
oilseeds	1449	0.65	942				942
spices	145	2.4	348				348
vegetables	870	4.0	3480				3480

Source: NERP estimates.

Table 10.9: Projected Crop Pattern - Future With Project (ha)

Crop Pattern	F0	F1	F2	F3	Total
b aman			695 (7)	1021 (45)	1716
l boro				1249 (55)	1249
hyv boro			4069 (41)		4069
b aus-rabi	1091 (19)	137 (3)			1228
b aus-lt aman	1091 (19)	504 (11)	198 (2)		1793
b aus-lt aman-rabi	115 (2)	275 (6)	298 (3)		688
b aus-hyv aman	459 (8)	229 (5)			688
b aus-hyv aman-rabi	115 (2)	183 (4)			298
jute-hyv aman-wheat	115 (2)	183 (4)			298
jute-hyv aman-potato		92 (2)			92
hyv aus-rabi	287 (5)	92 (2)			379
hyv aus-lt aman	804 (14)	229 (5)			1033
hyv aus-hyv aman	574 (10)	275 (6)			849
lt aman	344 (6)	641 (14)	1787 (18)		2772
lt aman-wheat		92 (2)	99 (1)		191
lt aman-potato			298 (3)		298
lt aman-rabi		183 (4)	298 (3)		481
lt aman-hyv boro	229 (4)	504 (11)	1985 (20)		2718
hyv aman	229 (4)	458 (10)	198 (2)		885
hyv aman-wheat		45 (1)			45
hyv aman-potato		45 (1)			45
hyv aman-rabi		92 (2)			92
hyv aman-hyv boro	287 (5)	321 (7)			608
TOTAL	**5740**	**4580**	**9925**	**2270**	**22515**

Note: Numbers in parenthesis indicate percent of cultivated area under the relevant land type.

Table 10.10: Crop Production - Future With Project

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	3521	1.3	4577	1174	1.04	1221	5798
hyv aus	2260	3.2	7232				7232
b aman	858	1.6	1373	858	1.28	1098	2471
lt aman	6482	2	12964	3491	1.6	5586	18550
hyv aman	3121	3.1	9675	780	2.48	1934	11609
l boro	1124	2.2	2472	125	1.54	193	2665
hyv boro	6656	4.3	28621	740	3.01	2227	30848
wheat	535	2.2	1177				1177
jute	390	1.65	644				644
potato	435	9	3915				3915
pulses	475	0.7	333				333
oilseeds	1582	0.65	1028				1028
spices	158	2.4	379				379
vegetables	949	4.0	3796				3796

Source: NERP estimates.

Table 10.11: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	597	604	476	419
Non-Cereals	135	138	109	95

respect to average yields under damage-free conditions, types of crops which are damaged, percent of the crop area which is damaged annually, the reduced yields of crops after flood damage, and other factors. These data were analyzed to obtain the total production which is presented in Table 10.6.

Without intervention, the further development of the Atrakhali khal will increase the crop damage due to flooding and sedimentation on the east side of the fan. The future cropping pattern and crop production without intervention are given in Tables 10.7 and 10.8.

With the project it is expected the cropping pattern will change as a result of the changes in the flood regime, and yields will increase as the flood damages are reduced. The changed cropping pattern is shown in Table 10.9 and the changed yields and total production are shown in Table 10.10.

Annual cereal production is expected to increase by about 10,000 tonnes from 70,589 tonnes (FWO) to 80,351 tonnes (FW) as a result of the project, an increase of 14%. Non-cereal production would increase by about 1250 tonnes or 14%. This increase in non-cereal crops is mainly due to an increase in the area of oilseeds and vegetables.

The increase in cereal production implies an increase in cereal availability from 419 gm per person per day (FWO) to 476 gm per person per day (FW), an increase of +14% (Table 10.11). Current Bangladesh average consumption is 440 gm per person per day.

10.4.5 Mitigation Measures Incorporated

As there will be little impact on the environment, no mitigation measures are required. The project area will remain open to the Kangsha River on the south and to the haor area (the central depression) on the east, permitting free migration to and from the adjacent areas. The project will also protect the beels and channels on the east side of the fan from sedimentation by the Someswari River. Impacts are described more fully in Section 10.9.

10.5 Project Operation and Maintenance

Under this development plan, requirements for operation and maintenance would be moderate. They would primarily consist of monitoring to detect impending channel changes within the Someswari River, the Shibganjdhala River, and the Old Someswari River, and implementation of appropriate measures to stabilize the channels before major problems develop. The Durgapur road-cum-embankment is a particular area of concern as it may come under attack as the Shibganjdhala shifts over its active floodplain. River training structures may be required (spur dikes and/or revetment) along the roadway from time to time. Continued vigilance will be required to monitor the channel bed levels in the vicinity of the Old Someswari bifurcation at Durgapur in order to detect the anticipated future avulsion into the Old Someswari River before it creates flooding problems along the Old Someswari. The need for flood embankments along the Old Someswari River will need to be re-assessed at that time.

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10.6 Organization and Management

The organization and management of this project have a high dependency on central government for key inputs. The extent to which project targets are realized will be determined by how effectively it serves people's needs and how actively the local community participates in all stages of project development.

Client groups would need to be organized to oversee project development. These client groups and other organization and management aspects would be similar to that for the Malijhee River Improvement Project (see Section 7.6).

10.7 Cost Estimates

Total project costs are Tk 83.4 million.

A summary of total costs is provided in Table 10.12 and details are provided in Annex C.

The estimates of physical works are based on preliminary designs and lay-out plans prepared using four inch to one mile topographic maps and historic hydrological data.

The embankment will follow the existing Jaria-Durgapur Road and there is government land along the road. As such, no land acquisition will be required.

Earthwork costs are based on BWDB Schedule of Rates for Mymensingh O&M circle indexed to June 1991 prices. Structure and pavement costs are based on parametric costs developed for the Region, also indexed to June 1991 prices in accordance with the FPCO Guidelines for Project Assessment.

Table 10.12: Capital Cost Summary

Item	('000 Tk)
Structures	-
Embankments	55,250
Channel Closure	2,790
Land Acquisition	-
BASE COST	58,040
Physical Contingencies (25%)	14,510
SUBTOTAL	72,550
Study Costs[1] (15% of Subtotal)	10,883
TOTAL	**83,433**
Net Area (ha)	22,515
Unit Cost (Tk/ha)	3,706

[1] Includes preparation of EIA and Environmental Management Plan.

10.8 Project Phasing and Disbursement Period

Three years are required to implement the project. One year (year zero) is required for completion of feasibility studies and conducting field surveys. Preparation of detail designs should start in year zero and should be completed in the same year. Construction activities should start in year one and should be completed in year two.

It is noted that the Atrakhali channel is continuing to develop and if unchecked it will likely become the main channel of the Someswari. Thus there is some urgency in the implementation of this project.

An itemized implementation schedule is shown in Table 10.13.

Table 10.13: Implementation Schedule

Activity	Year (% Completion)		
	0	1	2
Preconstruction Activities			
Feasibility Study	100		
Engineering Investigation	100		
Detail Designs	100		
Land Acquisition	-	-	
Construction Activities			
Construction of Embankments		50	50
Closure			100
Construction of Structures		30	70

10.9 Evaluation

10.9.1 Environmental

The key areas of environmental impact for this project are described briefly below. Additional information is given in Annex E, Initial Environmental Evaluation.

Land Use
The proposed embankment will use the existing Jaria-Durgapur Road by upgrading and strengthening it. There is government land in roadside borrow areas which may be used for the roadway improvement. No land acquisition will be required.

Agriculture
Increased cereal production is documented in Section 10.4.4, Expected Benefits. Briefly, the project is expected to increase the production of cereal crops by about 10,000 tonnes per year and to increase the production of non-cereal crops by 1250 tonnes per year. Cereal food availability would increase by 14% from 761 gm per person per day (FWO) to 866 gm per person per day (FW). Availability of non-cereals would increase by 14%, from 95 gm per person per day to 109 gm per person per day.

Openwater fisheries production
Generally three types of impacts are considered to be important. These are:

- reduced flood plain fisheries resulting from reduced grazing areas;
- reduced beel fisheries resulting from drainage and destruction of water links between beels and rivers;
- impacts on spawning resulting from destruction of water links between spawning grounds and rivers.

Impacts on production were assessed using a simplified model reflecting the current understanding of the system. The details of the model are given in Annex D. Values of various parameters which were used in the model to calculate future production with and without the project are also furnished in Annex D. Where standard values for the region or for a particular project type were used, these are noted.

As was discussed in Chapter 5, it is assumed that fish production will remain unchanged without the project, at 1943 tonnes.

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Table 10.14: Fish Production Indicators

Regime	FWO (2015)		FW (2015)		
	Area (ha)	Production (t)	Area (ha)	Production (t)	Production Impact ('000 kg)
Flood Plain (F1+F2+F3)	17075	751	16775	738	(-)13
Beels	1200	492	1200	443	(-)49
Channels/River	4000	700	4000	630	(-)70
Sub-total		1943		1811	(-)132
Pond	300	180	300	240	(+)60
Total		2123		2051	(-)72

Estimates of fish production are presented in Table 10.14 and the availability of food in the project region is summarized in Table 10.15 (including estimates of grain availability which were presented earlier). The flood control infrastructure will reduce the seasonally flooded area within the project by about 1.7%. The openwater fisheries production will be reduced by 132 tonnes per year, which is 6.8% of the FWO annual production of 1943 tonnes. This implies a decrease in openwater-source fish availability from 20.9 gm per person per day (FWO) to 19.5 gm per person per day (FW) as shown in Table 10.15.

The benefit to be derived from protecting beels from sedimentation on the east side of the fan has not been included in the economic analysis. This area does not contain a "mother fishery" so there are no regional effects on fisheries.

Aquaculture production

Aquaculture production will increase by 60 tonnes per year, or 33% of the FWO annual production of 180 tonnes per year. This implies an increase in availability of culture fish from 1.94 gm per person per day (FWO) to 2.59 gm per person per day (FW) as shown in Table 10.15.

Homestead flooding

Homestead flood damage would be significantly reduced. Due to the lack of historical data on flood damage costs, a simple model was used to estimate future costs assuming that there are about 32,890 homesteads in the area, the average plinth level is at about the 1:5 year flood level, and about 5% of the homesteads are affected by flooding of 10-20 cm in the 1:10 to 1:25 year floods. The estimated annualized economic value of reduced flood damage is Tk 1.2 million.

Table 10.15: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	597	604	476	419
Non-Cereals	135	138	109	95
Open Water Fish	30	25	20	21
Pond	2.8	3.28	2.59	1.94

Wetland Habitats and Grazing Area
Impacts are difficult to quantify, but a general impression is given by Table 10.16, which shows the impact on:

- **'Winter grazing area'**; defined as F0, F1, and F2 lands that lie fallow in the dry season (winter), plus any perennially-fallow highlands. This land has limited residual moisture. Although animals do graze on such areas the productivity per unit area is not known.

- **'Winter wetland'**; F3 land that lies fallow in the dry season, plus any perennially-fallow lowland (F4), beel, and channel areas. This land would likely have considerable residual moisture and could support a range of wetland plant communities.

- **'Summer wetland'**; F1, F2, and F3 land that lies fallow in the summer, plus perennially-fallow lowland (F4 area), beel, and perennial channel areas. This land would be inundated to a depth greater than 0.3 m and would support submerged, free-floating, rooted floating, and sedge/meadow plant communities.

The impact of the project would be to increase winter grazing area by 26%, decrease winter wetland area by 16%, and decrease summer wetland area by 22%.

Table 10.16: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	3481	3674	193	
sc/wf F1	1979	1923	-56	
sc/wf F2	2085	4069	1,984	
Fallow Highland	725	725	0	
Total	8,270	10,391	2,121	26

Land Type	Winter Wetland			
sc/wf F3	2169	908	-1,261	
F4, Beel, Channel	5475	5475	0	
Total	7,644	6,383	-1,261	-16

Land Type	Summer Wetland			
wc/sf F1	0	0	0	
wc/sf F2	282	1587	1,305	
wc/sf F3	5061	1362	-3,699	
F4, Beel, Channel	5475	5475	0	
Total	10,818	8,424	-2,394	-22

FW areas shown here do not reflect cultivable land acquired for infrastructure (see Land Use, Section 7.8.1). 'sc' - summer cultivated. 'wc' - winter cultivated. 'sf' - summer fallow. 'wf' - winter fallow.

Economic and employment impacts of the project on wetland plant and animal production can be only roughly estimated. Assuming an annual economic production of Tk 100 per hectare for both summer and winter wetland areas gives a total annual loss of Tk 365 thousand per year. Assuming that 1.0 pd/ha/yr is spent on harvesting, the impact on employment would be a loss of 3655 person-days per year.

Transportation/navigation
The total length of existing roads in the project is 100 km of which 10 km is inundated every year including the important Jaria-Durgapur Road. The project would make 10 km of these roads flood-free (up to the 1:25 year flood). Assuming a capital cost of Tk 190,000/km and damage

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of 15% during floods, the annual benefit of flood protection is Tk 0.3 million.

Impact on flood level
The proposed intervention will raise the Kangsha flood level at Jaria by 0.40 m above the present conditions. Without intervention the water levels are expected to fall at Jaria while the flows through the Shibganjdhala channel are expected to increase and to greatly increase the flooding and sedimentation on the east side of the fan.

10.9.2 Social

The key areas of social impact (or lack thereof) for this project are described below. Additional information is given in Annex E, Initial Environmental Evaluation.

Employment
There will be an overall increase in employment of 0.549 million person-days per year. This is composed of:

- an increase in owner-labour employment of 0.239 million pd/yr, of which very roughly 20% is post-harvest processing activities traditionally done by women of the household;

- an net increase in employment opportunities for landless people of 0.3096 million pd/yr, composed of changes in the following areas:

  - Agricultural hired labour: increase of 0.362 million pd/yr, of which about 10% is for post-harvest processing traditionally done by women;

  - Fishing labour: decrease of 0.0488 million pd/yr in addition to a corresponding loss in support activities such as net-making and post-catch processing (mainly drying), much of which is done by women;

  - Wetland labour (gathering wetland products): decrease of 0.0036 million/pd/yr. Fodder and building material are gathered mainly by men. Food, fuel, and medicine are gathered mainly by women.

Displacement impacts due to land use changes
In this study, it is assumed that the embankment will follow the existing roadway for the most part and thus will detour any homesteads. However at the time of implementation, it is likely that a few houses may require to be displaced and acquired by the project, for suitable cash compensation.

Households whose homestead land is acquired by the project may have difficulty relocating. This is because suitable homestead lands are so scarce that replacement land may not be available for purchase.

The experience of BWDB in resettling landless people on embankments in the Cyclone Protection Project may be relevant to the requirements of this project area. Two mitigation options bear consideration. Embankments could be constructed with berms at strategic locations to support homesteads. Alternatively, raised housing platforms could be constructed to facilitate relocation. Households whose homestead land is acquired, for proper cash compensation, by the project may have difficulty relocating. This is because suitable homestead lands are so scarce that availability of replacement land for purchase is not assured.

Conflicts
The possibility of conflict will be minimized in this project by upgrading the Durgapur roadway as the embankment, which will likely be supported by most residents.

Leaving households outside the embankment can be a source of conflict. When water levels are high, river side residents may cut the embankment in an attempt to relieve flooding in their area. Detailed settlement surveys will be required to assess the magnitude of this problem in this area.

Equity
The net equity impact would appear to be *regressive*. Who benefits?

- Landowners, in proportion to landholdings, benefit directly from investment in agriculture production. This is the main benefit of the project and its distribution is quite *regressive*.

Who loses?

- Families dependent upon fishing labour. These families are mainly landless and tend to be poorer than average. *Regressive*.

- Families involved in gathering wetland products. These families are mainly landless and tend to be very poor. *Regressive*.

Gender Equity
The net equity impact would appear to be somewhat *progressive*. Employment opportunities for women will increase in all categories except wetland gathering. Reduced homestead flood damage will favour women, given that most women still spend most of their lives within the homestead.

Qualitative Impact Scoring
Impacts of the project are scored qualitatively in Table 10.17 on an 11-level scale ranging from -5 to +5. The scoring procedure is analogous to that used in the FAP 19 EIA case studies, but was simplified to eliminate half-point scores (1.5, 2.5, 3.5, etc). Here, each score sums across five equally weighted logical (true/false) criteria, with each 'true' counting for a value of one and each 'false' for zero. The sign reflects whether the impact is positive or negative.

10.9.3 Economic

A summary of salient data in provided in Table 10.18.

The project has an economic rate of return of 21%, which compares well with the required rate of 12% as prescribed by government. It is a relatively low investment project, at Tk 83.4 million or Tk 3706 per hectare, and it covers a large geographic area (22,515 ha gross). The rate of return, however, is quite sensitive to the timing of the benefits, and a delay in benefits by two years would reduce the ERR to 14.1%. The other sensitive variable is capital cost (a 20% increase would reduce the rate of return to 17%). A 20% reduction in fish benefit (20% increase in fish losses) would also reduce the ERR to 17%.

Table 10.17: Qualitative Impact Scoring

Qualitative Impact	Impact Sign	True=1 False=0					Score
		Sensitive	Magnitude	Immediate	Sustainable Pos Impact/ Irreversible Neg Impact	No Mitigation Required/ Possible	
Ecological Character	-1	0	0	0	0	1	-1
Regional Biodiversity	-1	0	0	0	0	1	-1
Road Transportation	1	1	1	1	1	1	5
Navigation	-1	0	0	0	0	1	-1
Flood Levels Outside Project Area	-1	0	1	0	1	1	-3
Conflicts	-1	0	1	0	0	0	-1
Socioeconomic Equity	-1	0	0	0	0	1	-1
Gender Equity	1	0	0	1	1	1	+3

The foreign costs component of the project is low, at 7% (excluding FFW contributions).

Almost all of the benefits of the project relate to increased rice production, mostly resulting from shifts to hyvs and non-cereal production. Average crop yields would increase as a result of reduced flood damage. Cropping intensity would increase by 9%. Cereal and non-cereal production would increase by 14%. About 5% of project benefits would result from reduced homestead flooding.

Floodplain fish production would decrease by about 7%. The value of the lost fisheries output amounts to about 31% of the value of the increase in agricultural output. A small amount of disbenefit would result from loss of food, shelter, and tree products that are currently harvested from the seasonal wetlands.

It is anticipated that the established crop marketing system will handle the increased crop production without any reduction in prevailing average price levels. Assuming that the current annual growth in the demand for grain remains about 3%, the increased cereal production is unlikely to present any marketing difficulties.

A significant caution is that the economic benefits are based largely on assumed shifts in cropping patterns. Lessons of the past have shown that producers have not always responded as predicted, and this case warrants special efforts in predicting producer responses.

10.9.4 Summary Analysis

From a multi-criteria perspective (Table 10.19), some aspects of the project are not attractive. Negative aspects include:

- Fisheries and wetlands will be reduced.

- A small number of households would lose their homestead land to project land acquisition.
- Kangsha River flood levels would increase by an estimated 0.4 m.
- Conflicts between families living within and outside the embankment would increase.
- The project has a high dependency on central government for implementation.

The positive aspects of the project would be:

- The rate of return is favourable.
- Employment opportunities for owners and hired labourers will increase.
- Rice production will increase substantially.
- Economic returns to land owners will increase.
- Flood damage to homesteads and roads will decrease.
- Non-cereal production will increase.
- Gender equity of impacts is somewhat progressive.
- The project responds to expressed public concerns.

Table 10.18: Summary of Salient Data

Economic Rate of Return (ERR)	21			
Capital Investment (Tk million)	83.4			
Maximum O+M (Tk million/yr)	3			
Capital Investment (Tk/ha)	3,706			
Foreign Cost Component	7%			
Net Project Area (ha)	22515			
Land Acquisition Required (ha)				

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (Tk million / yr)	18			
Cropping Intensity		1.5	1.6	1.6
Average Yield (tonnes/ha)		2.3	2.3	2.5
Average Gross Margins (Tk/ha)		11857	11850	12359
Owner Labour (md/ha)		121	121	125
Hired Labour (md/ha)		32	34	42
Irrigation (ha)		5925	6126	9473
Incremental Cereal Prod'n (' 000 tonnes / yr)	10			
Incremental Non-Cereal (' 000 tonnes / yr)	1			
Incremental Owner Labour (' 000 pd / yr)	239			
Incremental Hired Labour (' 000 pd / yr)	362			

FISHERIES IMPACTS		Flood plain	Beels	River/ Channel	Pond
Incremental Net Econ Output (Tk million / yr)	-5.51	-0.3	-2	-3	-
Area (FWO) - ha		17075	1200	4000	300
Area (EW) - ha		16775	1200	4000	300
Average Gross Margins (Tk/ha)		1540	28700	12250	-
Remaining Production %		98%	90%	90%	133
Incremental Fish Production (tonnes / year)		(-)13	(-)49	(-)70	+60
Incremental Labour ('000 pd / yr)		(-)26	(-)6	(-)23	6.7

FLOOD DAMAGE BENEFITS				
Households Affected		1645		
Reduced Econ Damage Households (Tk M / yr)	1			
Roads/Embankments Affected -km		10		
Reduced Econ Damage Roads (Tk M / yr)	0.2			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	0.36			
Wetland Incremental Labour ('000 pd / yr)	3.6			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	-			
Persons Displaced by Homestead Acquisition	-			

Table 10.19: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	21
EIRR, Increase Capital Costs by 20%	per cent	17
EIRR, Delay Benefits by Two Years	per cent	14
EIRR, increase Fisheries losses by 20%	Percent	17
Net Present Value	Tk (mn)	27,989

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	9762	14
Incremental Non-Cereal Production	tonnes	1243	14
Incremental Fish Production	tonnes	(-)132	(-)7
Change in Floodplain Wetland/Fisheries Habitat	ha	(-)300	(-)2
Homesteads Displaced Due to Project Land Acquisition	homesteads	0	0
Homesteads Protected From Floods	homesteads	1645	5
Roads Protected From Floods	km	10	10
Kangsha River Levels	m PWD	0.40	-
Incremental Owner Employment	million pd/yr	0.239	9
Incremental Hired Employment (Agri+Fishing+Wetland)	million pd/yr	0.310	21

Qualitative Impacts (ranked from -5 ...0... +5)	
Impact	**Rank**
Regional Biodiversity	-1
Road Transportation	5
Navigation	-1
Flood Levels Outside Project Area	-3
Conflicts	-1
Socioeconomic Equity	-1
Gender Equity	+3
Decentralized Organization and Management	-1
Responds to Public Concerns	+4
Conformity to Regional Strategy	+4

[1] Percent changes are calculated relative to future-without-project values of: total production of cereal, non-cereal, and fisheries; total floodplain area; total number of homesteads (for displacement due to land acquisition); flood-affected homesteads; flood-affected roads; Kushiyara water level; and total employment for owners and hired labourers.

[2] Includes incremental production foregone due to acquisition of cultivated land.

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11. OUTSTANDING ISSUES

The analysis which is reported herein demonstrates the conceptual basis of the proposed basin development plan. However the results of the analysis should be considered preliminary owing to the coarse nature of the model discretization and the limitations in the available cross-section data at certain critical locations. Further work will be required to confirm the feasibility and details of the proposed plan during the feasibility study stage. Particular issues that need to be addressed during the feasibility studies include:

Closure of the left overbank spill from the Bhogai River upstream of Sarchapur (extension of the Konapara embankment)
Modelling indicates that this embankment could cause water levels to rise by as much as 0.5m near the Malijhee confluence. If this is the case it would cause additional flooding in the Malijhee River which could compromise the feasibility of extending the embankment. However the accuracy of the existing model in this reach is low because no surveyed cross-sections were available in this reach and the model uses several assumed sections. Furthermore there are no measurements of discharges within the existing spill channel with which to confirm the model results. Therefore revision and extension of the model are planned in this reach based on more detailed field surveys and hydrometric monitoring.

Impacts of diversion on the Mogra River basin
The impacts of diverting 100 m^3/s from the Bhogai to the Mogra could be defined in only a preliminary fashion owing to the limited survey data in the affected channels. More detailed surveys are required along the diversion route (the Mogra, the Bismai, and the upper Saiduli Rivers) to determine the potential impacts and mitigation measures more precisely.

Closure of two bridge openings in the Jaria-Durgapur Road
The plan proposes to leave open the Kaghria and Bila khals which pass through bridges in the Jaria-Durgapur road in order to minimize the potential impact on the lower Kangsha River. The possibility of closing these bridge openings and the potential impact and mitigation measures are being reviewed in greater detail in conjunction with the regional modelling.

Revisions to the HD model
Extension and expansion of the HD model will be required to better define the water levels and flows and the changes due to the projects, including field cross-section surveys, extension of the model further upstream in the Malijhee River, extension of the Someswari model, revisions to the floodplain schematization; and revision of the drainage area in the NAM model.

Measurement of water levels and discharges at several locations
Water level gauges should be installed and operated for one water year at several locations including: at the confluence of the Bhogai and Malijhee Rivers, on the Malijhee River near the upstream limit of the project area, on the Bhogai River near its bifurcation into the north branch and south (Malijhee) branch, and at several locations in the Mogra basin.

Discharges should be measured at several locations for at least one monsoon season: in the Kangsha floodplain which bypasses the Sarchapur gauge, in the Gangina channel which spills over the Bhogai left bank, in the Durgapur Road bridge openings, and at select locations in the Mogra River basin. In addition, greater attention will be needed to measure peak discharges at border stations in order to better define the rating curves which are used for calculating the boundary inflows.

ANNEX A

TABLES

Table A.1: Climatological Data

Station: Mymensingh

Location: 24°46N:90°24'E

Month	Temperature			Rain (mm)	Evaporation (m)	Relative Humidity (Per %)	Sunshine Hours (hrs/day)	Wind Speed (km3/s)	Potential Evapotranspiration (mm)
	M Max (°C)	M Min (°C)	Mean (°C)						
Jan	20.2	16.9	18.5	11	2.3	74	8.0	6	91
Feb	22.9	18.5	20.9	18	3.3	68	7.5	4	106
Mar	26.4	21.5	25.0	40	4.4	67	8.1	5	149
Apr	29.0	23.1	27.7	103	5.9	71	7.7	6	162
May	29.5	20.9	27.6	327	5.5	79	6.4	6	160
Jun	29.4	21.7	28.1	419	4.7	84	4.5	5	132
Jul	29.8	21.7	28.4	410	4.6	85	3.5	5	134
Aug	29.8	21.7	28.5	367	4.6	84	3.7	5	134
Sep	29.7	21.5	28.4	319	3.9	84	3.9	4	122
Oct	29.9	21.4	27.1	202	3.9	81	7.0	4	124
Nov	25.3	21.1	23.7	23	2.9	75	8.0	3	105
Dec	21.3	18.2	19.9	5	2.4	75	8.4	3	87
Year	26.0	21.1	25.4	2219	4.0	77	6.4	4	1506

Source: BMD

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Table A.2: Area-Elevation
Upper Kangsha River Basin

Elevavion (m,PWD)	Area (ha)	Elevavion (m,PWD)	Area (ha)	Elevavion (m,PWD)	Area (ha)
4.9	101	13.5	139066	22.5	221167
5.0	304	14.0	144539	23.0	222586
5.5	1115	14.5	152648	23.5	223600
6.0	2230	15.0	162176	24.0	224614
6.5	3548	15.5	171095	24.5	226033
7.0	7197	16.0	178900	25.0	227249
7.5	14393	16.5	186097	25.5	228161
8.0	24935	17.0	192178	26.0	228668
8.5	33956	17.5	198463	26.5	229073
9.0	44193	18.0	202720	27.0	229479
9.5	55444	18.5	205558	27.5	229986
10.0	64972	19.0	208801	28.0	230391
10.5	75716	19.5	210727	28.5	230991
11.0	85649	20.0	213058	29.0	231506
11.5	97204	20.5	215187	29.5	232114
12.0	109063	21.0	216809	30.0	232824
12.5	121835	21.5	217721	30.5	233229
13.0	131768	22.0	219545	31.5	233770

Table A.3: Monsoon Annual Peak Flood Discharge

River	Station No. & Name	Period Record	Discharge (m^3/sec)					
			2-yr	5-yr	10-yr	20-yr	50-yr	100-yr
Nitai	314 Ghosegaon	1965-89	334	473	592	734	965	1182
Shibganjdhala	263A Durgapur	1964-89	1396	1802	2037	2240	2474	2630
Bhogai	34 Nakugaon	1964-89	480	715	903	1112	1432	1716
Bhogai-Kangsha	36 Jaria-Jhanjail	1964-89	969	1166	1314	1472	1701	1894

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Table A.4: Pre-Monsoon (Prior to May 15) Annual Peak Flood Level

River	Station No. Name	Period Record	Discharge (m³/sec)					
			2-yr	5-yr	10-yr	20-yr	50-yr	100-yr
Chillakhali	53 Bathkuchi	1964-89	24.37	24.73	24.90	25.02	25.14	25.20
Nitai	314 Ghosegaon	1965-89	13.28	14.70	16.17	n.a.	n.a.	n.a.
Someswari	262 Bagmara	1964-90	14.02	14.47	14.74	14.97	15.24	15.42
	263 Durgapur	1964-89	11.00	11.47	11.74	11.98	12.26	12.44
Updakhali	263.1 Kalmakanda	1964-89	4.94	5.50	5.74	5.92	6.07	6.15
Bhogai-Kangsha	34 Nakuagaon	1964-89	20.94	21.61	22.15	22.77	n.a.	n.a.
	35 Nalitabari	1964-89	15.25	15.69	15.94	16.15	16.37	16.52
	35.5 Sarchapur	1964-89	9.19	10.06	10.64	11.21	11.94	12.50
	36 Jaria-Jhanjail	1964-89	6.80	7.82	8.29	8.62	8.94	9.11
Mogra	310 Netrokona	1977-89	5.18	5.89	6.18	6.37	6.54	6.62

n.a. - data not available

Table A.5: Monsoon Annual Peak Flood Level

River	Station Name	Period Record	Water Level m,PWD					
			2-yr	5-yr	10-yr	20-yr	50-yr	100-yr
Chillakhali	53 Bathkuchi	1964-89	25.83	26.40	26.85	27.35	28.11	28.78
Nitai	314 Ghosegaon	1965-89	16.69	17.04	17.20	17.32	17.43	17.50
Sommeswari	262 Bagmara	1964-89	17.23	17.72	17.96	18.15	18.34	18.45
	263 Durgapur	1964-89	13.86	14.24	14.45	14.63	14.83	14.95
Updakhali	263.1 Kalmakanda	1964-89	7.79	8.29	8.70	9.16	9.86	10.49
Bhogai-Kangsha	34 Nakuagaon	1964-89	24.58	24.91	24.07	25.18	25.28	25.34
	35 Nalitabari	1964-89	17.87	17.98	18.03	18.08	18.13	18.17
	35.5 Sarchapur	1964-89	13.40	13.75	13.96	14.15	14.37	14.53
	36 Jaria-Jhanjail	1964-89	11.04	11.25	11.35	11.42	11.49	11.53
Mora	310 Netrokona	1977-89	9.17	9.51	9.73	9.93	10.20	10.39

Table A.6: Water Bodies in Upper Kangsha River Basin

Thana	Open Water Bodies (Dry Season) Area[1] (ha)	Closed Water Bodies			
		No.of Ponds	Pond Area[2] (ha)	Average Pond Size (ha)	Pond Concentration (nos/km^2)
Barhatta	14	19	3	0.16	1.08
Durgapur	883	2216	248	0.11	7.67
Dhobaura	679	2216	243	0.11	7.67
Haluaghat	678	2470	277	0.11	8.58
Jhenaigati	24	599	84	0.14	2.92
Kalmakanda	554	1545	173	0.11	10.07
Nalitabari	818	992	140	0.14	2.85
Nakhla	80	195	28	0.14	2.93
Netrokona	838	1093	122	0.11	7.74
Phulpur	90	1328	149	0.11	8.30
Purbadhala	727	1631	183	0.11	6.32
Sherpur	105	291	41	0.14	2.93
Sribardi	10	63	9	0.14	3.02
Total	**5500**	**14658**	**1700**		

Source: [1] CIDA (1989); [2] BFRSS, 1986

Table A.7: Morphological Characteristics of the Bhogai-Kangsha River

Reach	Physiographic Unit	Channel Pattern	Bars/ Islands	Vertical Stability	Lateral Stability	Bed Material D_{65} (mm) D_{50} (mm) D_{35} (mm)	Bank Material	Sinuosity (Lc/Lv)	Slope (m/km) Average Monsoon	Bankfull Dimensions Top Width(m) Depth (m) Area (m^2)
Bhogai R. to Nalitabari	Piedmont Floodplain	Single Channel Regular meanders	Point Bars No Islands	Stable	Erosion due to progressive meander migration, recent widening due to high floods	0.33 0.26 0.21	Mainly Sand	1.55	0.280	74 3.7 278
Nalitarbari to Kharia R. junction	Old Brahmaputra Floodplain	Split Channel Tortuous meanders	No Bars No Islands	Slow aggradation	Irregular shifts, cutoffs	0.20 0.18 0.15	Silt & Silty clay	2.11	0.062	
Kharia R. to Shibganjdhala R.	Old Brahmaputra Floodplain	Single Channel Irregular/Sinuous	No Bars No Islands	Slow aggradation	Slow Infilling	0.34 0.28 0.22	Silt & Silty Clay	1.86	0.040	92 4.3 400
Shibganjdhala R. to Thakarakona	Old Brahmaputra Floodplain	Single Channel Irregular/Sinuous	Point Bars No Islands	Stable	Cutoffs, irregular shifts	0.25 0.19 0.11	Silty Clay	1.90	0.040	170 4.1 700
Lower Kangsha R. to Baulai R.	Central Basin	Single Channel Irregular Meanders	Point bars No Islands	Aggrading	Channel is being abandoned due to shift to Ghulamkhali channel	0.25 0.19 0.11	Silty Clay	1.68	Backwater Controlled	45 3.3 150
Ghulamkhali Channel to Someswari River	Central Basin	Single Channel Irregular Sinuous	Point Bars No Islands	Probably degrading due to channel enlargement	Slowly widening	0.11 0.09 0.08	Silty Clay	1.36	Backwater Controlled	90 5.0 450
Lower Someswari River to Baulai River	Central Basin	Single Channel Irregular Sinuous	Point bars No Islands	Slow aggradation	Cutoffs, irregular shifts	0.11 0.09 0.08	Silty Clay	1.33	Backwater Controlled	90 2.2 200

1.River classification criteria based on Neill and Galay, "Systematic Evaluation of River Regime", (1967).
2.Hydraulic geometry estimated from SWMC cross sections
3.Bed material data from SWMC and NERP
4.Channel Sinuosity = Channel Length/Valley Length

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Table A.8: Duars in Kangsha River (Purbadhala - Thakurakona Reach)

Name of Duar	Location	Depth (m)	Boromach	Chotomach
Raghurampur	Raghurampur	5-6	LC, MC	B,L,R,Ch,P
Bandukhali	Manikpur	8-9	As above	As above
Kamarkhali	Purakadulia	8-9	LC, C,MC	As above
Khataurir duba	Jaria	5-6	LC,MC,C	As above
Sharishtala	Sharistala	5-6	As above	As above
Kumarbari	Jaria	6-7	As above	As above
Kulunja	Jaria	5-6	As above	As above
Kawtahaas	Jaria	5-6	As above	As above
Moishkhali	Choruivita	5-6	As above	As above
Anammya	Koilati	5-6	As above	As above
Mucharbari	Jamdhala	6-7	As above	As above
Durgabari	Kurikuinna	5-6	As above	As above
Purbadohor	Puradohor	6-7	As above	As above
Lomboogachir	Chandragona	5-6	As above	As above
Borailarduba	Borail	5-6	As above	As above
Moinakhali	Moiakhali	5-6	As above	As above
Bautar duba	-	5-6	As above	As above
Kalomduar	Betati	8-9	LC,C,MC	As above
Tetuliar duba	Paspai	6-7	As above	As above
Chitalia	Baghura	8-9	As above	As above

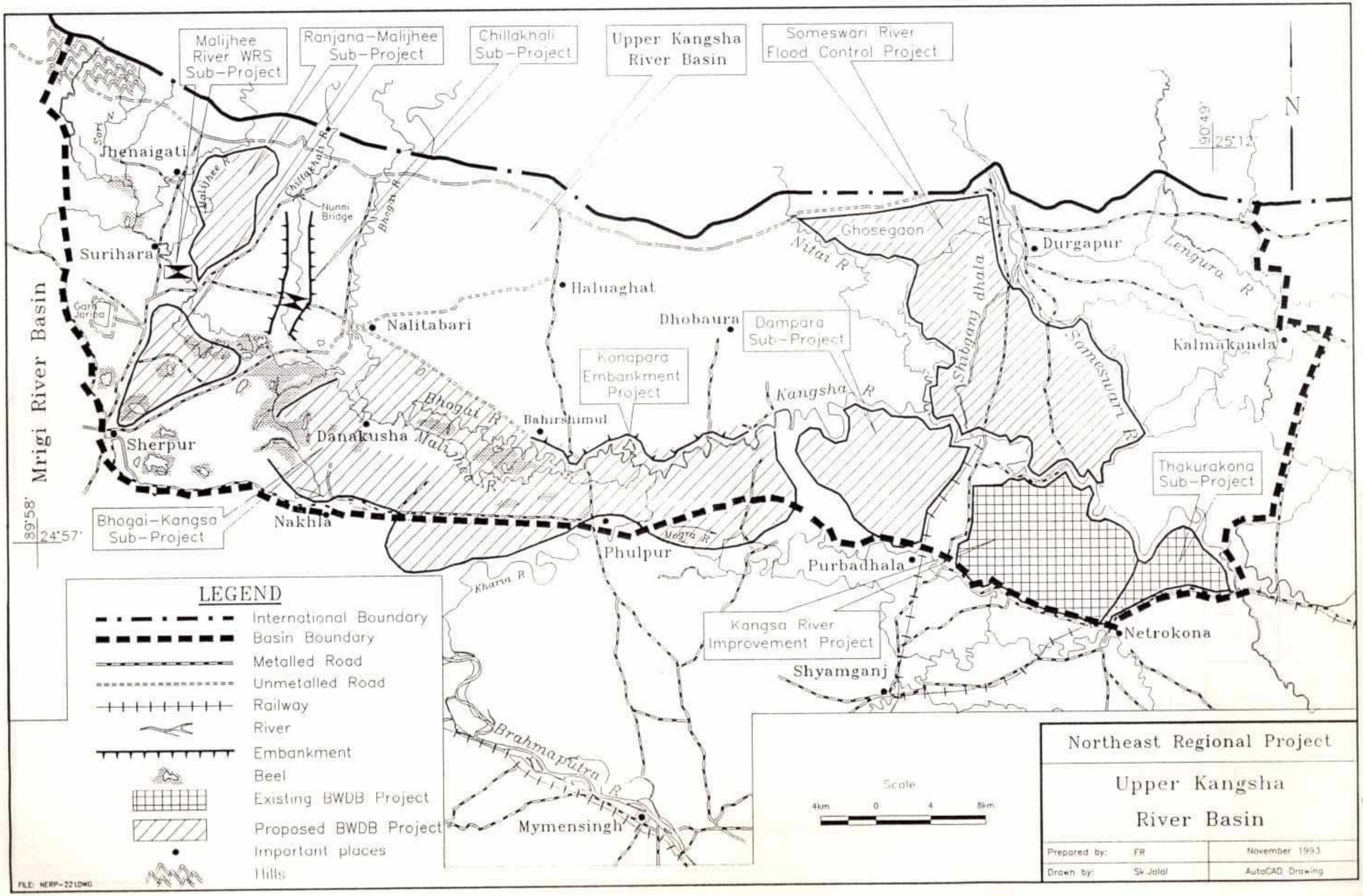
B: Bacha; C: Chital; Ca: Chapila; Ch: Chela; G: Golda Chingri; LC: Large catfish; MC: Major carp.

Source: NERP, 1992

ANNEX B

FIGURES

Figure 1


Malijhee River WRS Sub-Project
Ranjana-Malijhee Sub-Project
Chillakhali Sub-Project
Upper Kangsha River Basin
Someswari River Flood Control Project
N
90°49'
25°12'
Jhenaigati
Surihara
Nunni Bridge
Ghosegaon
Nitai R
Durgapur
Lengura R
Haluaghat
Nalitabari
Dhobaura
Dampara Sub-Project
Konapara Embankment Project
Kalmakanda
Kangsha R
Someswari R
Shibganj dhala R
Bhogai R
Bahirshimul
Danakusha
Malijhee R
Sherpur
Mrigi River Basin
89°58'
24°57'
Bhogai-Kangsa Sub-Project
Nakhla
Phulpur
Purbadhala
Thakurakona Sub-Project
Kharia R
Netrokona
Kangsa River Improvement Project
Shyamganj
Brahmaputra R
Mymensingh
LEGEND
International Boundary
Basin Boundary
Metalled Road
Unmetalled Road
Railway
River
Embankment
Beel
Existing BWDB Project
Proposed BWDB Project
Important places
Hills
Scale
4km 0 4 8km
Northeast Regional Project
Upper Kangsha River Basin
Prepared by: FR
November 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-22.DWG

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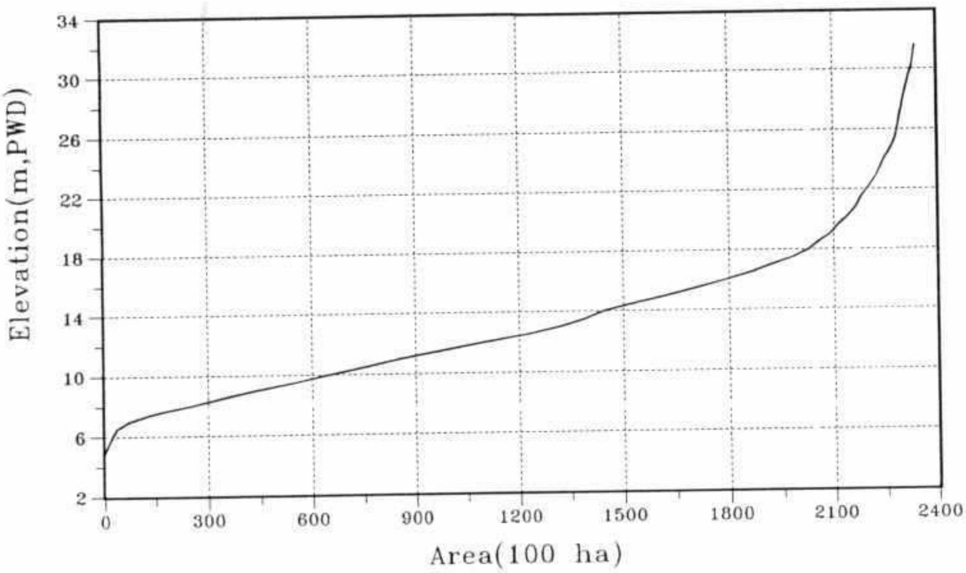
Area - Elevation Curve
Upper Kangsha River Basin



Data :

El(m,PWD)	4.93	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00
	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	18.00
Area(ha)	101	304	1115	2230	3548	7197	14393	24935	33956	44193	55444	64972	75716	85649
	97204	109063	121835	131768	139066	144539	152648	162176	171095	178900	186097	192178	198463	202720
El(m,PWD)	18.50	19.00	19.50	20.00	20.50	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00
	25.50	26.00	26.50	27.00	27.50	28.00	28.50	29.00	29.50	30.00	30.50	31.00	31.50	
Area(ha)	205558	208801	210727	213058	215187	216809	217721	219545	221167	222586	223600	224614	226033	227249
	228161	228668	229073	229479	229986	230391	230999	231506	232114	232824	233229	233635	233770	

Northeast Regional Project

Area - Elevation Curve
Upper Kangsha River Basin

Prepared by : F.Rahman/NR

January 1994

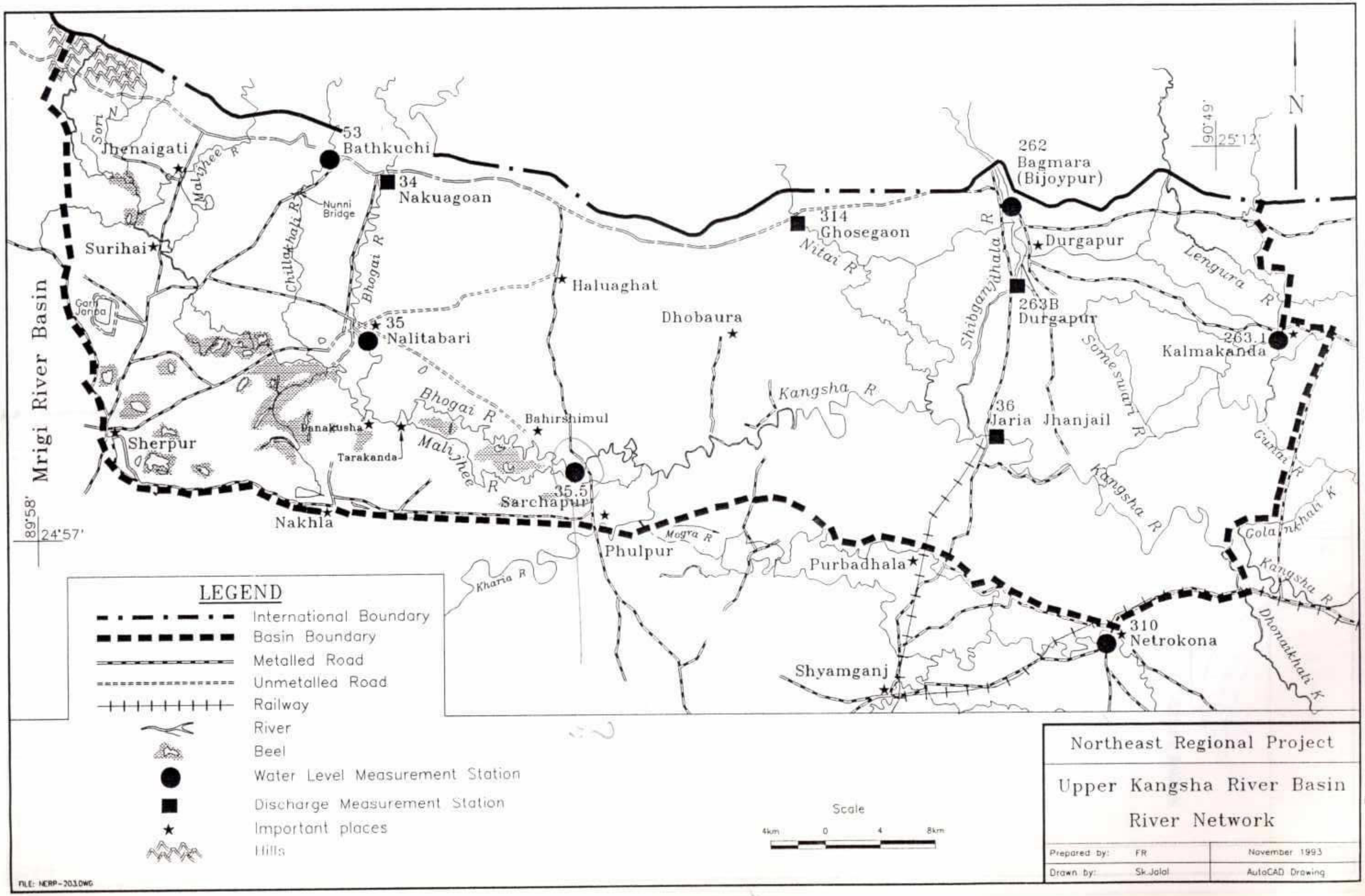

N
90°49'
25°12'
89°58'
24°57'
Mrigi River Basin
53
Bathkuchi
34
Nakuagoan
Nunni Bridge
Jhenaigati
Surihai
Sherpur
Nakhla
35
Nalitabari
Haluaghat
Dhobaura
314
Ghosegaon
262
Bagmara
(Bijoypur)
Durgapur
263B
Durgapur
263.1
Kalmakanda
36
Jaria Jhanjail
35.5
Sarchapur
Bahirshimul
Tarakanda
Phulpur
Purbadhala
Shyamganj
310
Netrokona
Sori N
Malijhee R
Chillakhali R
Bhogai R
Mali jhee R
Nitai R
Kangsha R
Shibganjdhala R
Someswari R
Lengura R
Gunai R
Golakhali K
Dhonaikhali K
Mogra R
Kharia R
LEGEND
International Boundary
Basin Boundary
Metalled Road
Unmetalled Road
Railway
River
Beel
Water Level Measurement Station
Discharge Measurement Station
Important places
Hills
Scale
4km
0
4
8km
Northeast Regional Project
Upper Kangsha River Basin
River Network
Prepared by: FR
November 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-203.DWG

Figure 3

Figure 4

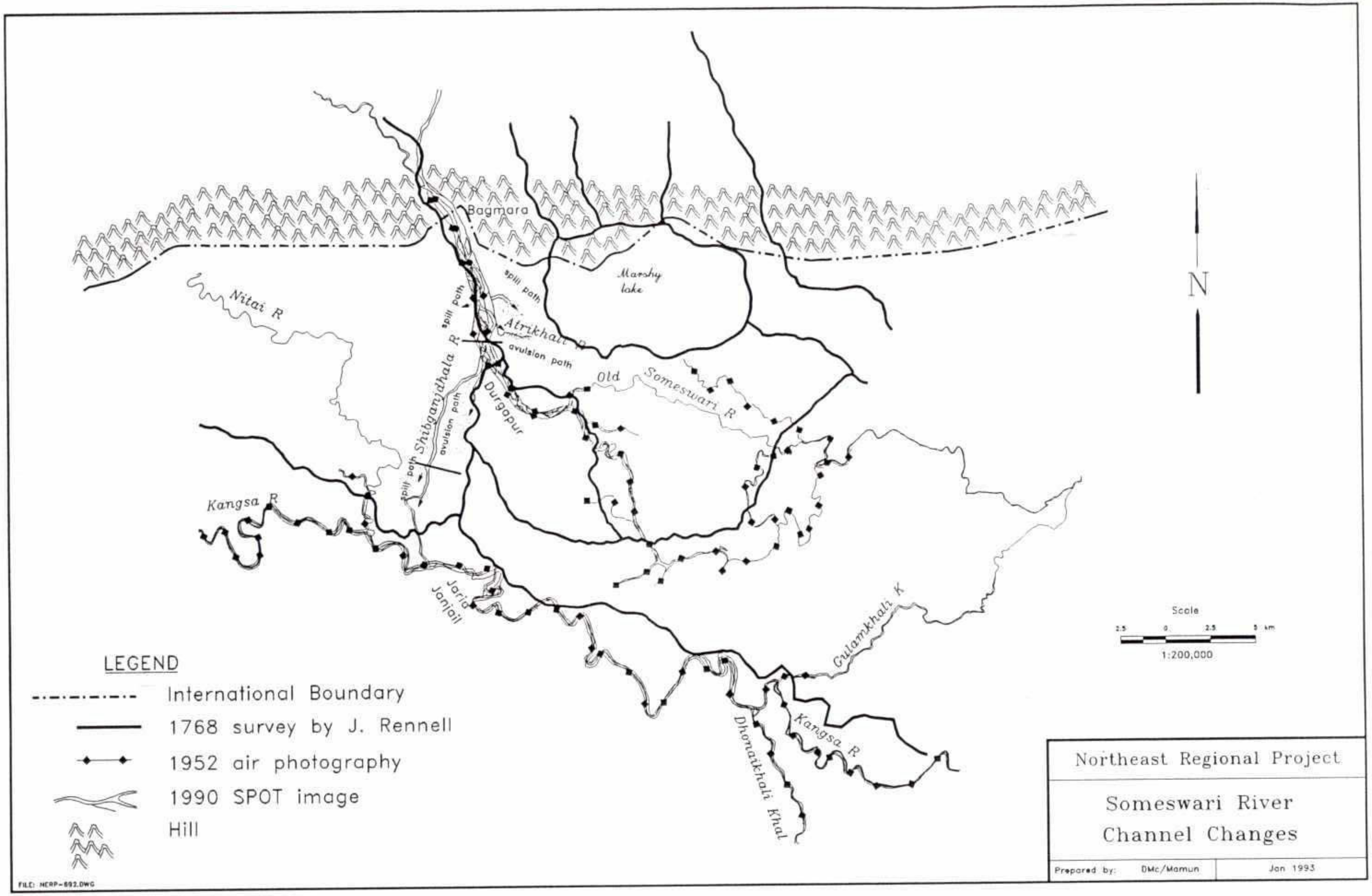
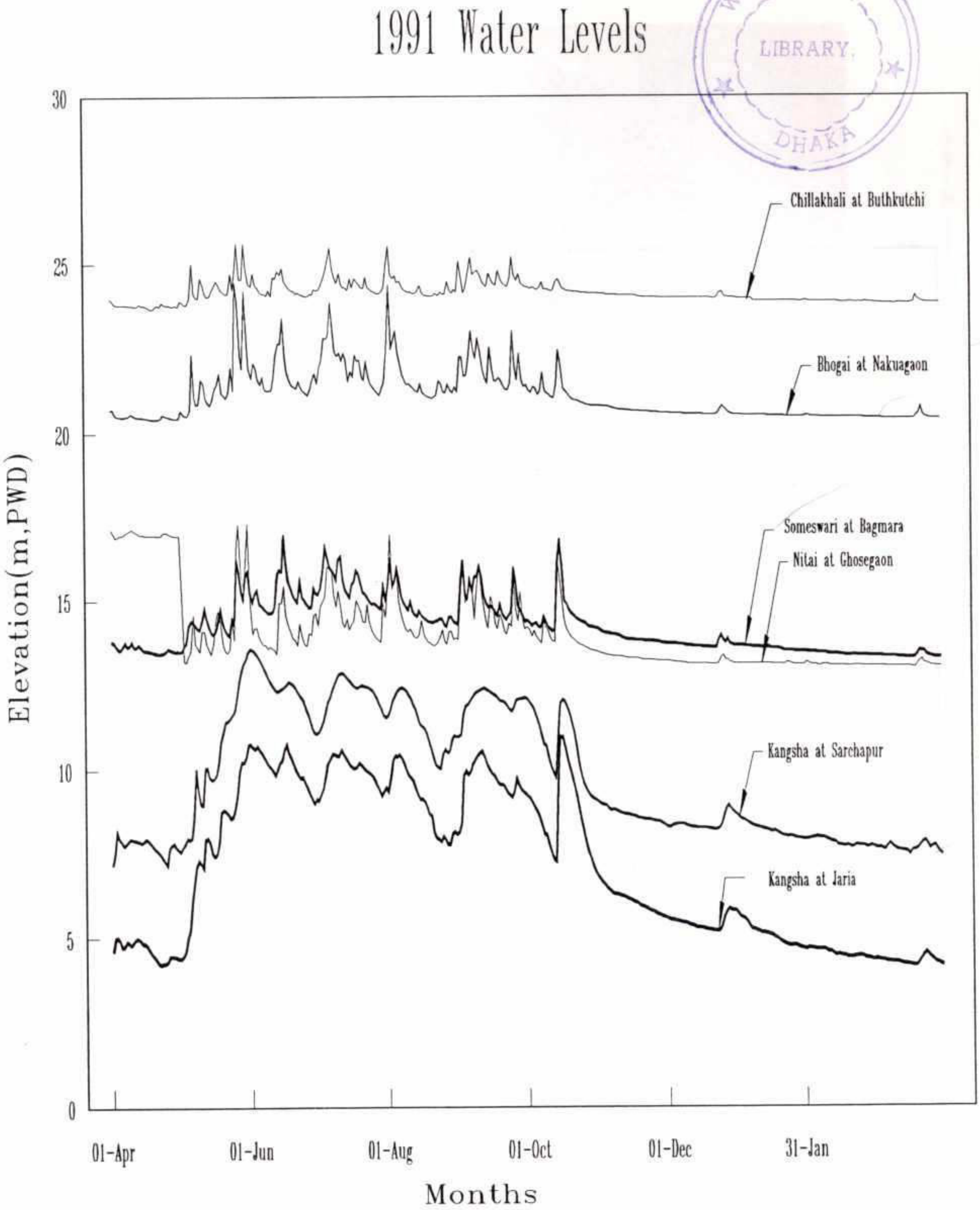

Bagmara
Marshy lake
spill path
Nitai R
Atrikhali R
avulsion path
Shibganjdhala R
Old Someswari R
Durgapur
spill path
avulsion path
spill path
Kangsa R
Jaria Janjail
Gulamkhali K
Dhonaikhali Khal
Kangsa R
N
Scale
2.5 0 2.5 5 km
1:200,000
LEGEND
International Boundary
1768 survey by J. Rennell
1952 air photography
1990 SPOT image
Hill
Northeast Regional Project
Someswari River
Channel Changes
Prepared by: DMc/Mamun
Jan 1993
FILE: NERP-892.DWG

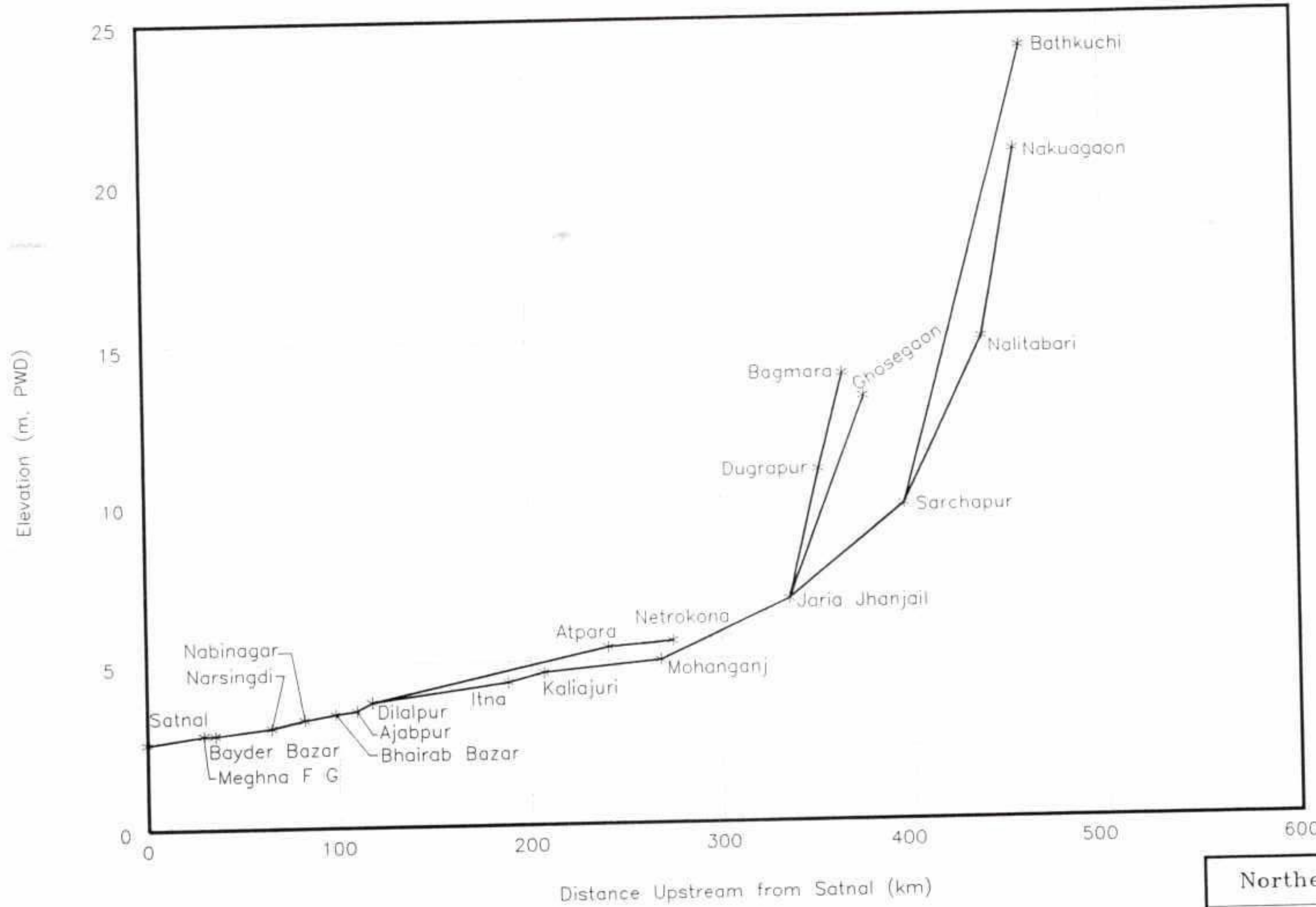
Figure 5



Northeast Regional Project	
Water Level Hydrograph Kangsha System	
Prepared by: FR/NR	November 1993

FILE: WL-91DWG

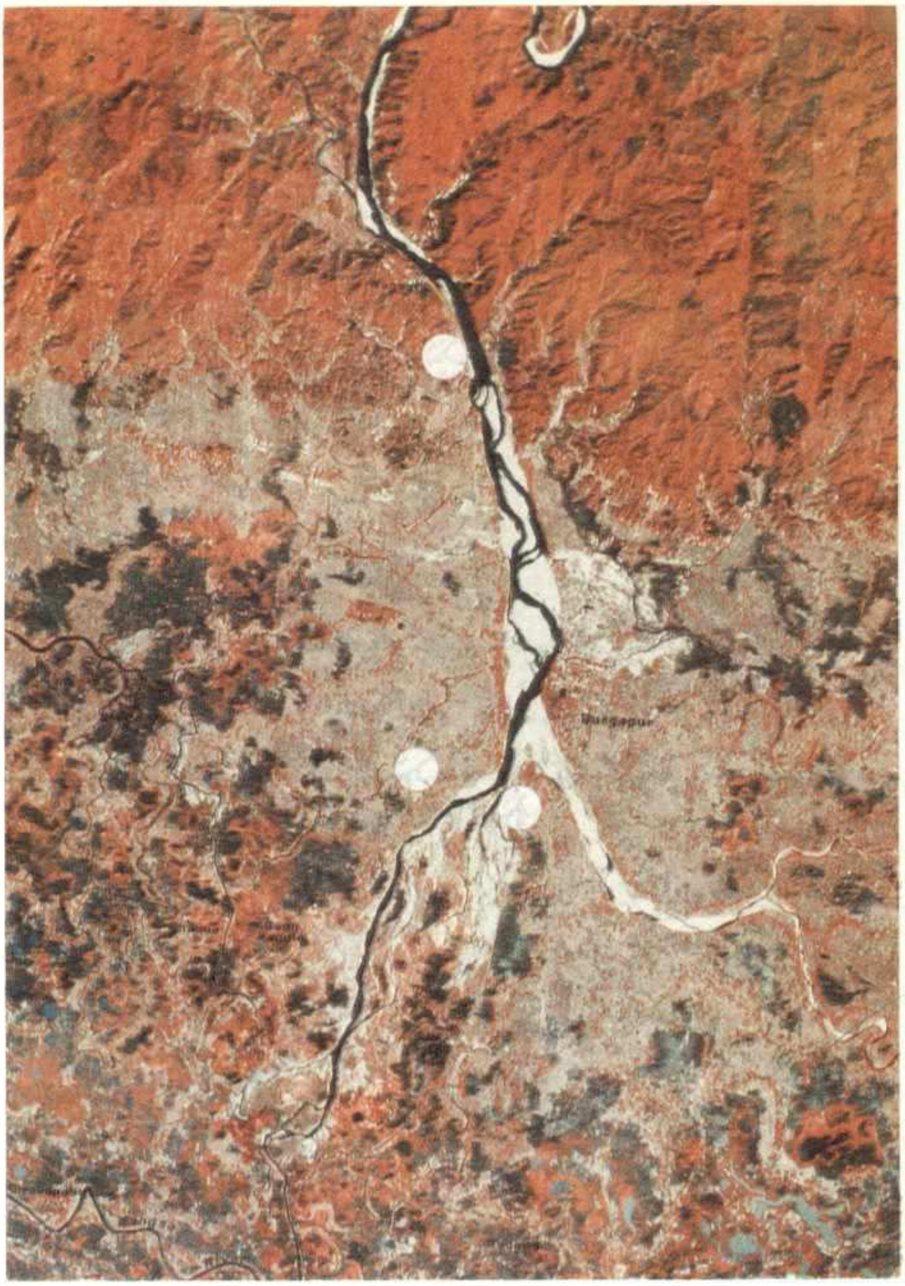
Figure 6



Northeast Regional Project	
Mean Water Level Profile Meghna, Baulai, Kangaha	
Prepared by: Michael E. Ibbitt	May 1993
Drawn by: Mamun	AutoCAD Drawing

FILE: NERP-614.DWG

Figure 7



N

Site Location

Scale

2 0 2 4 km

Approx.

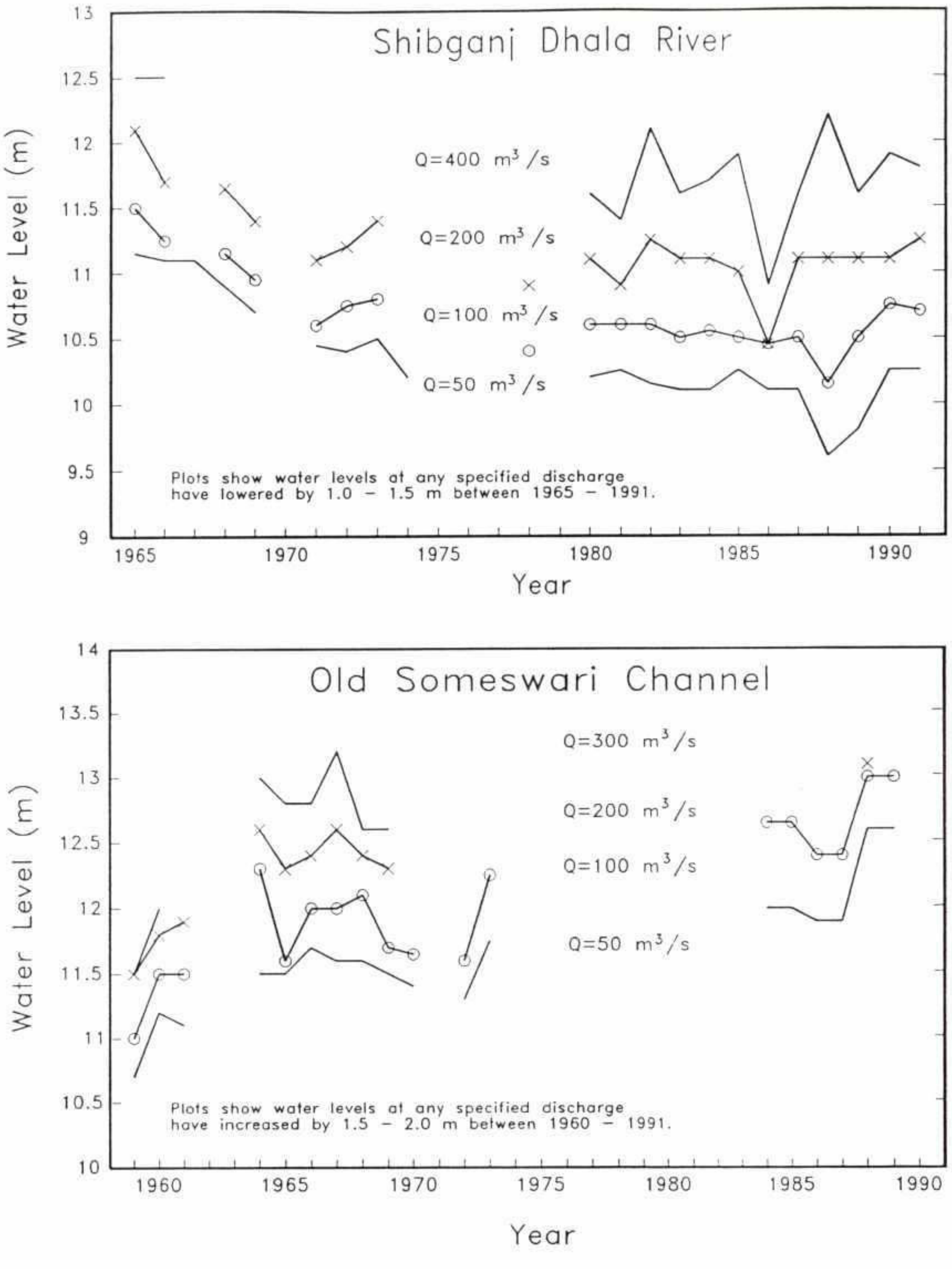
Northeast Regional Project

Someswari River
Alluvial Fan

Prepared by: DMc	May 1993

FILE: Fig. 17.DWG

Figure 8



Note:

1. Specific guare plots show long–term vatiations in water levels for four specific discharges.
2. Plots wer constructed by comparing stage–discharge rating curves for each year of observation.

FILE: DM–246.DWG

Northeast Regional Project	
Specific Gauge Someswari Fan	
Prepared by: CHW	May 1993

Figure 9

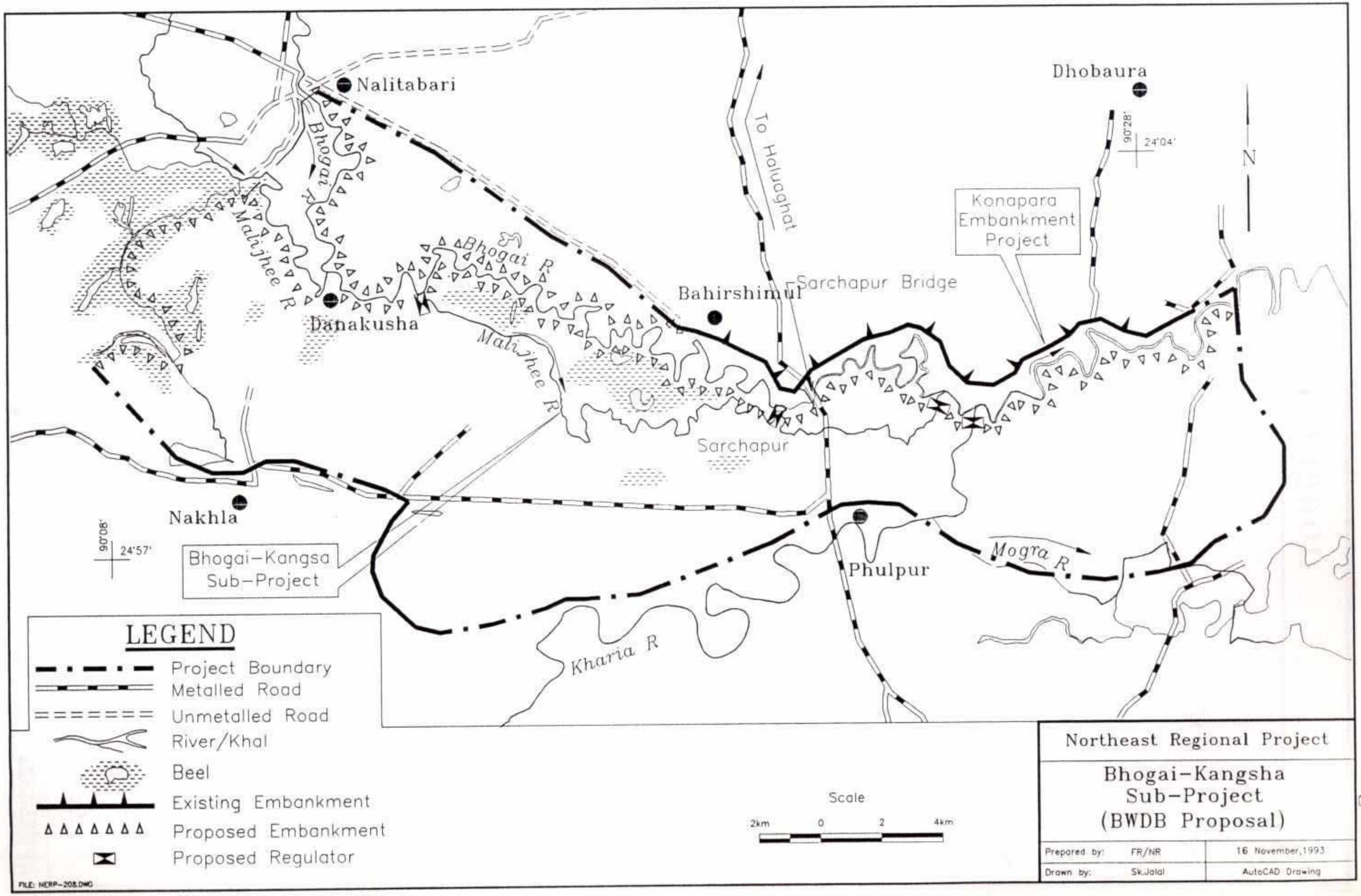

Nalitabari
Dhobaura
Bhogai R
Malijhee R
Danakusha
Bahirshimul
Sarchapur Bridge
To Haluaghat
Konapara Embankment Project
Sarchapur
Nakhla
Phulpur
Mogra R
Kharia R
90°28'
24°04'
90°08'
24°57'
N
Bhogai-Kangsa Sub-Project
LEGEND
Project Boundary
Metalled Road
Unmetalled Road
River/Khal
Beel
Existing Embankment
Proposed Embankment
Proposed Regulator
Scale
2km 0 2 4km
Northeast Regional Project
Bhogai-Kangsha Sub-Project (BWDB Proposal)
Prepared by: FR/NR
16 November, 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-208.DWG

Figure 10

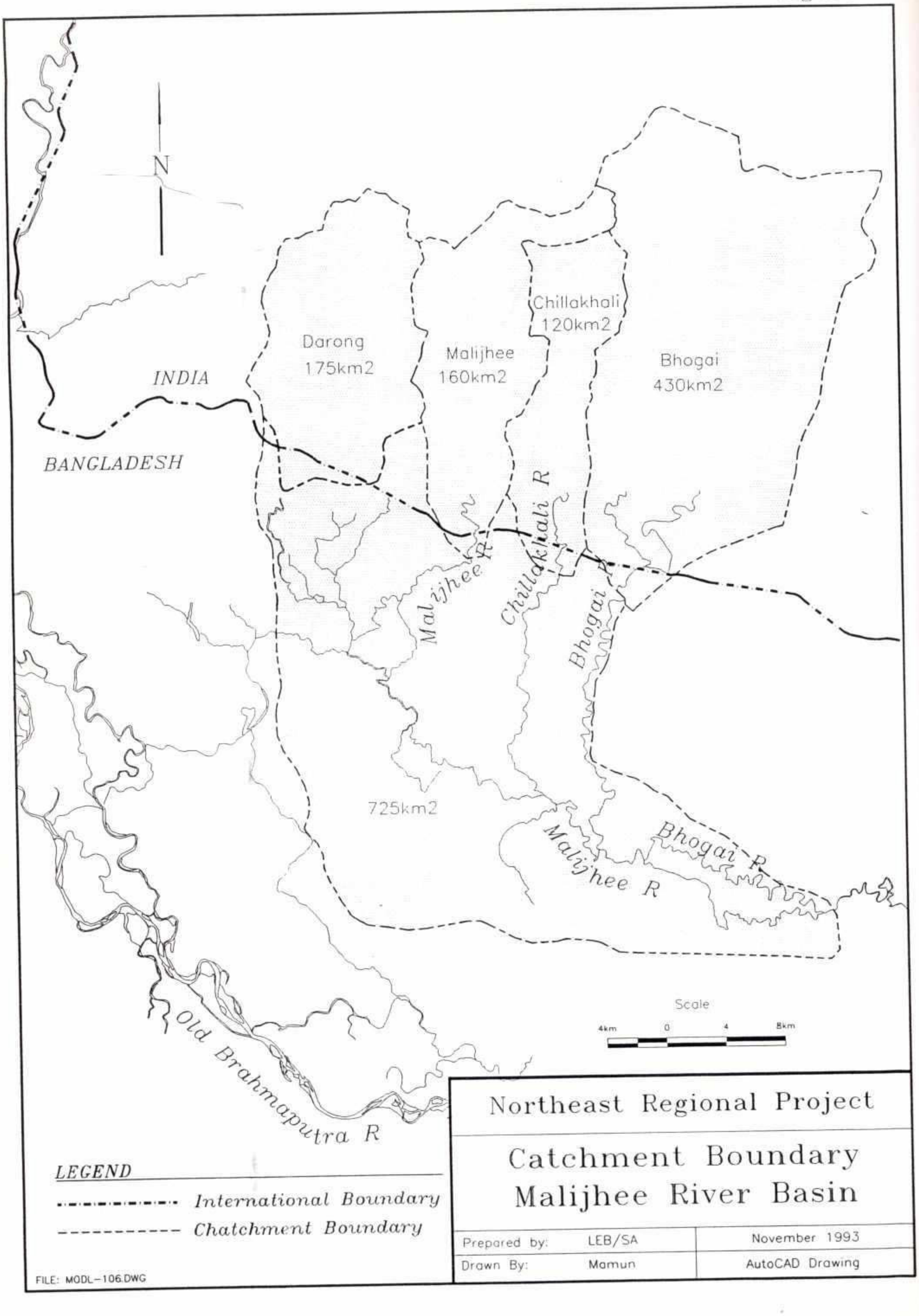
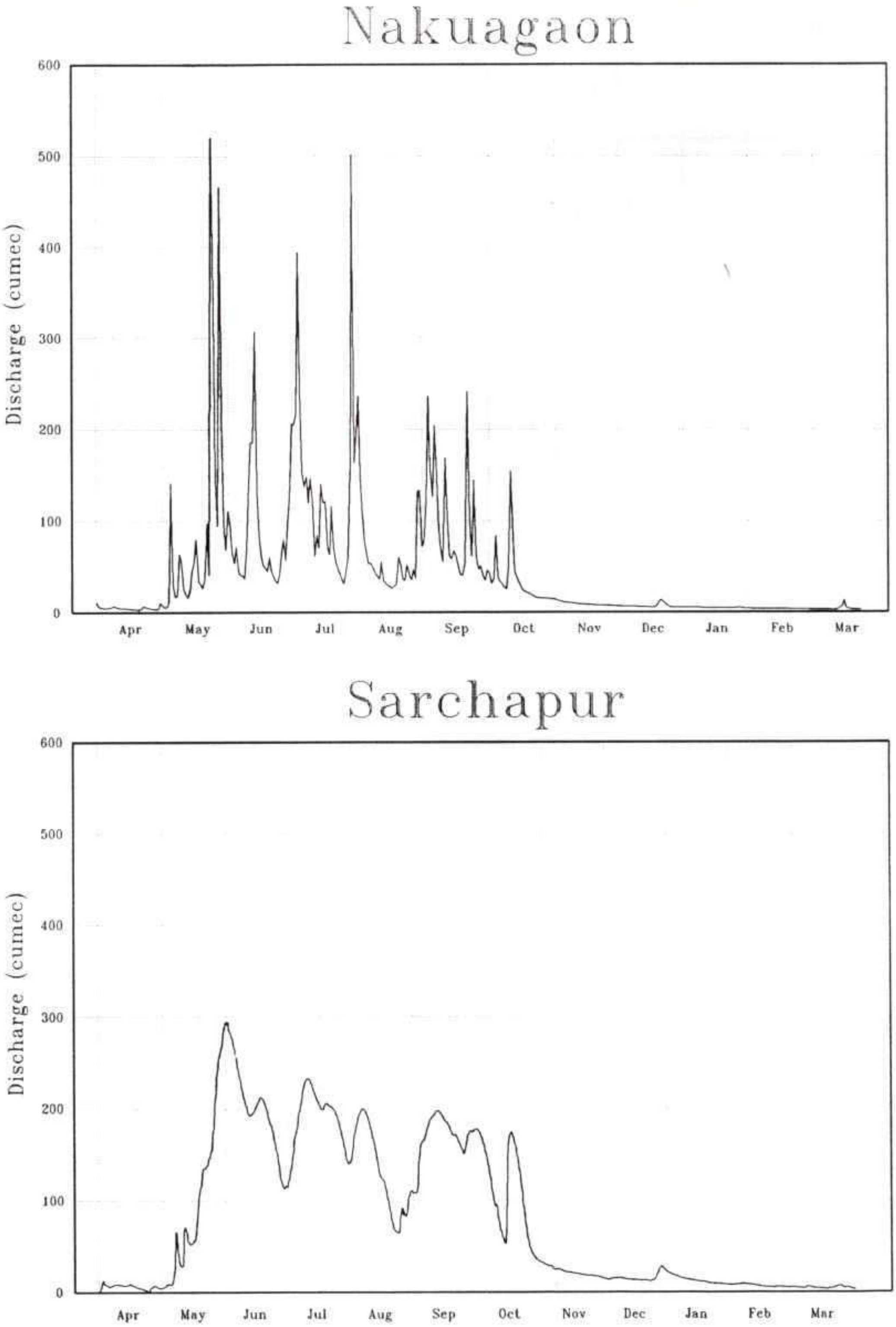

N
INDIA
BANGLADESH
Darong
175km2
Malijhee
160km2
Chillakhali
120km2
Bhogai
430km2
Malijhee R
Chillakhali R
Bhogai R
725km2
Malijhee R
Bhogai R
Old Brahmaputra R
Scale
4km 0 4 8km
LEGEND
International Boundary
Chatchment Boundary
FILE: MODL-106.DWG
Northeast Regional Project
Catchment Boundary
Malijhee River Basin
Prepared by: LEB/SA
November 1993
Drawn By: Mamun
AutoCAD Drawing

Figure 11

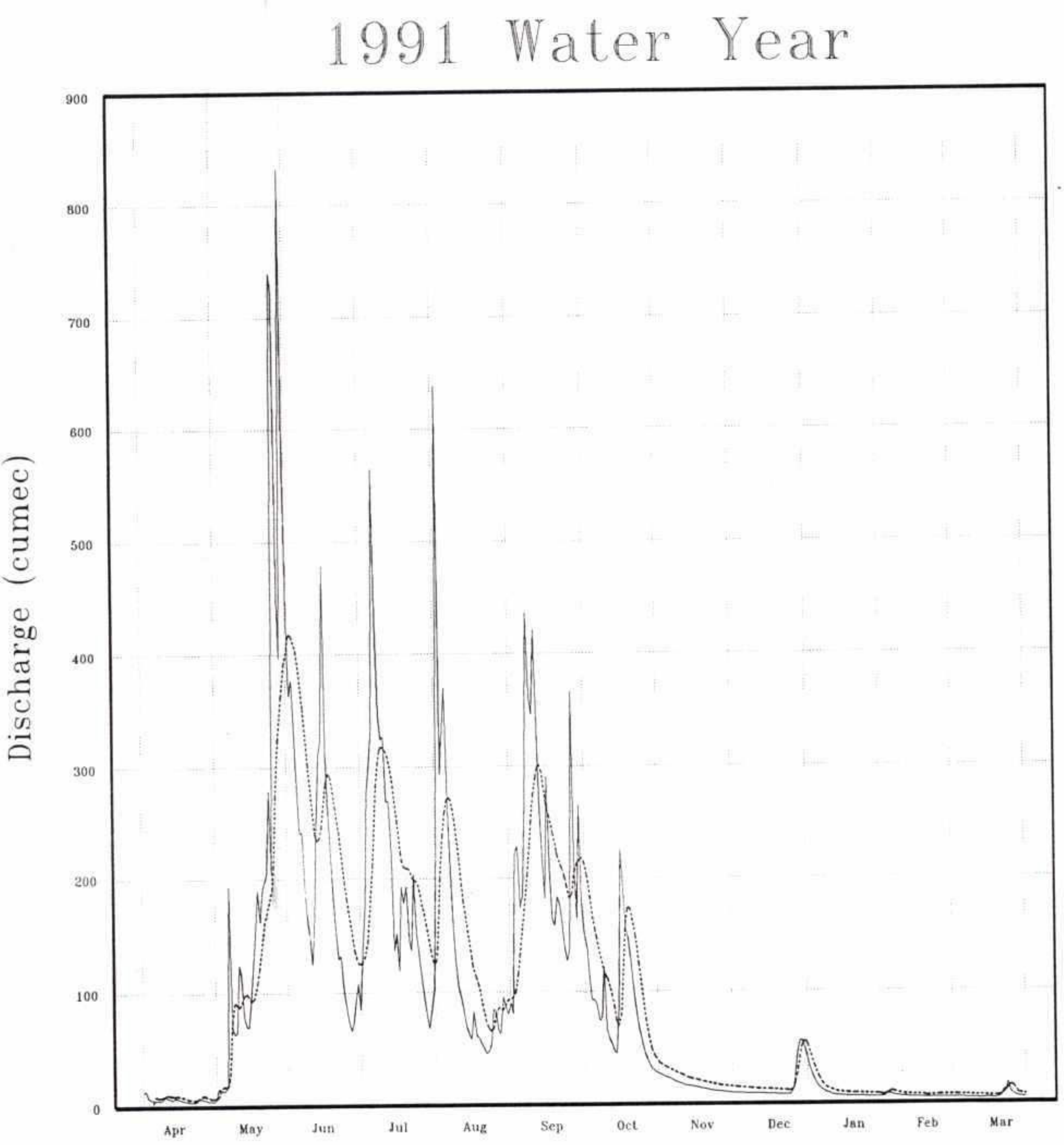


Note: 1991 water year

Northeast Regional Project	
Recorded Discharges in the Upper Bhogai & Kangsha Rivers	
Prepared by: LEB/Awlad	December 1993

FILE:MODL-102.DWG

240

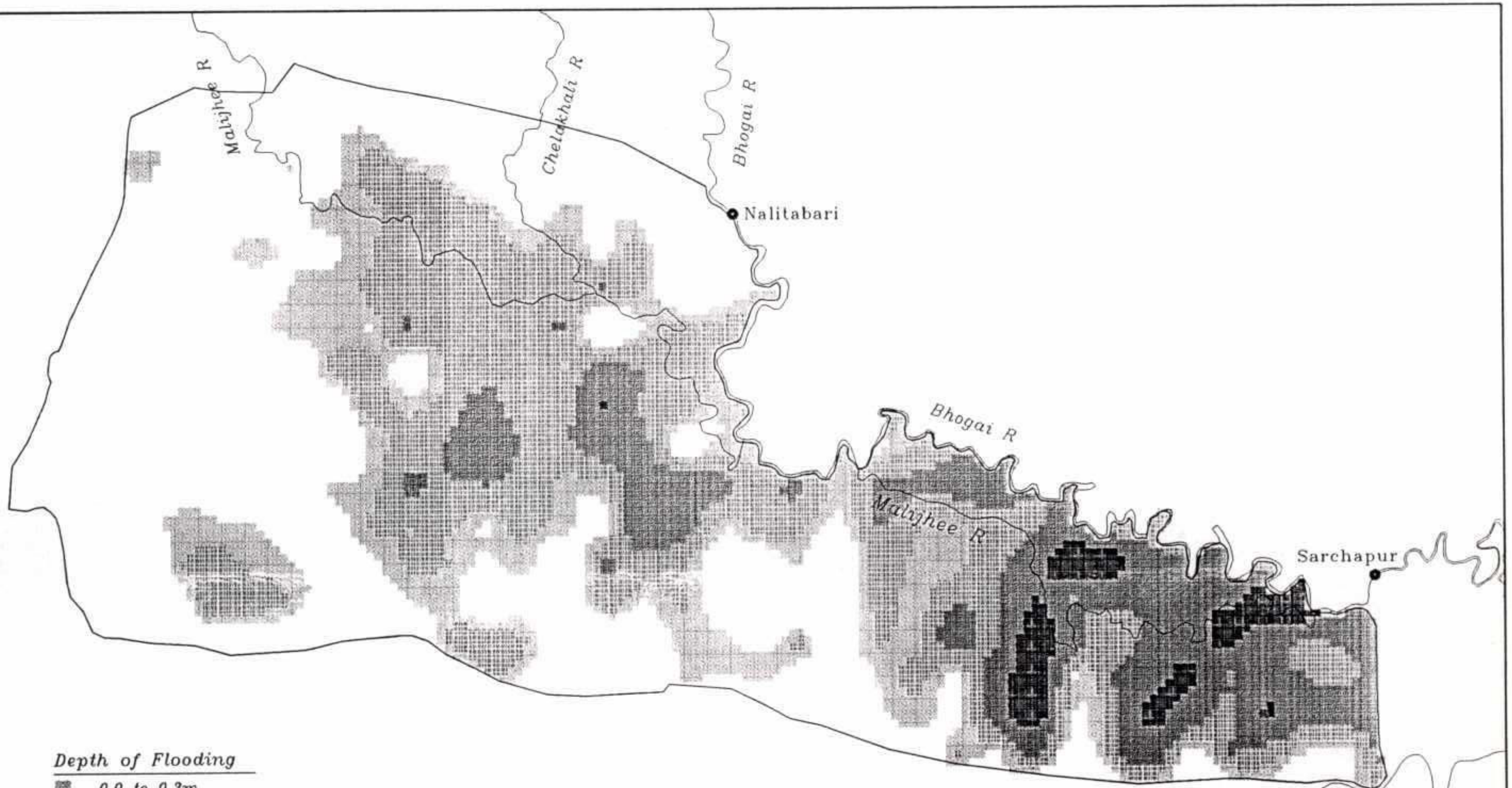


Legend:
——— *Inflow hydrograph*
········· *Outflow hydrograph*

Northeast Regional Project	
Inflow and Outflow Hydrographs in the Malijhee River Basin	
Prepared by: LEB/Awlad	December 1993

FILE: MODL-105.DWG

Figure 13



Depth of Flooding

- *0.0 to 0.3m*
- *0.3 to 0.9m*
- *0.9 to 1.8m*
- *greater than 1.8m*

Note: – prepared from computer model results
– for peak water levels in 1991 water year

FILE: MODL-190.DWG

Northeast Regional Project

Flooding in the Malijhee River Basin

Prepared by: LEB/Awlad | December 1993

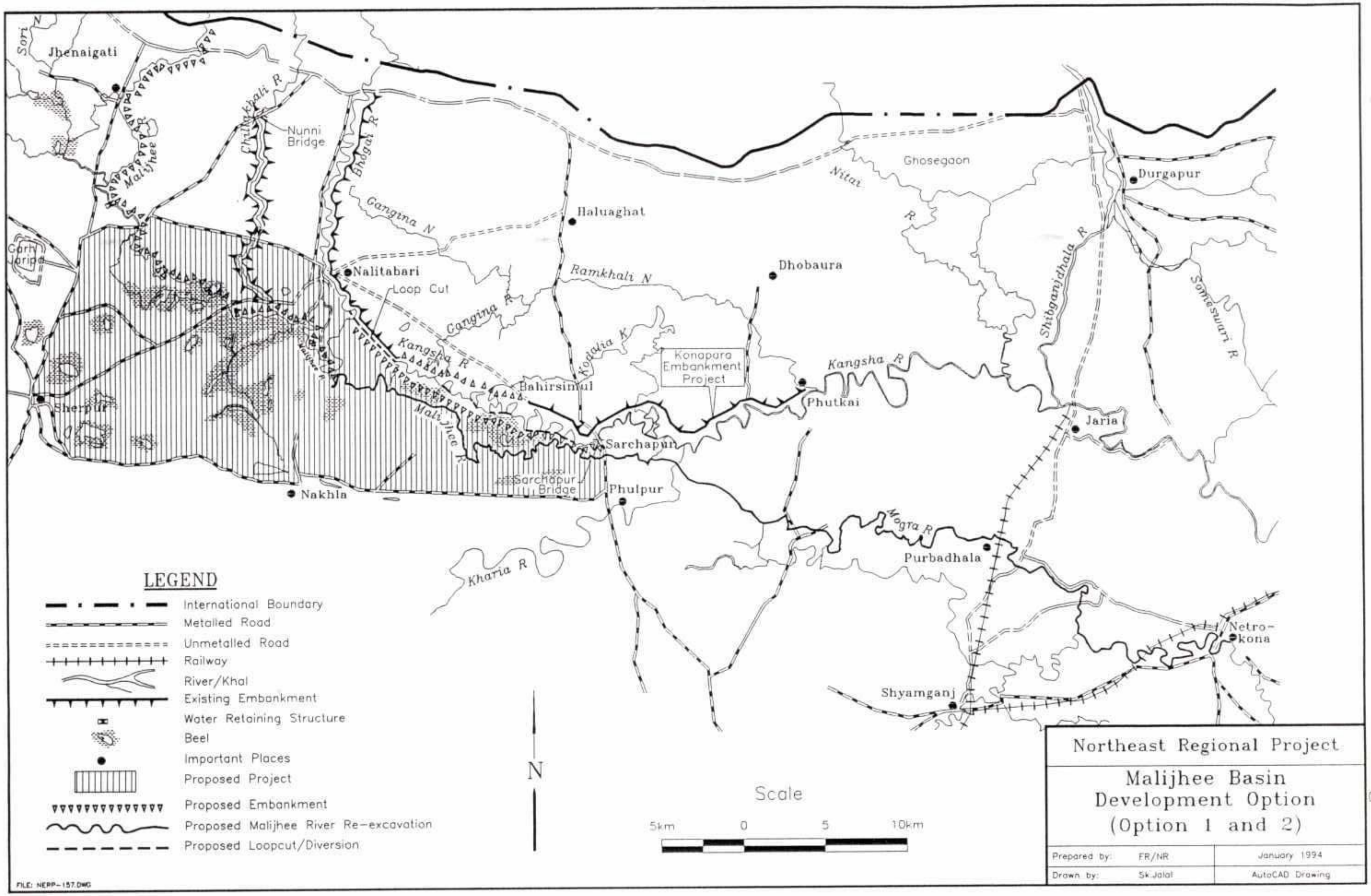
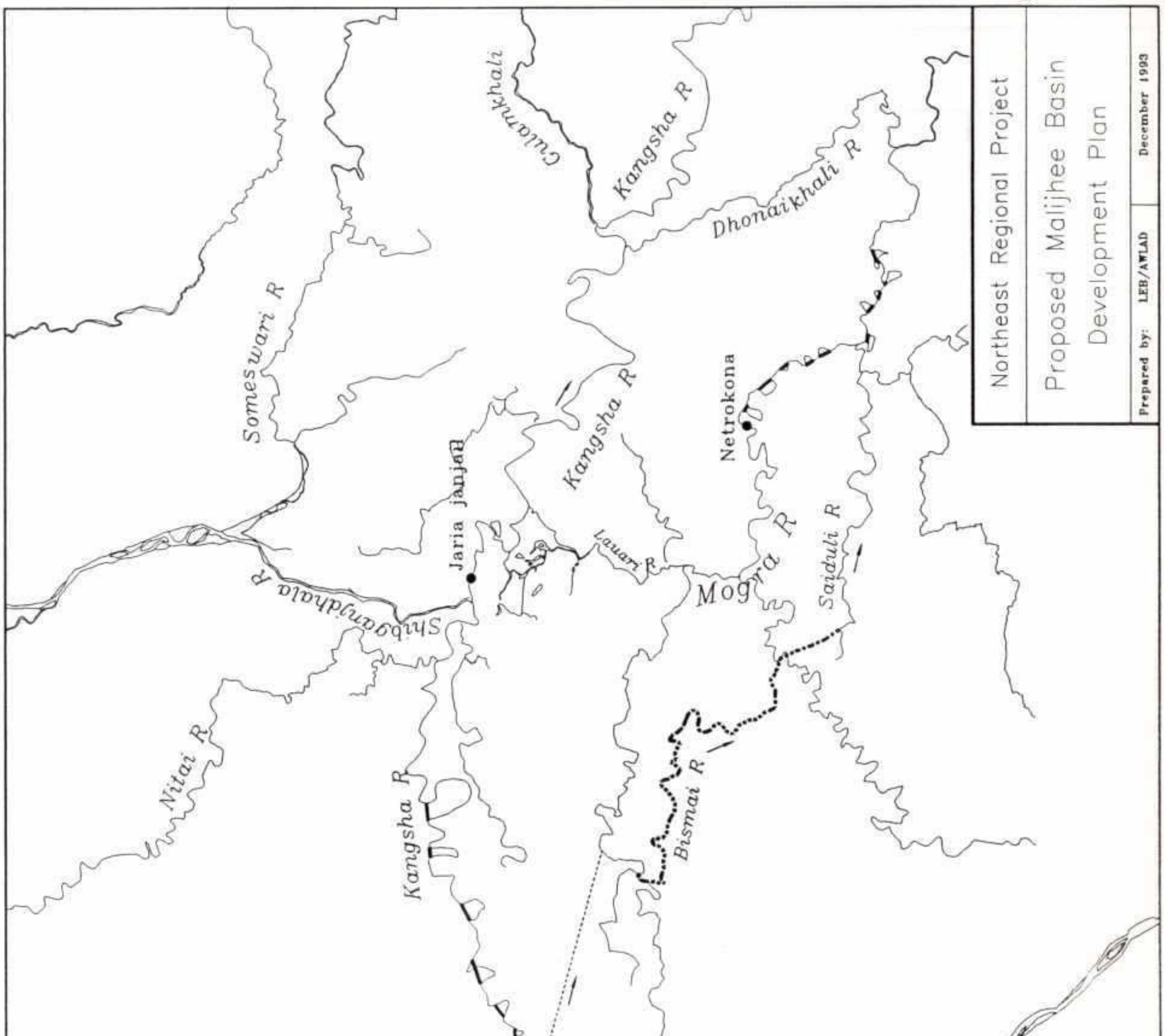

Sori N
Jhenaigati
Malijhee
Chillakhali R
Nunni Bridge
Bhogai R
Gangina N
Haluaghat
Ghosegaon
Nitai R
Durgapur
Garh Jaripa
Nalitabari
Loop Cut
Ramkhali N
Dhobaura
Gangina R
Shibganjdhala R
Someswari R
Kangsha R
Kodalia K
Konapara Embankment Project
Kangsha R
Bahirsimul
Phutkai
Sherpur
Mali Jhee R
Sarchapur
Jaria
Sarchapur Bridge
Nakhla
Phulpur
Mogra R
Purbadhala
Kharia R
Netro-kona
Shyamganj
LEGEND
International Boundary
Metalled Road
Unmetalled Road
Railway
River/Khal
Existing Embankment
Water Retaining Structure
Beel
Important Places
Proposed Project
Proposed Embankment
Proposed Malijhee River Re-excavation
Proposed Loopcut/Diversion
N
Scale
5km 0 5 10km
Northeast Regional Project
Malijhee Basin Development Option (Option 1 and 2)
Prepared by: FR/NR
January 1994
Drawn by: Sk Jalal
AutoCAD Drawing
FILE: NERP-157.DWG

Figure 14

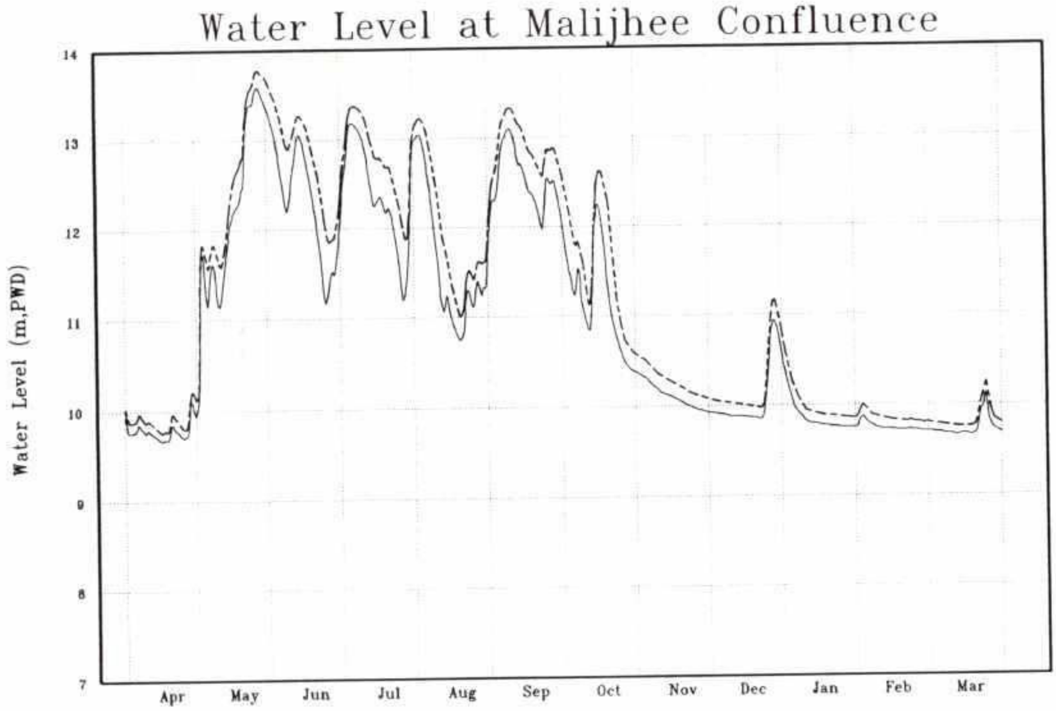
246

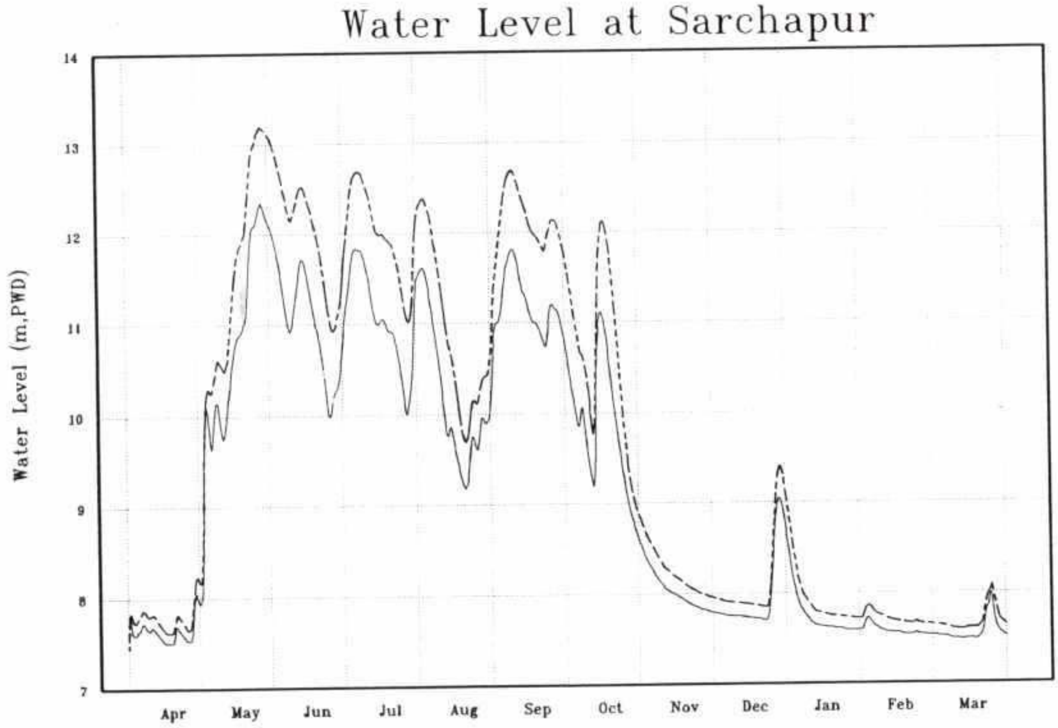
Figure 15



248

Figure 16





Legend:

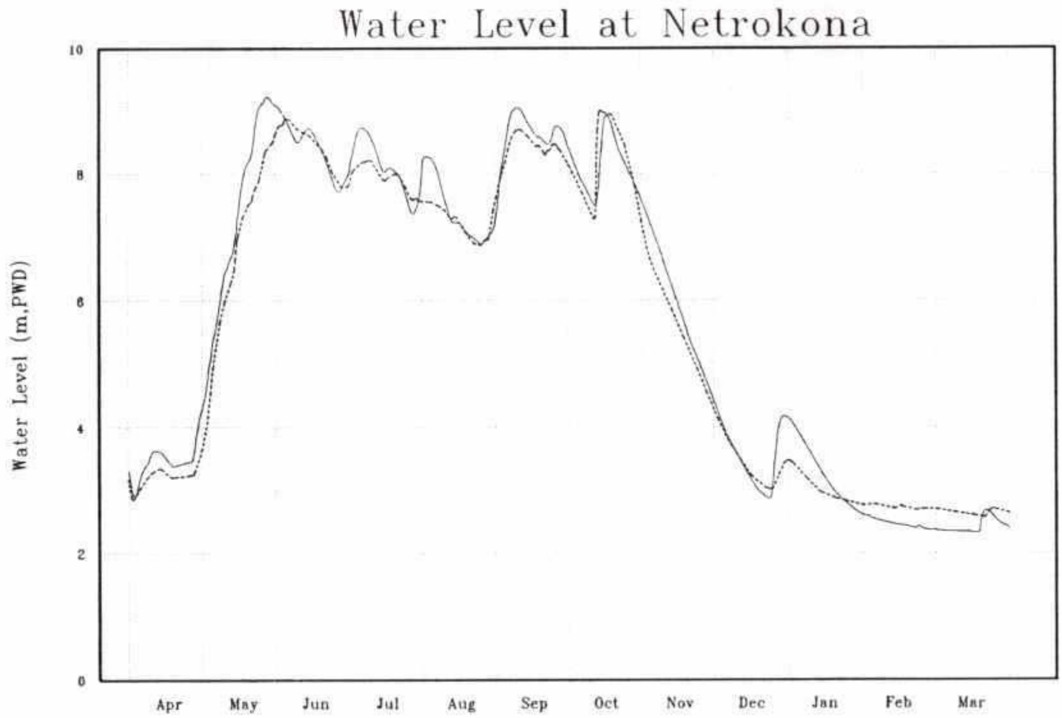
---- *Existing condition*

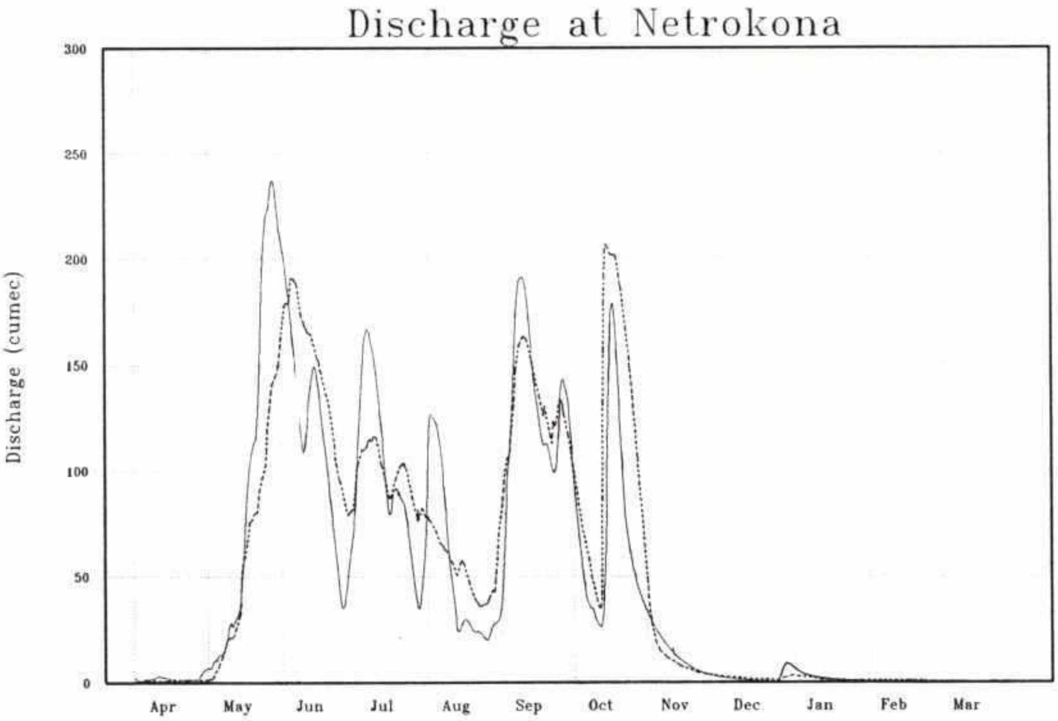
—— *With proposed development plan*

Northeast Regional Project	
Bhogai River Water Levels with Recommended Options	
Prepared by: LEB/Awlad	December 1993

FILE: MODL-103.DWG

Figure 17





Legend:

.... *Existing condition*

—— *With proposed development plan*

Northeast Regional Project

Mogra River Levels with Proposed Development Plan

Prepared by: LEB/Awlad | December 1993

FILE:MODL-104.DWG

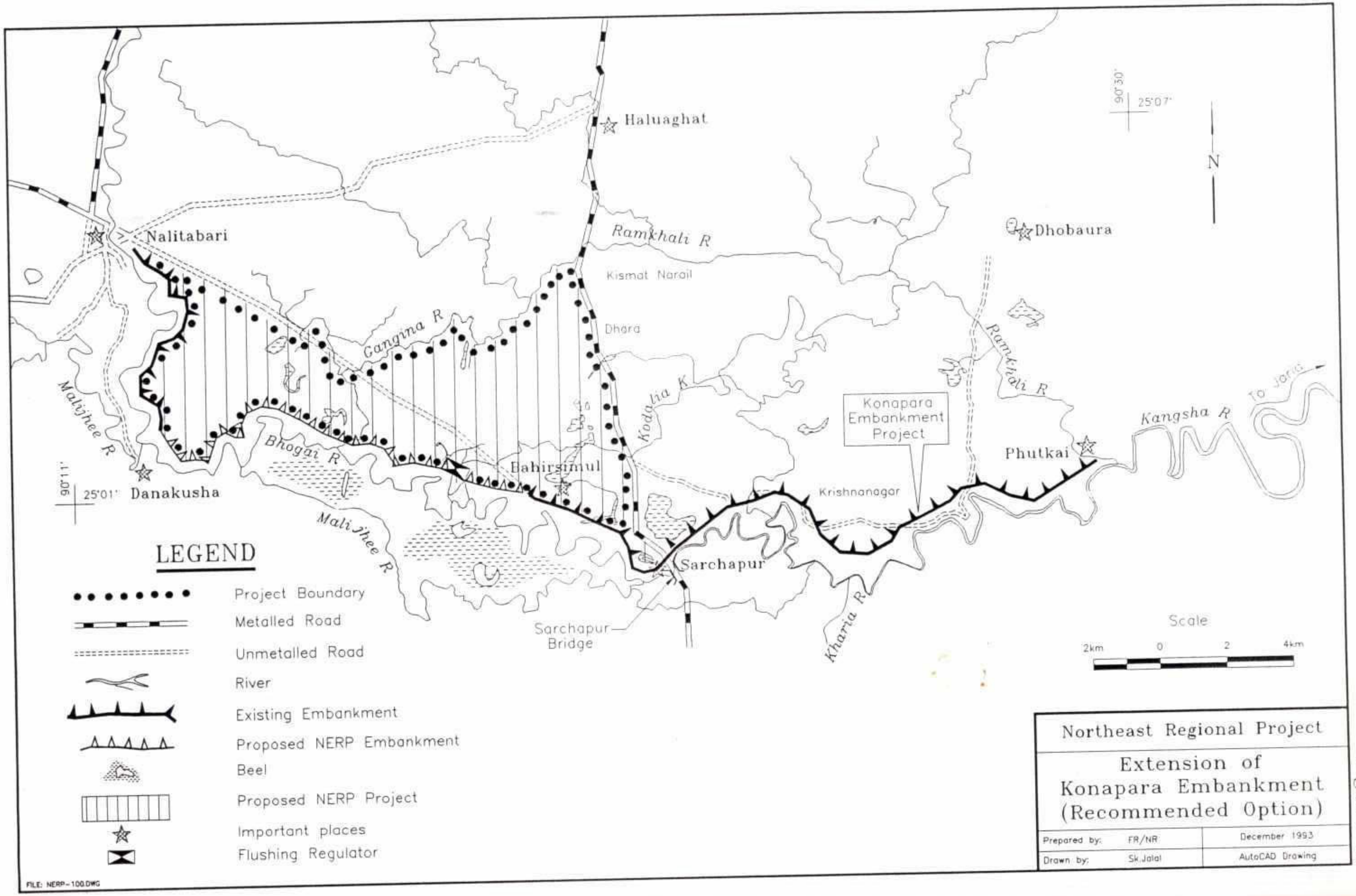
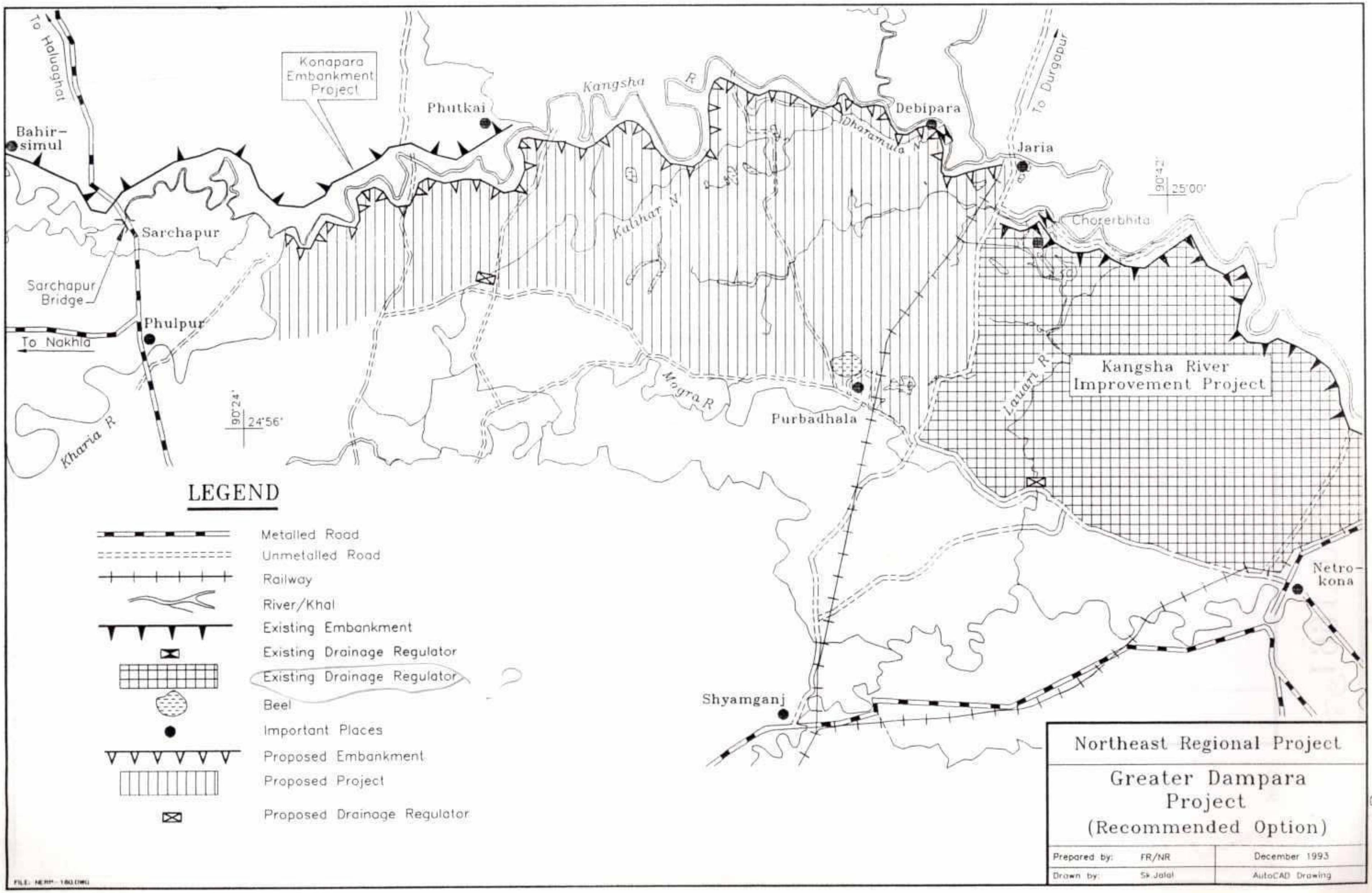
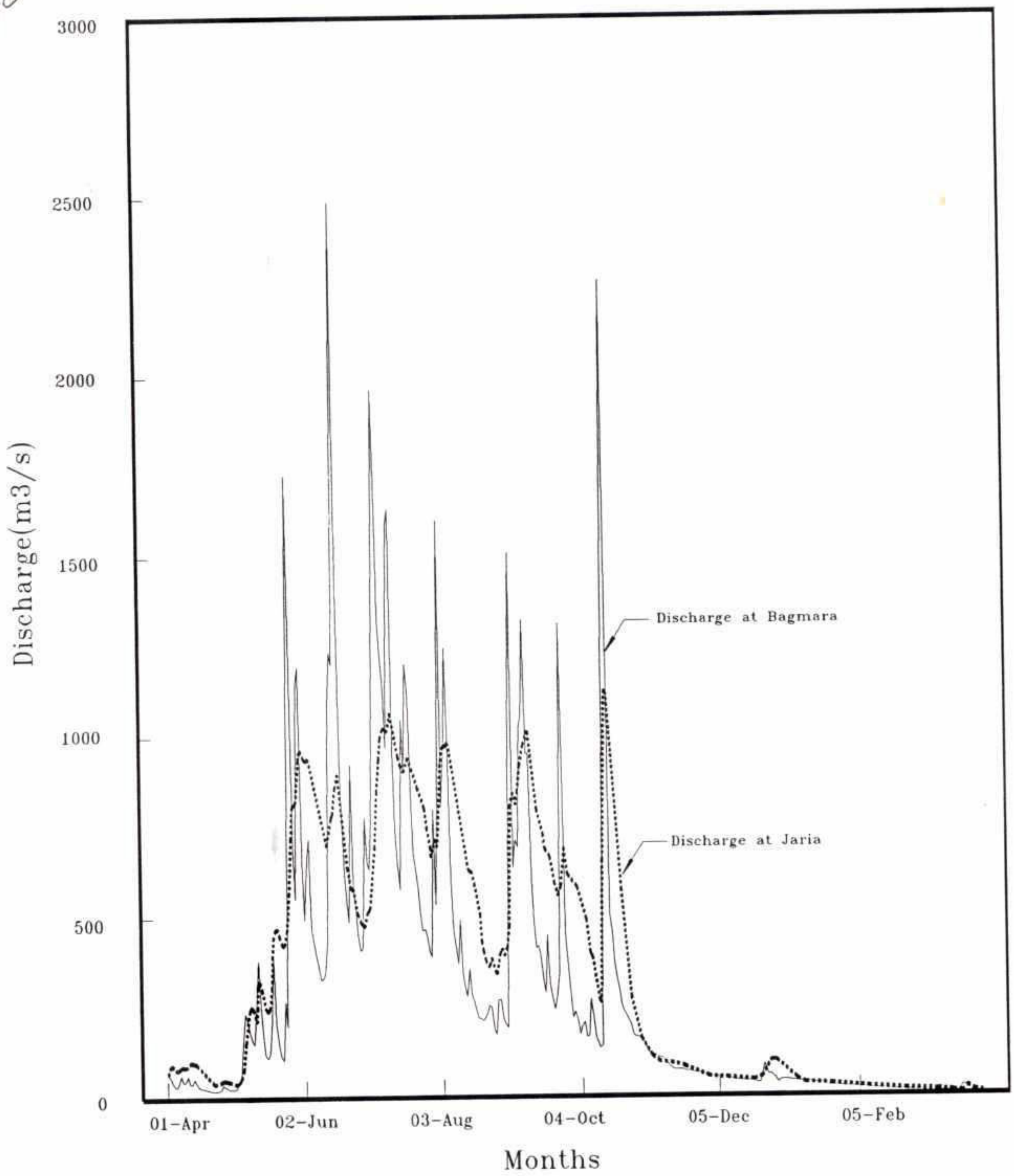

Haluaghat
Nalitabari
Dhobaura
Ramkhali R
Kismat Narail
Dhara
Gangina R
Kodalia K
Ramkhali R
Konapara Embankment Project
Kangsha R
To Jaria
Phutkai
Malijhee R
Bhogai R
Bahirsimul
Krishnanagar
90°11'
25°01'
Danakusha
90°30'
25°07'
N
Mali Jhee R
Sarchapur
Sarchapur Bridge
Kharia R
LEGEND
Project Boundary
Metalled Road
Unmetalled Road
River
Existing Embankment
Proposed NERP Embankment
Beel
Proposed NERP Project
Important places
Flushing Regulator
Scale
2km
0
2
4km
Northeast Regional Project
Extension of Konapara Embankment (Recommended Option)
Prepared by: FR/NR
December 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-100.DWG

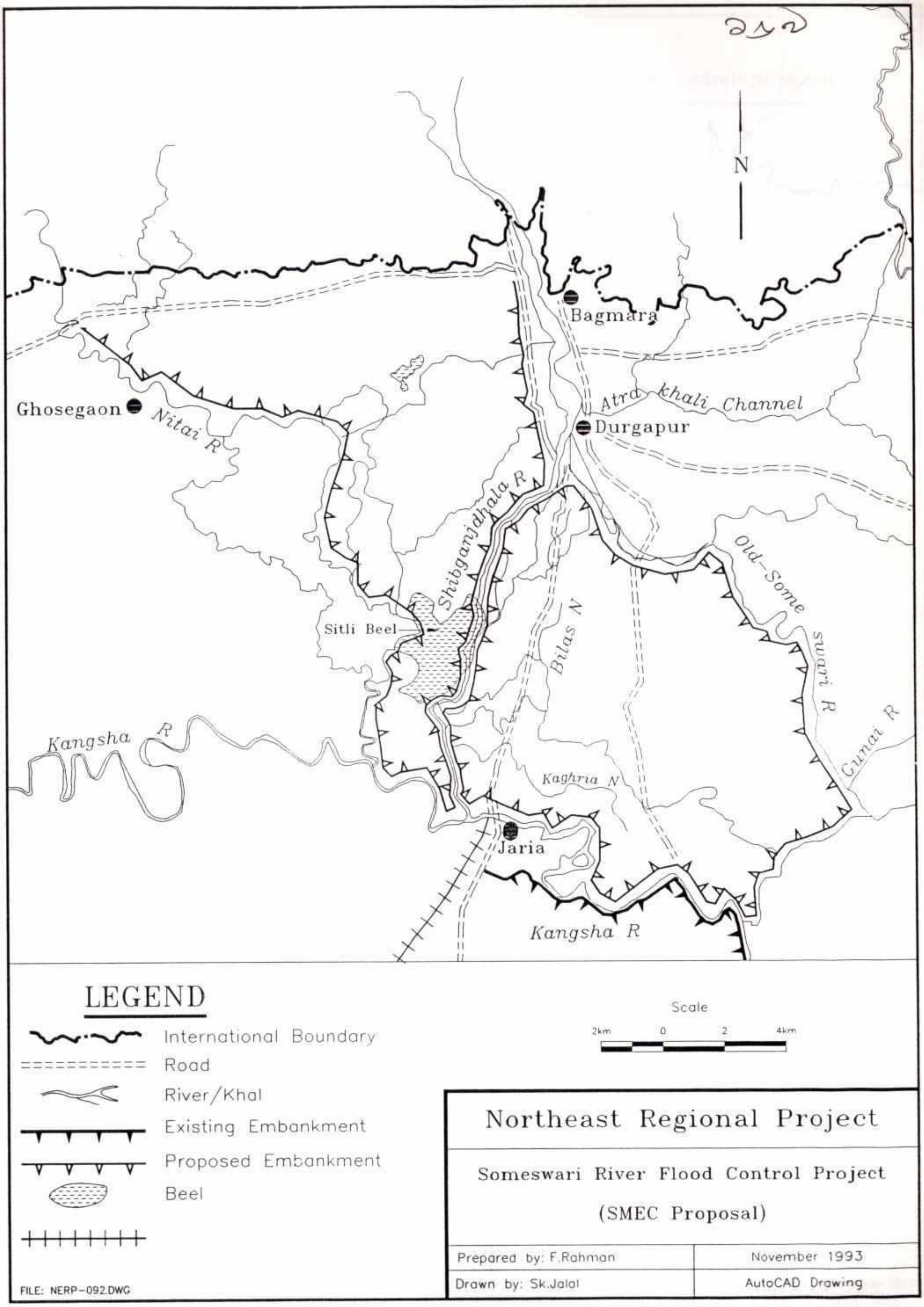
Figure 18


To Haluaghat
Bahir-simul
Sarchapur
Sarchapur Bridge
Phulpur
To Nakhla
Kharia R
Konapara Embankment Project
Phutkai
Kangsha R
Kalihar N
Debipara
Dharamula N
To Durgapur
Jaria
90°42'
25°00'
Chorerbhita
Mogra R
Purbadhala
Lauari R
Kangsha River Improvement Project
90°24'
24°56'
Shyamganj
Netro-kona
LEGEND
Metalled Road
Unmetalled Road
Railway
River/Khal
Existing Embankment
Existing Drainage Regulator
Existing Drainage Regulator
Beel
Important Places
Proposed Embankment
Proposed Project
Proposed Drainage Regulator
Northeast Regional Project
Greater Dampara Project
(Recommended Option)
Prepared by: FR/NR
December 1993
Drawn by: Sk Jalal
AutoCAD Drawing
FILE: NERP-180.DWG
Figure 19

1991 Discharge Hydrograph

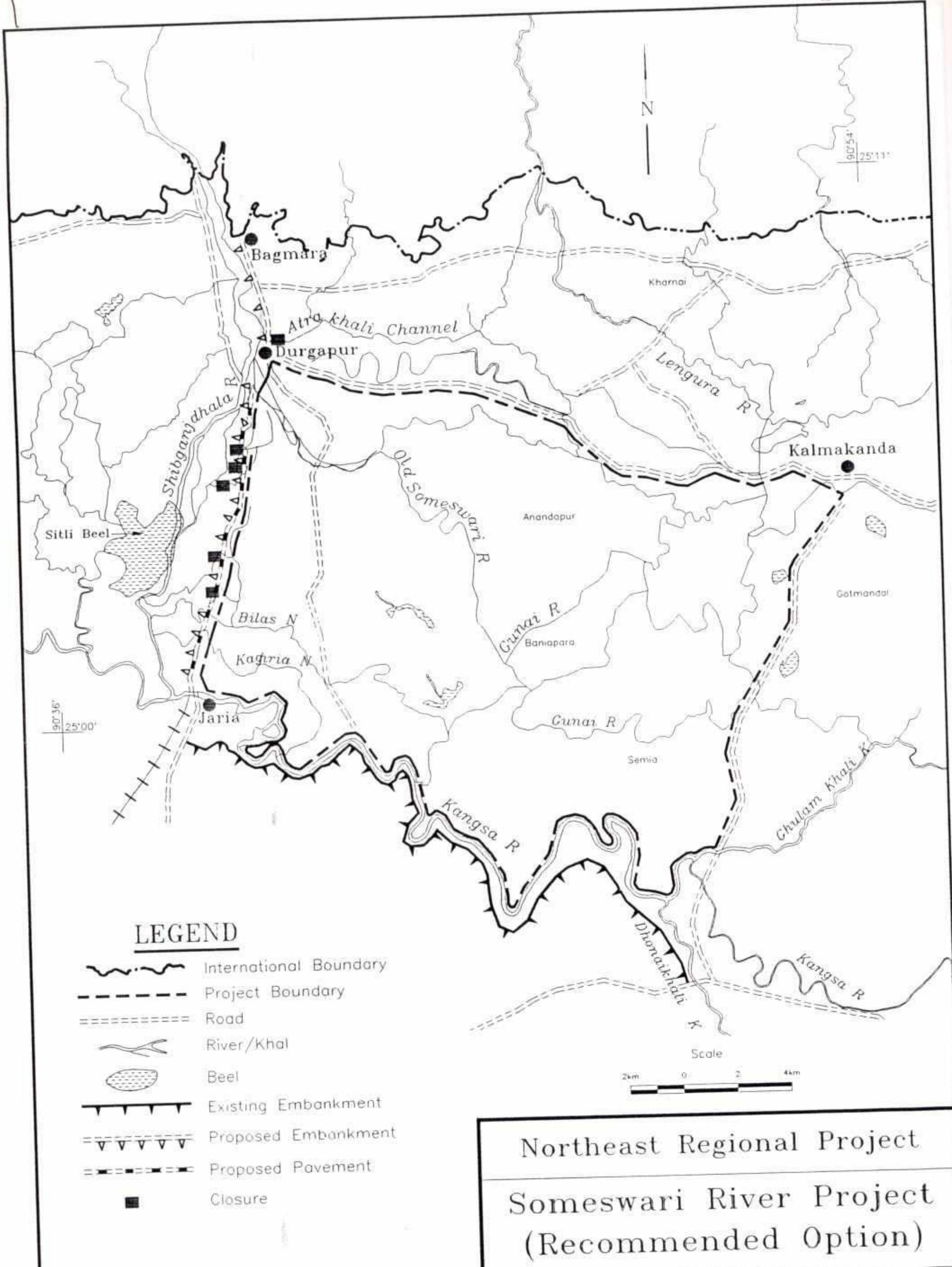


Northeast Regional Project	
Discharge Hydrograph Someswari-Kangsha System	
Prepared by : FR/NR	November 1993


N
Bagmara
Ghosegaon
Nitai R
Atrakhali Channel
Durgapur
Shibganjdhala R
Old-Someswari R
Sitli Beel
Bilas N
Kangsha R
Gunai R
Kaghria N
Jaria
Kangsha R
LEGEND
International Boundary
Road
River/Khal
Existing Embankment
Proposed Embankment
Beel
Scale
2km 0 2 4km
Northeast Regional Project
Someswari River Flood Control Project
(SMEC Proposal)
Prepared by: F.Rahman
November 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-092.DWG

290

Figure 22



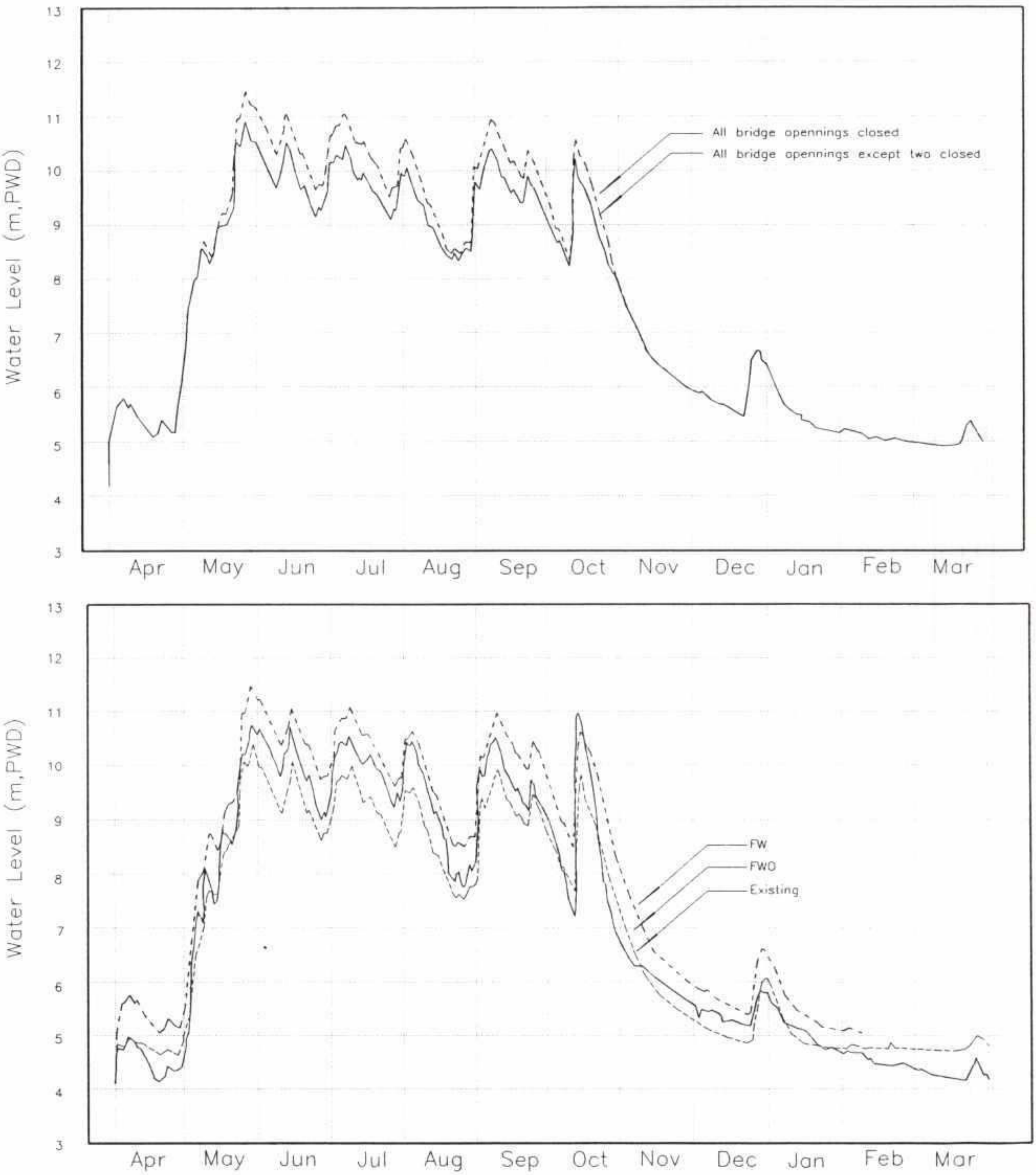
Northeast Regional Project	
Someswari River Project (Recommended Option)	
Prepared by: FR/NR	December 1993
Drawn by: Sk.Jalal	AutoCAD Drawing

FILE: NERP-099.DWG

092

Figure 23

Kangsha River Water Level at Jaria (1991 hydrologic condition)



Northeast Regional Project

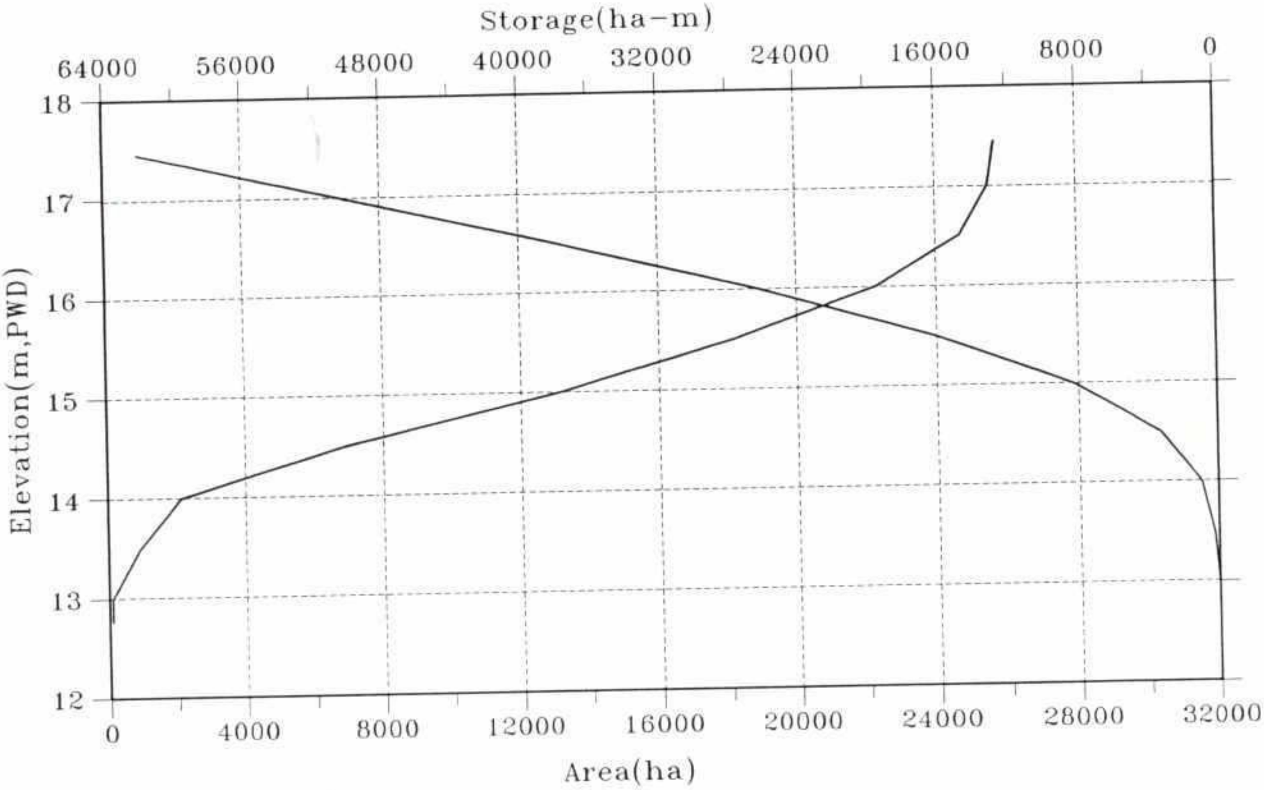
Water Level Hydrographs at Jaria Janjail

Prepared by:	FR/Awlad	January 1994

FILE:MODL-109.DWG

292

Area-Elevation-Storage Curve
Malijhee River Improvement Project



Data :

El(m,PWD)	12.76	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.45
Area(ha)	100	100	903	2107	6924	13145	18162	22277	24685	25488	25688
Storage(ha-m)	0	24	275	1028	3285	8303	16129	26239	37980	50523	62037

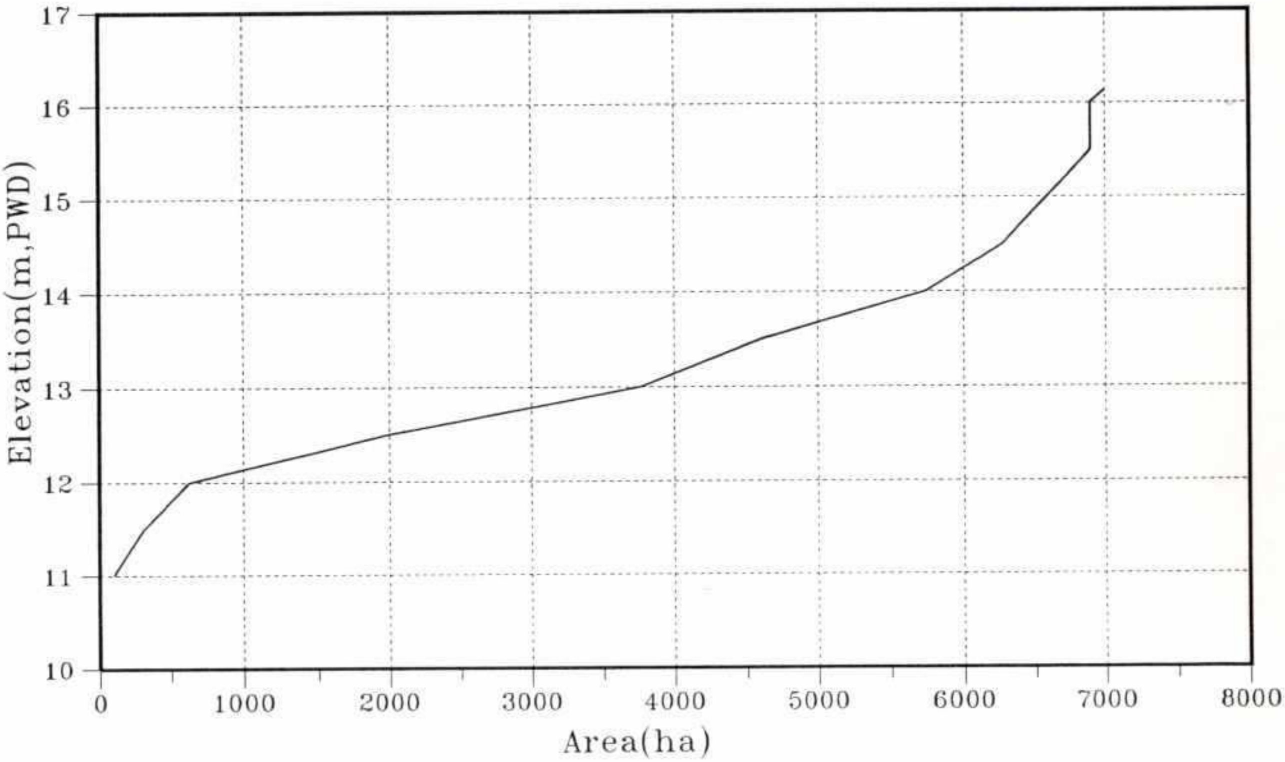
Northeast Regional Project

Area-Elevation-Storage Curve
Malijhee River Improvement Project

Prepared by : F.Rahman/NR	January 1994

२९

Area Elevation Curve
Extension of Konapara Embankment Project



Data :

El(m,PWD)	11.01	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.14
Area(ha)	104	313	627	1985	3761	4597	5746	6269	6582	6896	6896	7000

Northeast Regional Project	
Area-Elevation Curve Extension of Konapara Embankment Project	
Prepared by : F.Rahman/NR	January 1994

ANNEX C

ENGINEERING ANALYSIS

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ANNEX C : ENGINNERING ANALYSIS

C.1. MALIJHEE RIVER IMPROVEMENT PROJECT

C.1.1 Area under different flood depths

The flood depth and extent have been mapped for both pre-project and post-project conditions, based on model results for the 1991 water year and ground levels obtained from MPO's database. The 1991 flood is approximately the 2-year event in the area. The model water levels for both pre- and post-project conditions are given for select locations in Table C.1 and the computed flood areas for various depths are presented in Table 7.3.

Table C.1: 1991 Peak water levels

Location	Flood level m,PWD	
	Pre-project	Post-project
Kanasia	15.05	14.84
Konnagar	15.03	14.81
Ramnagar	13.78	13.62
Sarchapur	13.20	12.50

C.1.2 Loopcuts

Loops cuts are proposed to be excavated to about 70% of the existing river cross-sectional area in the reach. A smaller section was not considered feasible as the bank material is mainly clayey silt and would be expected to resist scouring to the ultimate section. Furthermore this provision will reduce deposition of the eroded material in the river bed downstream of the cutoff section.

C.1.3 Diversion Channel

The diversion rate to the Mogra River will be limited to approximately 100 m^3/sec in order to minimize the impacts on the Mogra River. To provide this capacity it is estimated that the diversion channel will have a bed width of 30.0 m and side slopes of 2:1. The capacity and size of the re-excavated Bismai River channel will vary from place to place according to the drainage area and discharge.

It is assumed that about 20% of the total earthwork necessary for the diversion channel will be saved with the use of existing channels.

C.1.4. Quantity and Cost Estimate

Earthwork for Loopcuts

(a) Bhogai and Malijhee Rivers - Between Sarchapur Bridge and Malijhee confluence

Total length of loopcuts : 6.93 km + 2.77 km = 9.7 km
Existing cross-sectional area of the river at ground level
: 495 m^2 (average)
Required earthwork : 0.70 x 495 x 9700 m^3 = 3.36 Mm^3

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(b) Kangsha River - Between Sarchapur Bridge and Jaria

Total length of loopcuts : 6.92 km
Existing cross-sectional area of the river at ground level
: 477 m^2 (average)
Required earthwork : 0.70 x 477 x 6920 m^3 = 2.31 Mm^3

(c) Mogra River - Between Netrokona and Atpara

Total length of loopcuts : 5.77 km
Existing cross sectional area of river at ground level
: 342 m^2
Required earthwork : 0.70 x 342 x 5770 m^3 = 1.38 Mm^3

Earthwork for Diversion Channel
Average area at ground level : 111 m^2
Length of the Diversion channel : 35 km
Required earthwork : 0.80 x 111 x 35,000 m^3 = 3.1 Mm^3
(assuming 20% reduction by following existing channels)

Improvement of Bishmai Channel : 0.93 Mm^3
(Assumed 30% earthwork of Diversion Channel)

Structure
Provision for two road bridges, each of 50.0 m span, has been made in the cost estimate in anticipation that the proposed diversion will cut off main links at two locations. The bridge cost has been estimated based on parametric costs developed for the Region indexed to 1991 prices.

Land acquisition
(a) Loopcuts on Bhogai, Malijhee and Kangsha Rivers

The average top width of the rivers is 70.0 m. It is assumed that 60.0 m top width is required in the cut sections.

Total length of loopcuts : 6.93 km + 2.77 km + 6.92 km = 16.62 km
Land required : 60 m x 16620 m /10,000 = 99.72 ha

(b) Loopcuts on Mogra River

The average top width of the River is about 60.0 m. It is assumed that 50.0 m top width is required in the cut sections.

Total length of the loopcuts : 5.77 km
Land required : 50 m x 5770 m /10,000 = 28.85 ha

(c) Diversion Channel

Top width : 40.0 m ; Length : 35.0 km
It is assumed that 50% of the required land is available from Government land.

Land acquisition required : 0.5 x 40 m x 35000 m /10,000 = 70 ha.

It is assumed that 100% of the land required for re-excavation of the Bishmai channel will be available from the Government land.

It is also assumed that about 35.0 ha of land will be required for disposal of the spoil from loopcuts (this will be reduced if the spoil is used for housing platforms.

Total land acquisition : 99.72 ha + 28.85 ha + 70 ha + 35.0 ha = 233.0 ha.

A summary of quantities and estimate of costs are provided in Table C.2.

Table C.2 : Bill of Quantities

Item	Description of Item	Unit	Quantity	Rate (MTK/Unit)	Amount (MTK)
Earthwork	Earthwork in excavation/re-excavation of Channels and river loopcuts including dewatering, heaping the soil at selected locations etc.	Mm^3	11.08	21.16	234.4
Road Bridge	**Construction of two road bridges as per design and specifications**	**m**	**100 m**	**0.561**	**56.1**
Land Acquisition	Land acquisition for loopcuts, diversion channel etc	ha	233	0.3	69.9
TOTAL					

C.2. EXTENSION OF KONAPARA EMBANKMENT PROJECT

C.2.1 Area under different flood depths

Areas under different flood depths for pre-project conditions have been obtained from MPO's catchment data.

Under project conditions, water levels in the Gangina-Ramkhali channel will control the flooding in the project area. For want of cross-sectional data in the Gangina-Ramkhali khal, the water surface profile could be only approximately estimated. A water surface profile of 4 cm/km has been assumed from Phutkai to the project site based on the Kangsha River water surface slope. A 1 in 2-yr flood level of Kangsha River at Phutkai has been computed by interpolating the values of 1:2-yr water level of Kangsha at Sarchapur and Jaria-Jhanjail.

Two year water level at Sarchapur	:	13.40 m,PWD
Two year water level at Jaria	:	11.04 m,PWD
River distance between Sarchapur and Jaria	:	60.0 km
River distance between Phutkai and Jaria	:	30.0 km
Two year water level at Phutkai	:	12.22 m,PWD
Distance between Phutkai and project site	:	25.0 km
Two year water level at project site	:	13.22 m,PWD

Gross areas under different flood depths have been computed from the area-elevation curve. Net areas exclude homesteads, beels, ponds, channels, fallow land, and infrastructure areas. The net areas are given in Table 8.4.

C.2.2 Embankment crest level

The embankment is proposed to protect against the 20-year annual peak flood.

The proposed project embankment lies between two water level measurement stations at Nalitabari and Sarchapur. A linear interpolation of water levels between the two gauges is not feasible in this instance because the Bhogai River has a steep slope between Nalitabari and the Malijhee confluence and a mild slope between the Malijhee confluence and Sarchapur. Therefore a simple relationship was established from the computer model results to relate the water level at the Malijhee confluence with the corresponding water level at Sarchapur. The equation is:

Water level at Malijhee = 0.935 (water level at Sarchapur)+2.605

By applying this equation to the 20-year flood level at Sarchapur (14.15 m,PWD derived from statistical analysis of historic water levels) the correponding 20-yr water level at the Malijhee confluence is estimated to be 15.84 m,PWD.

The 20-yr water level at Bahirshimul (14.65 m,PWD) was estimated by interpolation between the Malijhee confluence and Sarchapur.

Freeboard of 0.91 m was added to find the embankment crest level of 16.75 m,PWD at the Malijhee confluence and 15.56 m,PWD at Bahirshimul.

These estimates of design embankment levels should be considered preliminary because of the coarse model resolution, the lack of surveyed cross-sections in the project reach, and the lack of direct measurements with which to confirm the overbank discharge rate. Design crest elevations will be confirmed in the feasibility study stage.

The proposed embankment could raise the water level by 0.5 m at the Malijhee confluence. No allowance was made for this increase in consideration of the preliminary nature of the estimates of embankment elevation.

C.2.3. Quantity and Cost Estimate

The following structural components are required for the scheme:

a. **Flood Embankment.**

Length	:	20.0 km (from Malijhee confluence to Bahirshimul)
Top width	:	4.27 m
Side slope	:	2:1 & 3:1
Average height	:	3.0 m
Earthwork	:	38.84x20,000 m^3 = 0.7768 Mm^3
Turfing	:	20.70x20,000 m^2 = 0.414 Mm^2

b. **Flushing Regulator over Kodalia khal - 1 required**

c. **Land acquisition : 100 ha**

A summary of the quantity estimates is provided in Table C.3.

Table C.3: Bill of Quantities

Item	Description of Item	Unit	Quantity	Rate (MTK/Unit)	Amount (MTK)
Structure	1. Flushing Regulator	No.	1	L.S	2.20
Embankment	1. Construction of 20.00 km of new embankment as per design and specification	Mm^3	0.7768	17.09	13.28
	2. Turfing	Mm^2	0.414	2.20	0.91
Sub-total					**14.19**
Land acquisition	1. Land for embankment and structure	ha	100	0.30	30.00
TOTAL					**46.39**

C.3. GREATER DAMPARA PROJECT

C.3.1 Area under different flood depths

Areas under different flood depths for pre-project conditions have been obtained from MPO's catchment data. The areas under different flood depths for post-project conditions were taken from BWDB's 'Feasibility Report - Dampara sub-Project, 1986', adjusted for the increased project area. The Feasibility Report used the 1976-77 hydrological conditions which are considered to represent a 1 in 5-year drainage condition.

C.3.2 Embankment crest level

The embankment will be designed for a 20-yr flood level in the Kangsha River plus 0.91 m freeboard.

The 20-yr flood level is 14.15 m,PWD at Sarchapur and 11.42 m,PWD at Jaria, as determined by statistical analysis of historic water levels using the GEV distribution.

It is expected that the confinement effect (rise in water levels due to the embankment) will not be significant because of three factors:

- the River will remain open to the floodplain on the other bank in the downstream portion of this reach;
- water levels will be lowered in the upstream portion of the embanked reach by the channel improvements which are proposed under the Malijhee drainage improvement project;
- the rate of overbank spill that the embankment will cut off is judged to be relatively small.

These observations are supported by model results. Therefore no allowance was made for confinement effects in determining the preliminary design elevations for the embankment.

C.3.3. Quantity and Cost Estimates

The following structural components are required for the scheme.

a. Flood Embankment.

Length	:	35.0 km (from Jaria to Banastala)
Average height	:	3.0 m; Top width: 4.27 m; Side slope: 2:1& 3:1
Earthwork	:	38.84x35,000 m^3 = 1.36 Mm^3
Turfing	:	20.70x35,000 m^2 = 0.725 Mm^2

b. **Drainage channel**
Quantity : 400,000 Mm^3 (From Dampara Feasibility Report)

c. **Drainage Regulator**

Require : 24 vents with openings of 1.52 m x 1.83 m (based on Dampara Flood Routing analysis)

Existing : 15 vents;
10-1.52 m x 1.83 m at Chorerbhita and 5-1.52 m x1.83 m at Debipara.

Proposed new construction:
Regulator (Provisional Item) : 7 vents; 7-1.52 m x 1.83 m at Lauri outfall and 2-1.52 m x 1.83 m at Kalihar outfall.

d. **LLP Inlets : 29 nos (Lump Sum)**

e. **Land acquisition : 180 ha**

These estimates are subject to review as a result of more detailed analysis during feasibility studies.

A summary of quantities is provided in Table C.4.

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Table C.4: Bill of Quantities

Item		Description of Item	Unit	Quantity	Rate (MTK/Unit)	Amount (MTK)
Structure	1.	Construction of drainage Regulator as per design and specification				
		7-1.52mx1.83m	no	1	10.5	10.500
		2-1.52mx1.83	no	1	5.0	5.000
	2.	Construction of LLP inlets as per design and specifications	no	29	0.055	1.600
Sub-total						**17.100**
Embankment	1.	Construction of 35.0 km of new embankment as per design and specifications	Mm^3	1.36	17.09	23.241
	2.	Construction of LLP inlets as per design and specifications	Mm^3	0.725	2.20	1.595
Sub-total						**24.836**
Channel	1.	Re-excavation of channels including disposal of excavated earth as per design and specification	Mm^3	0.40	15.0	6.0
Land acquisition	1.	Land for embankment and structure construction	ha	180	0.30	54.0
TOTAL						**101.936**

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C.4. SOMESWARI RIVER PROJECT

C.4.1 Area under different flood depths

Areas under different flood depths for pre-project conditions have been obtained from MPO's catchment data.

Although the Someswari River spill will be largely eliminated with the project, the southern and eastern portions of the project area will not be protected from flooding from the Kangsha River and from the rivers to the east. In post-project conditions, the areas under different flood depths have been mapped from 2-yr flood levels at Jaria, Thakurakona, and Kalmakanda and MPO's one kilometre grid ground elevation data. In the absence of a long period of record at Thakurakona (records are only available since 1991) the 2-yr flood level at that point has been estimated by correlation with Jaria. Using the recorded 1991 water level data the following relationship between the two gauges was obtained:

WL at Thakurakona = 0.425 x (WL at Jaria) + 3.354

The estimated 2-yr flood level at Thakurakona is 8.05m,PWD

The 2-yr flood levels at Jaria and Kalmakanda are given in Table A.5 and the areas under different flood depths are given in Table 10.4 after deduction for areas of homesteads, beels, ponds, channels, fallow, and infrastructure.

C.4.2. Embankment crest level

The proposed embankment will be designed for the 20-yr annual flood. Flood levels were estimated at Bagmara and Jaria from frequency analysis of historic water level data using the GEV distribution and are given in Table A.5. Freeboard of 0.91 m was added to the 20-year flood levels to estimate the embankment crest elevations.

As was discussed in Chapter 10 the peak flood level at Jaria will be increased by 0.40 m under 1991 hydrologic conditions. As the estimated rise is very preliminary and does not make a material change to the design concept and quantitities, it has not been included in the preliminary embankment levels. However, during detailed feasibility study, this aspect will be given due consideration in the selection of design levels.

C.4.3. Quantity and Cost Estimate

The following structural components are required for the scheme. A summary of the estimated quantities and costs is provided in Table C.5.

a. Flood Embankment.

The existing Jaria-Durgapur Road (20.0 km) is proposed to be upgraded and paved to act as a

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flood embankment. In the absence of a road survey, the following assumptions have been made:

Existing Road:

Average top width	:	6.00 m; average height : 3.0 m
Side Slope	:	2:1 on both sides

Proposed Road/Embankment:

Average top width	:	7.32 m;
Average height	:	4.50 m
Pavement width	:	6.10 m;
Paved length	:	18.0 km

(from Jaria Jhanjail to Old Someswari)

Earthwork:

Earthwork of proposed section : (7.32+2x4.5)x4.5 = 73.44 m^3/m
less earthwork available from existing section:
(6.00+2x3.0)x3.0 = 36.00 m^3/m

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equals earthwork required = 37.44 m^3/s

Total earthwork	: 37.44x20,000 m^3 = 748800 m3	
Unit cost of work including turfing and mechanical compaction	: Tk 36.0/m^3	
Embankment Cost	: Tk. 36.0x748800	MTK 26.957
Pavement Rate	: (TK 1220/7.32)x6.1x1000=MTK 1.017/km	
Pavement Cost	: MTK 1.017x18.0	MTK 18.300
Raising of Kangsha embankment	: lump sum	MTK 10.00

b. Closure

Closing of Atrakhali Channel:

Length of Closure	: 150 m; Top width: 7.32 m;	
height	: 10.0 m; Side slope : 2:1 and 3:1	
Volume of work	: 48,495 m^3	
Cost	: Tk. 36.0x48,495	MTK 1.75
Closing of bridge openings	: lump Sum	MTK 1.04

Table C.5: Bill of Quantities

Item		Description of Item	Unit	Quantity	Rate (MTK/Unit)	Amount (MTK)
Embankment	1.	Construction of 20.0 km of new embankment Including turfing and mechanical compaction and as per design and specifications	Mm^3	0.7488	36.0	26.95
	2.	Paving of 6.1 m wide	km	18	1.017	18.30
	3.	Raising of Kangsha embankment			L.S.	10.00
Sub-total						**55.25**
Closure	1.	Closing of Atrakhali Channel	Mm^3	0.485	36.0	1.75
	2.	Closing of all bridge opening	L.S			1.04
Sub-total						2.79
TOTAL						**58.04**

ANNEX D

FISHERIES MODEL

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ANNEX D : FISHERIES MODEL

This annex briefly describes the model used to analyze fisheries impacts for the project.

The openwater fishery ecosystem is extremely complex. Impacts on production are assessed here using a highly simplified model. The limitations of the model mirror the limitations of the current understanding of and information about the system.

The major system processes about which some insight exists are:

- Migration access and timing. It seems to be accepted that:
  - a multiplicity of access points is desirable (i.e. that closing any or some channels is still deleterious,
  - the most important channels are those at the downstream end of the system (that with flood onset, fish mainly migrate upstream and onto the floodplain, and downstream out of the beels into the river), and
  - delay of flooding, as in partial flood control schemes, is highly disruptive

- Overwintering (dry season) habitat extent.

- Wet season habitat (floodplain grazing extent and duration). [It is expected that production also varies as a function of land type (F1, F2, F3) — probably such that shallower (F1, F2) land is more productive than deeper (F3) land — but as data to show this has been lacking it has been neglected from the model.]

- Habitat Quality. Habitat quality would include water quality, vegetation, and other conditions (presence of preferred types of substrate e.g. rocks, sand, brush). Water quality would appear to be most relevant during low volume/flow periods, and during the time of flood onset and recession when contaminants can disperse or accumulate.

- Spawning. Production <u>outside the project area</u> can also be impacted if habitats suitable for spawning within the project are adversely affected. It is believed that most of the region's fish production stems from spawning occurring in: mother fishery areas, which are those exhibiting extensive, well-interconnected, and varied habitats with good water quality; key beels; and river <u>duars</u>. <u>Duars</u> are somewhat a separate problem as they are located in rivers and larger channels, not on the floodplain.

The foregoing is represented quantitatively here as:

FWO production =

$$(R_0 * P_{R0}) + (B_0 * P_{B0}) + (W_0 * P_{W0})$$

FW production =

$$[M * Q * (R_1 * P_{R0})] + [M * Q * (B_1 * P_{B0})] + [M * (W_1 * P_{W0})]$$

Thus,

$$\text{Impact} = \text{FW} - \text{FWO production} =$$

$$\{ [(M * Q * R_1) - R_0] * P_{RO} \} +$$

$$\{ [(M * Q * B_1) - B_0] * P_{BO} \} +$$

$$\{ [(M * W_1) - W_0] * P_{WO} \}$$

where

sub-0 and sub-1 refer to FWO and FW respectively
R, B, and *W* are river/channel, beel, and floodplain (F1+F2+F3) areas, in ha
P is the unit FWO production in kg/ha for the respective habitats. Estimated regional average values are 175, 410, and 44 respectively.
M is the FW quality-weighted migration access remaining, relative to FWO conditions (range 0 to 1 for negative impacts, >1 for positive impacts)
Q is the FW acceptability of habitat/water quality relative to FWO conditions (range 0 to 1 for negative impacts; >1 for positive impacts).
A_M is the area of mother fishery and key beels affected times a factor (range 0 to 1 for negative impacts, >1 for positive impacts) reflecting the degree of degradation/enhancement
T is the estimated annual regional fish production attributable to spawning exported from mother fisheries/key beels (a constant of 50,000 tonnes, which is 50% of the total regional fish production of 100,000 tonnes)
A_T is the estimated regional mother fishery/key beel area (a constant of 100,000 ha).

Estimated values for this basin are shown in Tables D.1 through D.4 for four individual projects. Where standard values, established for the region or for a particular project type, are used, this is noted. Comments on project-specific values are also shown.

It is estimated that one person-day is required to capture half kilogram of fish on the flood plain, eight kilograms in the beel, three kilograms in river/channel and nine kilograms in pond.

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Table D.1: Fisheries Parameters

Malijhee River Improvement Project
(Drainage Improvement)

Var	Value	Stnd value?	Comments
M	1.0	>1.0	Fish migration routes will be improved with channel re-excavation. However, to be on the safe side, no benefit has been taken into consideration
Q	1.0	>1.0	Water quality is expected to improve since water will not stagnate in the system. However, to be on the safe side, no benefit has been taken into consideration.
R_0	1500		-
R_1	1500		-
B_0	1570		-
B_1	1570		-
W_0	11190		-
W_1	7990		Improved drainage under project condition will reduce the flooded area
P_{R0}	50	175	NERP field observation
P_{B0}	50	410	NERP field observation
P_{W0}	35	44	NERP field observation
A_M	-	100000	There is no "mother fishery" in this area

Table D.2: Fisheries Parameters

Extension of Konapara Embankment Project
(Bottom - open spill protection)

Var	Value	Stnd value?	Comments
M	0.8	>0.8	To reflect restricted migration.
Q	0.8	>0.8	To reflect smaller, less frequent spills.
R_0	120		-
R_1	120		-
B_0	180		-
B_1	180		-
W_0	3510		-
W_1	2906		Spill protection reduces the flooded area.
P_{R0}	100	175	NERP field observation
P_{B0}	150	410	NERP field observation
P_{W0}	30	44	NERP field observation
A_M	-	100000	There is no "mother fishery" in the area

Table D.3: Fisheries Parameters

Greater Dampara Project
(Full Flood Control)

Var	Value	Stnd value?	Comments
M	0.3	>0.3	To reflect severe restriction on migration access.
Q	0.5	>0.5	To reflect total spill protection.
R_0	400		-
R_1	400		-
B_0	230		-
B_1	230		-
W_0	7850		-
W_1	6700		Project's flood control works reduce flooded area.
P_{R0}	200	175	NERP field observation
P_{B0}	200	410	NERP firld observation
P_{W0}	35	44	NERP field observation
A_M	-	100000	There is no "mother fishery" in the area

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Table D.4: Fisheries Parameters

Someswari River Project
(Two sides open at the bottom)

Var	Value	Stnd value?	Comments
M	1.0	1.0	There will be no affect on migration as the project will remain open along Kangsha River and the eastern haor area, the main sources of fishes.
Q	0.9	1.0	To reflect the smaller spill from Someswari River.
R_0	4000		-
R_1	4000		-
B_0	1200		-
B_1	1200		-
W_0	17075		-
W_1	16775		Project's works reduce flooded area.
P_{R0}	175	175	NERP field observation
P_{B0}	410	410	NERP field observation
P_{W0}	44	44	NERP field observation
A_M	-	100000	There is no "mother fishery" in the area

ANNEX E

INITIAL ENVIRONMENTAL EXAMINATION

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ANNEX E: INITIAL ENVIRONMENTAL EXAMINATION

E.1 Introduction

This Initial Environmental Examination (IEE) (pre-feasibility level Environmental Impact Assessment or EIA) follows the steps specified in the *Bangladesh Flood Action Plan Guidelines for Environmental Impact Assessment* (ISPAN, 1992). These steps are illustrated in Figure 2 of ISPAN (1992).

Much of the information required for the IEE/EIA appears in the main body of the study. The section and chapter references given below cite this information.

E.2 Alternative 1: Proposed FCD Project

E.2.1 Project Design and Description (Step 1)

Project Description, as in Section 7.4 (Malijhee River Improvement Project), Section 8.4 (Extension of Konapara Embankment), Section 9.4 (Greater Dampara Project) and Section 10.4 (Someswari River Project).

E.2.2 Environmental Baseline Description (Step 2)

As in Chapter 2, Biophysical Description, and Chapter 3, Settlement, Development, and Resource Management.

E.2.3 Scoping (Step 3)

Technical:

Literature review: Presented in Chapter 4, Previous Studies.

Local community: As described in Section 3.1.9, People's Perception.

E.2.4 Bounding (Step 4)

Physical:

Gross area: 233,770 ha (Basin Area).
Impacted (net) area: 68,165 ha (Project's net Area).
Impacted area outside project:none

Temporal:

Preconstruction: year 0 through year 1
Construction: year 1 through year 3
Operation: Embankments, Structures and channel maintenance will be required.
Abandonment: after year 50.

Cumulative impacts:

With other floodplain infrastructure: none
With pre-existing no-project trends. Described in Chapter 5.

E.2.5 Field Investigations (Step 5)

Field investigations were limited to fifteen to twenty days of informal reconnaissance by a multi-disciplinary team for all the four projects.

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E.2.6 Impact Assessment (Step 6)

At this level of detail, a screening matrix (Table E.1) was filled out by the project team. Impacts are designated by:

+	positive impact
-	negative impact
•	neutral impact (such as conversion from one productive land use to another)
?	insufficient information to designate

Impacts are discussed in Section 7.9 (Malijhee River Improvement Project), 8.9 (Extension of Konapara Embankment), 9.9 (Greater Dampara Project) and 10.9 (Someswari River Project).

E.2.7 Quantify and Value Impacts (Step 7)

Quantification and evaluation of impacts is documented in Section 7.9 and Tables 7.13 through 7.17 (Malijhee River Improvement Project), Section 8.9 and Tables 8.14 through 8.18 (Extension of Konapara Embankment Project), Section 9.9 and Tables 9.14 through 9.18 (Greater Dampara Project) and Section 10.9 and Tables 10.14 through 10.17 (Someswari River Project).

E.2.8 Environmental Management Plan (Step 8)

At a pre-feasibility level, this section focuses on "identification of broad management options and major constraints" (p. 28, ISPAN, 1992).

Mitigation and enhancement. Negative impacts are expected to be minimal; so no mitigation measures were incorporated.

Compensation. Land acquisition will be required for construction of embankment and diversion channel. Market value compensation is required to be paid and independent monitoring is required to ensure that proper compensation does occur.

Monitoring. There is a need to define monitoring needs and methodologies at regional, institutional (BWDB), and project levels. This exercise should reflect (i) the need for greater people's participation in all project activities, which would include monitoring project function and opportunities for discussion with BWDB and (ii) the need for greater emphasis on operation and maintenance, of which monitoring can play an important role.

People's participation. There is a need at regional, institutional, and project levels to maintain enthusiasm for people's participation, and to develop effective and efficient public participation modalities.

Disaster management (contingency planning). The project will improve the flooding conditions in the Kangsha River Basin. This will permit the farmers to shift to more intensive and higher input agriculture. The risks associated with this relate to gradual infilling of diversion channel and deterioration of embankments over time as a result of no ongoing maintenance and a gradual return to pre-project conditions.

EMP institutionalization. Arrangements for sharing EMP responsibility between BWDB and local people would need to be worked out. Project implementation should be contingent upon agreement on this matter between BWDB and local people.

Residual impact description. This should be generated as part of the feasibility-level EIA.

Reporting and accountability framework. At a national or regional scale, there is a need to develop satisfactory reporting/accountability arrangements involving BWDB, DOF and DOE, probably through an Environmental Cell within BWDB linked to DOE and DOF. At the project level, the client committee and local BWDB staff should develop reporting/accountability arrangements satisfactory to themselves. Project implementation should be contingent upon development of satisfactory arrangements at the local level, at a minimum.

Budget estimates. These should be generated as part of the feasibility study.

E.1 : Environmental Screening Matrix
1. Malijhee River Improvement Project

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Preconstruction	Normal	Surveys & instrumentation: landmark, topographic, benchmark, hydrologic, climatic, socio-economic, land use, natural resource		•	•	•	•	•	•	•	•	
		Land acquisition		—	•	•	•	•	—	•	•	
		People's participation activities		+	+	•	•		+			
	Abnormal											
Construction	Normal	Site preparation: vegetation removal, infrastructure removal/relocation, resettlement, levelling, temporary structure installation (access roads, godowns, accommodations, garages and parking sites, cooking and eating facilities, waste disposal sites, water supply, drainage, sanitary facilities)		•	•	•	•	•	•	•	•	
		Canal excavation: labor and materials mobilization, crossdam construction, spoil transport, spoil disposal		—	—	•	•	•	•	•	•	
		Embankment construction: labor and materials mobilization, topsoil removal, soil taking and transport, compaction, turfing, paving										
		Structure (sluice gate, culvert, pump house, and so on) construction: labor and material mobilization, de-watering, excavation, pile driving, foundation works, structure construction, earthwork filling, turfing, paving		—	—	•	•	•	•	•	•	
		Tube well installation: boring, distribution facilities, electrification N/A										
	Abnormal	Suspension of construction before completion, construction delays		—	+	•	•	•	•	•	•	
		Incorrect construction practices or techniques		—	?	•	•	•	—	•	•	

E.1 : Environmental Screening Matrix
1. Malijhee River Improvement Project

Screening matrix PHASE	Normal/ Abnormal	Activity	Important Environmental Component	Land Use	Agri- culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Construction (continued)	Abnormal (cont'd)												
Operation	Normal	Pre-monsoon flood protection											
		Monsoon flood protection											
		Surface water irrigation	N/A										
		Ground water irrigation	N/A										
		Drainage			+	–							
		Agriculture: operation of institutions, extension, credit, seed distribution, fertilizer and pesticide storage and use, farmer groups			+								
		Water management: activities of BWDB, subproject implementation committee, local water user groups, structure committees and guards			+								
	Abnormal (relative to FWO, not FW normal)	Pre-monsoon flooding (due to extreme event, infrastructure failure)											
		Monsoon flooding (due to extreme event, infrastructure failure)											
		Embankment overtopping											
		Under- and over-drainage			–	–				?			
		Improper operation (public cuts, mistiming of scheduled O&M events etc)											
		Riverbed aggradation/degradation			–	+							
Abandonment	Normal	Re-occupation of infrastructure sites			–								
		Reclamation of materials											
	Abnormal												

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E.1 : Environmental Screening Matrix
2. Extension of Konapara Embankment

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Preconstruction	Normal	Surveys & instrumentation: landmark, topographic, benchmark, hydrologic, climatic, socio-economic, land use, natural resource		•	•	•	•	•	•	•	•	
		Land acquisition		—					—			
		People's participation activities		+	+							
	Abnormal											
Construction	Normal	Site preparation: vegetation removal, infrastructure removal/relocation, resettlement, levelling, temporary structure installation (access roads, godowns, accommodations, garages and parking sites, cooking and eating facilities, waste disposal sites, water supply, drainage, sanitary facilities)										
		Canal excavation: labor and materials mobilization, crossdam construction, spoil transport, spoil disposal										
		Embankment construction: labor and materials mobilization, topsoil removal, soil taking and transport, compaction, turfing, paving		—								
		Structure (sluice gate, culvert, pump house, and so on) construction: labor and material mobilization, de-watering, excavation, pile driving, foundation works, structure construction, earthwork filling, turfing, paving		—								
		Tube well installation: boring, distribution facilities, electrification N/A										
	Abnormal	Suspension of construction before completion, construction delays		—	+							
		Incorrect construction practices or techniques		—	?							

E.1 : Environmental Screening Matrix
2. Extension of Konapara Embankment

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Construction (continued)	Abnormal (cont'd)											
Operation	Normal	Pre-monsoon flood protection										
		Monsoon flood protection		+	−	−						
		Surface water irrigation N/A										
		Ground water irrigation N/A										
		Drainage										
		Agriculture: operation of institutions, extension, credit, seed distribution, fertilizer and pesticide storage and use, farmer groups		+								
		Water management: activities of BWDB, subproject implementation committee, local water user groups, structure committees and guards		+								
	Abnormal (relative to FWO, not FW normal)	Pre-monsoon flooding (due to extreme event, infrastructure failure)										
		Monsoon flooding (due to extreme event, infrastructure failure)		−	+	+			−		−	
		Embankment overtopping		−	+	+			−		−	
		Under- and over-drainage										
		Improper operation (public cuts, mistiming of scheduled O&M events etc)		−	+	+			−		−	
		Riverbed aggradation/degradation										
Abandonment	Normal	Re-occupation of infrastructure sites		−					−			
		Reclamation of materials										
	Abnormal											

E.1 : Environmental Screening Matrix
3. Greater Dampara Project

Screening matrix / PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Preconstruction	Normal	Surveys & instrumentation: landmark, topographic, benchmark, hydrologic, climatic, socio-economic, land use, natural resource		•	•	•	•	•	•	•	•	
		Land acquisition		–					–			
		People's participation activities		+	+							
	Abnormal											
Construction	Normal	Site preparation: vegetation removal, infrastructure removal/relocation, resettlement, levelling, temporary structure installation (access roads, godowns, accommodations, garages and parking sites, cooking and eating facilities, waste disposal sites, water supply, drainage, sanitary facilities)										
		Canal excavation: labor and materials mobilization, crossdam construction, spoil transport, spoil disposal		–	–							
		Embankment construction: labor and materials mobilization, topsoil removal, soil taking and transport, compaction, turfing, paving		–								
		Structure (sluice gate, culvert, pump house, and so on) construction: labor and material mobilization, de-watering, excavation, pile driving, foundation works, structure construction, earthwork filling, turfing, paving										
		Tube well installation: boring, distribution facilities, electrification N/A										
	Abnormal	Suspension of construction before completion, construction delays		–	+							
		Incorrect construction practices or techniques		–	?							

E.1 : Environmental Screening Matrix
3. Greater Dampara Project

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri- culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Construction (continued)	Abnormal (cont'd)											
Operation	Normal	Pre-monsoon flood protection										
		Monsoon flood protection		+	–	–						
		Surface water irrigation N/A										
		Ground water irrigation N/A										
		Drainage										
		Agriculture: operation of institutions, extension, credit, seed distribution, fertilizer and pesticide storage and use, farmer groups		+								
		Water management: activities of BWDB, subproject implementation committee, local water user groups, structure committees and guards		+								
	Abnormal (relative to FWO, not FW normal)	Pre-monsoon flooding (due to extreme event, infrastructure failure)										
		Monsoon flooding (due to extreme event, infrastructure failure)		–	+	+			–		–	
		Embankment overtopping		–	+	+			–		–	
		Under- and over-drainage										
		Improper operation (public cuts, mistiming of scheduled O&M events etc)		–	+	+			–		–	
		Riverbed aggradation/degradation										
Abandonment	Normal	Re-occupation of infrastructure sites		–					–			
		Reclamation of materials										
	Abnormal											

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E.1 : Environmental Screening Matrix
4. Someswari River Project

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Preconstruction	Normal	Surveys & instrumentation: landmark, topographic, benchmark, hydrologic, climatic, socio-economic, land use, natural resource		•	•	•	•	•	•	•	•	
		Land acquisition		•	•	•	•	•	•	•	•	
		People's participation activities		+	+							
	Abnormal											
Construction	Normal	Site preparation: vegetation removal, infrastructure removal/relocation, resettlement, levelling, temporary structure installation (access roads, godowns, accommodations, garages and parking sites, cooking and eating facilities, waste disposal sites, water supply, drainage, sanitary facilities)										
		Canal excavation: labor and materials mobilization, crossdam construction, spoil transport, spoil disposal										
		Embankment construction: labor and materials mobilization, topsoil removal, soil taking and transport, compaction, turfing, paving		—					+			
		Structure (sluice gate, culvert, pump house, and so on) construction: labor and material mobilization, de-watering, excavation, pile driving, foundation works, structure construction, earthwork filling, turfing, paving		—					+			
		Tube well installation: boring, distribution facilities, electrification N/A										
	Abnormal	Suspension of construction before completion, construction delays		—	+							
		Incorrect construction practices or techniques		—	?							

E.1 : Environmental Screening Matrix
4. Someswari River Project

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Construction (continued)	Abnormal (cont'd)											
Operation	Normal	Pre-monsoon flood protection										
		Monsoon flood protection		+	–							
		Surface water irrigation N/A										
		Ground water irrigation N/A										
		Drainage										
		Agriculture: operation of institutions, extension, credit, seed distribution, fertilizer and pesticide storage and use, farmer groups		+								
		Water management: activities of BWDB, subproject implementation committee, local water user groups, structure committees and guards		+								
	Abnormal (relative to FWO, not FW normal)	Pre-monsoon flooding (due to extreme event, infrastructure failure)										
		Monsoon flooding (due to extreme event, infrastructure failure)		–	+				–			
		Embankment overtopping		–	+				–			
		Under- and over-drainage										
		Improper operation (public cuts, mistiming of scheduled O&M events etc)		–	+				–			
		Riverbed aggradation/degradation										
Abandonment	Normal	Re-occupation of infrastructure sites										
		Reclamation of materials										
	Abnormal											

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