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)

KUSHIYARA - BIJNA INTERBASIN DEV PROJECT.

November 1993

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

BANBEIS	Bangladesh Bureau of Educational Information and Statistics
BBS	Bangladesh Bureau of Statistics
BIWTA	Bangladesh Inland Water Transport Agency
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
DTW	deep tube well
EIA	environmental impact assessment
EIRR	economic internal rate of return
EMP	Environmental Management Plan
EPWAPDA	East Pakistan Water and Power Development Agency
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
STW	shallow tube well

US $1 = Tk 38

EXECUTIVE SUMMARY

The purpose of the project is to protect *boro* crops from pre-monsoon flood damage; to a lesser degree, to protect monsoon crops from flood damage; to protect homesteads and roads from flood damage; and to provide supplemental irrigation.

Historically, the project area was drained via the Bibyana River to the Kushiyara River. In recent years, the Bibyana River has been abandoned as a result of morphologic changes, so that drainage must now be effected further downstream through the Ratna River system. Consequently, post-monsoon drainage is impeded which delays planting of the *boro* crop. In addition, pre-monsoon drainage has also become less effective. Therefore, the single *boro* crop (produced on low land) which was a risky enterprise in the past, is becoming more and more vulnerable to flood damage.

Proposed project infrastructure would consist of 48.5 km of full flood control embankments on the left bank of the Kushiyara River, 33 km of submersible embankments on the left bank of the Kalni River downstream of Markuli, nine drainage cum flushing regulators, five irrigation inlets, and 55 km of channel re-excavation. Several of the regulators would be sited explicitly to enhance fisheries production; for example, the regulators at the Bibyana off-take and the Kaiyer Dhana channel will retain water to support fisheries longer into the dry season.

The proposed project relates synergistically to the suggested "Kushiyara Dredging Project" (described in a separate pre-feasibility study). Spoil earth resulting from dredging in the Kushiyara could form the basis of the submersible embankments required for this project. Implementation of this project increases the pre-monsoon discharge and thus facilitates Kushiyara bed scouring — reducing dredging requirements.

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1. INTRODUCTION

1.1 General Information

BWDB Division:	Habiganj
District:	Habiganj, Moulvibazar and Sunamganj
Thanas:	Baniachong, Ajmiriganj, Nabiganj, Habiganj, Astagram, Moulvibazar, Jagannathpur, Derai, Mitamain and Madna
MPO Planning Areas:	27, 28 and 29
Gross Area:	100,000 ha
Net Area:	84,000 ha

1.2 Scope and Methodology

This is a pre-feasibility study that was undertaken intermittently over a period of five months in 1993. The study team consisted of a water resources engineer, a socio-economist, an agronomist, a fisheries specialist, and a wetland resources specialist. Additional analytical support was provided by an environmental specialist and economist.

1.3 Data Base

The project analyses presented in this report were carried out using mainly secondary data sources, and information obtained during field inspections and personal interviews.

The information and data sources used in different specialist analyses are listed below:

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

Agricultural analysis: Data published in Land Resources Appraisal for Agricultural Development in Bangladesh (AEZ Reports) for soils and Water Resources Planning Organization (WARPO) for agricultural inputs, 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 at Sylhet in June, 1992 and at Habiganj in April, 1993.

Wetland analysis: Topographic maps, local revenue department records, personal field observations and interviews with local people, CIDA Inception Report (1990).

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

1.4 Report Layout

A description of the biophysical features of the project 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 area. 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 Chapter 7 provides an analysis of the best option. The annexes consist of detailed information to support the main body of the report.

2. BIOPHYSICAL DESCRIPTION

2.1 Location

The Kushiyara-Bijna Interbasin Project covers a gross area of 100,000 ha in the north of Habiganj district, between latitude 24° 42' and 24° 25' N, and longitude 91° 43' and 91° 15' E. The project area is bounded by the Kushiyara River in the north, north east and west and Shaka Barak-Bijna-Gangajuri-Ratna River system in the south, south east and west (Figure 1).

2.2 Climate

The climate of the project area is monsoon tropical with hot wet summers and cool dry winters. The highest temperature in the area was recorded at 41.7 °C in May and the lowest at 1.7 °C in January. The lowest monthly temperature is in January, when the mean is 9 °C and the highest monthly temperature is in May, when the mean is 32.6°C. The climate of the area based on data from Bangladesh Meteorological Department (BMD) is summarized in Table A.1.

Rainfall distribution shows a general pattern of gradual increase from south to north. Average annual rainfall in the area ranges from about 2800 mm in the south near Habiganj to about 3600 mm in the north near Markuli (Figure 2). Mean monthly rainfall varies from 15 mm in January to 577 mm in June, and mean annual rainfall is 3286 mm. Potential evapotranspiration is lowest in December/January at 49 mm/month and highest in April at 114 mm/month.

2.3 Land (Physiography)

2.3.1 General Description

The Kushiyara-Bijna Interbasin, and the Habiganj district in general, are low-lying areas. The northwestern part of the project area is lower than the eastern side. Land elevations in the northwestern area are about four or five meters PWD, except in Baniachong thana where landfill areas have elevation over 7.5 m PWD. Land elevations in the eastern area are generally six meters PWD and above (Figure 3).

Topographically the land is flat with no hills or undulating land. The land generally slopes from east to west and previously drained to the Kushiyara-Kalni River system below Ajmiriganj. Due to the severe siltation of channels in the Ajmiriganj area, the southwestern area mainly drains through the Ratna River system particularly during the pre-monsoon season.

The project basin elevations and cumulative areas are presented in Table A.2.

2.3.2 Soils

The Kushiyara-Bijna Interbasin is covered mostly by the Old Meghna Estuarine Floodplain and partly by the Old and Young Surma-Kushiyara floodplain.

Landscape in the Old Meghna estuarine floodplain is almost level, without river meander scars and cut-offs. The soils occurring on narrow ridges generally consist of a grey to dark grey puddled silt loam topsoil with medium acid to near neutral reaction overlying an olive to olive-brown mottled silt loam topsoil with blocky structure, friable consistency, and medium acid

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reaction. The poorly drained basin soils consist of a grey to dark grey, friable, silt loam to silty clay loam topsoil with medium acid to near neutral reaction, overlying a grey to olive mottled silt loam to silty clay loam subsoil with blocky structure, friable consistency and medium acid reaction. Locally where the land was under natural swamp grasses for a long period, the topsoil colour became dark grey to very dark grey.

Landscape in the Old Surma-Kushiyara floodplain comprises extensive, nearly level to very gently undulating basins, crossed by some narrow high ridges adjoining rivers and creeks. The main ridge soils of this landscape consist of a grey, massive, puddled topsoil overlying a grey, mottled, silty clay loam to clay subsoil with blocky or prismatic structure and medium to strongly acid reaction. The poorly drained basin soils are grey to dark grey, clay with prismatic or blocky structure and medium to strongly acid reaction. The very poorly drained basin clays which remain saturated throughout the year, have a strongly reduced colour and near neutral reaction.

Landscape in the Young Surma-Kushiyara floodplain is criss-crossed by numerous cut-off channels, eroded levee-remnants and broader basins giving an impression of an undulated topography. The major soils on the ridges are grey to olive grey, loams to light clays, sometimes stratified from the surface or from below the plough layer. The ridge soils consist of a grey, massive, puddled loamy topsoil with strongly to medium acid reaction overlying a grey, mottled clay subsoil with prismatic or blocky structure. The poorly drained basin soils consist of grey clays having prismatic or blocky structure and medium to strong acid reaction. The poorly drained basin clays which remain saturated throughout the year have a reduced colour, near neutral reaction and massive structure.

2.4 Water (Hydrology)

The principal river governing the project's hydrology is the Kushiyara River. In the upper catchment of the Kushiyara, on the Barak River in India, a large multi-purpose water resource project is proposed: the Tipaimukh Dam Project. This project would change flows in the Kushiyara and would affect the Kushiyara-Bijna interbasin. Other projects impacting on the interbasin include the Kushiyara Dredging. Feasibility studies should refect these proposed developments (see *Northeast Regional Water Management Plan, NERP, September, 1993*).

2.4.1 Runoff Patterns

The major river systems affecting the interbasin are the Kushiyara-Kalni River system from the north and the Lungla, Karangi, and Khowai Rivers from the south (Figure 1).

The Barak River enters Bangladesh at Amalshid and bifurcates into the Kushiyara and Surma Rivers. A study of annual flows indicates that the proportion of flows to the Kushiyara and Surma Rivers has been remarkably constant through the period from 1964 to 1989; the proportion of the annual flow of the Barak into the Surma and Kushiyara was found to be 35% and 65%, respectively. The study also shows that the flow proportions during the dry season become 5% and 95% for the Surma and Kushiyara Rivers, respectively (reference *Page A-18, Interim Report, NERP,1993)*.

In addition to the Amalshid flow, the Kushiyara River has eight tributaries all originating in Tripura State, India and entering the Kushiyara from the south. Four of these tributaries enter the Kushiyara upstream of Sherpur gauging station (Sonai Bardal, Juri, Manu and Dhalai) and flow throughout the year. The remaining four tributaries (Lungla, Karangi, Khowai and Sutang) enter the Kushiyara-Kalni River around Madna. During the monsoon season water from these tributaries flows overland and enters the Kushiyara River around Ajmiriganj (for further details see *Specialist Study; Surface Water Resources of Northeast Region, 1993).*

Figure 4 shows the pattern of maximum annual discharges and maximum pre-monsoon discharges that have been recorded at Sheola. The pre-monsoon time period was defined as the interval between March 1 and May 15. The figure shows a trend of rising annual maximums between 1965 and 1991. There appear to be two sudden jumps in the record, the first occurring around 1967-68 and the second occurring around 1982. Pre-monsoon peak discharges have not followed this trend and have varied more randomly from year to year.

Monsoon water levels have changed over the last 40 years. The maximum annual water levels at Sheola have risen gradually by about one metre from 1950 to 1990. The maximum levels at Manumukh show a sudden rise of 1.0 m to 1.5 m around 1959. Levels are remarkably constant after 1960. By contrast, the annual maximum levels on the Kalni River at Markuli have decreased over the period 1951-91 by approximately one metre. This decrease is probably due to the reduction in discharges in the Kalni River caused by the shift in the Surma River towards the Baulai River. Water levels at Sheola, Manumukh/Sherpur, and Markuli over the period 1950 to 1991 are given in Figure 5.

The pattern of pre-monsoon flooding at Sheola, Sherpur and Markuli is fairly consistent. There have been several periods (1957-58, 1964, 1973, 1977, 1980, 1983 and 1990-91) when the maximum pre-monsoon level has approached the maximum monsoon level. Maximum pre-monsoon levels have risen by an average of about two metres at Markuli and by about one metre at Sherpur since 1965.

Minimum water levels have risen progressively by about 1.5 m since the mid-1960's (Figure 5). This is possibly due to channel aggradation in the lower reaches of the river (for details, see Specialist Study, *"River Sedimentation and Morphology" Draft Final Report, May 1993, NERP*).

During the pre-monsoon season, the Kushiyara spills through the Bibiyana offtake which in turn flows to the project area through the Singli Nadi and its branches. Spilling also occurs in the reach below the confluence of Bibiyana and Suriya Rivers during the pre-monsoon season. Local people have stated that the Kushiyara River was breached at Kaiyardhala in April, 1993 and that boro crops were damaged in Matikata and Mokar Haors. The Shaka Barak River which originates just upstream of Sherpur also spills to the project area both during pre-monsoon and monsoon seasons. At the Habiganj Seminar and during field visits it was reported that the Kushiyara River spills almost every year during the pre- and monsoon seasons in the reach between Sherpur and Ajmiriganj (refer to the *Proceedings of the Habiganj Seminar, April, 1993, NERP*).

The Lungla River originates within Bangladesh and flows northwards to Hail haor where numerous small tributaries add to the Lungla flow. Further north, at Terapasha, Lungla River joins Bijna River, follows a southwesterly course for 20 km to its confluence with the Karangi River, where it turns westward and is called Ratna River. It follows a circuitous route for 25 km to its confluence with the Kalni near Madna. Between Terapasha and the Karangi confluence numerous distributaries take off from the Bijna River into a complex network of minor channels which ultimately flow to the Kalni between Markuli and Madna. Local people have reported that many of these minor channels spill during the pre- and monsoon seasons and cause substantial damage to boro and monsoon crops.

The Karangi River originates in India and flows to the Lungla - Bijna system about seven kms northeast of Habiganj. The Karangi has a few small tributaries. Reportedly large spills from the adjacent Khowai River enter the Karangi River. The Khowai River below Habiganj spills both during the pre-and monsoon seasons and damages crops in the Ratna River basin.

NERP hydro-morphological studies show that flows in the southern rivers (Lungla, Karangi and Khowai) have increased significantly from the 1980's (reference Specialist Study, *"Surface Water Resources of Northeast Region", NERP, May 1993*) and are impacting adversely on the project area.

There is a wide range of discharges for the rivers in the project area (Table 2.1). The daily discharge for the Kushiyara River at Sherpur varies from about 46 m^3/sec to 3950 m^3/sec. Flood discharges and water levels for various return periods for the pre- and monsoon seasons for the Kushiyara River and its tributaries are given in Tables A.3 and A.4. Mean monthly discharges and water levels are presented in Tables A.5 and A.6.

2.4.2 Flooding

The Project area experiences two types of floods, the pre-monsoon flash floods occurring from March to May and seasonal monsoon floods occurring between June and October and damaging aus and aman crops. In some years the flash floods also appear in the post-monsoon season from October to December.

Peak pre-monsoon and monsoon water levels for various return periods at six gauging stations are presented in Table A.4. Average water levels for these six stations are presented in Table 2.2.

Table 2.1: Recorded Mean Daily Discharges in m^3/sec

River	Station	Range of Daily Discharge			Period (Years)
		Minimum	Mean	Maximum	
Kushiyara	Sheola	27.7	681.7	2960	27
	Sherpur	45.6	1101.2	3950	10
Lungla	Motiganj	< 1	8.7	333	14
Karangi	Sofiabad	< 1	8.1	500	23
Khowai	Shaistaganj	0.8	36.4	1050	27

Source: NERP

During the pre-monsoon season about 57,000 ha (57% of the gross area) are inundated by the 1:2 year return period flood. The inundated area increases substantially for higher return periods, ranging from about 63,000 ha for the 1:5 year flood to about 75,000 ha for the 1:10 year flood (Table 2.3).

During the monsoon season, about 96,000 ha (96% of the project area) is inundated by floods having a 1:2 return period. About 64,000 ha (64%) is flooded to depths exceeding 1.8 m (Table 2.3). Even in an average year (1:2 return period), monsoon flooding becomes covers almost the entire project area.

Table 2.2: Peak Water Levels (m,PWD)

Flood Condition	Return periods			
	1:2	1:5	1:10	1:20
Pre-monsoon	5.38	5.84	6.11	6.28
Monsoon	7.48	7.75	7.94	8.12

Source: NERP

Table 2.3: Flooded Areas

Flood Condition	Return Period	Non Flooded	Flooded Area (ha)			
		< 0.3 m	0.3 to 0.9 m	0.9 to 1.8 m	> 1.8 m	TOTAL
Pre-monsoon	1:2	43000	30000	19000	8000	57000
	1:5	37000	24000	29000	10000	63000
	1:10	25000	25000	30000	20000	75000
Monsoon	1:2	4000	12000	20000	64000	96000
	1:5	3000	7000	19000	71000	97000
	1:10	1000	7000	10000	72000	99000

Source: NERP

2.4.3 Drainage

The Project area mainly drains to the Kushiyara-Kalni River through the Bijna-Gangajuri-Ratna and Singli-Lokhchara-Old Kushiyara systems (Figure 1). Apart from the flow from the Lungla River, the Bijna-Gangajuri-Ratna system collects most of the accumulated rainfall runoff through the many collector drains located on the left bank of this system. Local people reported that sediment deposition has occurred in this channel at several locations particularly around Terapasha and below Baniachong thana and that the depth and duration of pre-monsoon flooding has increased.

Sediment deposition has occurred at the outfall of the Singli-Lokhchara-Old Kushiyara system causing pre-monsoon drainage congestion. Previously this system drained to the Kushiyara-Kalni River north of Ajmiriganj. Now the entire drainage load is initially collected in the lower depressions in the north of Baniachong thana, and then drains to the Ratna River through Sutki River and Jhingari Nadi. Local people stated that the channel sections of Jhingari Nadi and Sutki River are not adequate to carry this additional drainage load and consequently depths and duration of flooding have increased. Local people also said that before Bibiyana River channel avulsion, a substantial area drained to the Bibiyana River. Now there is no drainage through the Bibiyana River due to siltation of the river channel bed. They requested that all the major drainage channels be re-excavated. Information gathered from the field studies was confirmed at the Habiganj seminar.

2.4.4 Water Bodies

Open water bodies

About 96% of the project area (96,000 ha) is inundated by monsoon floods to a depth of greater than 0.3 m, of which 3.4% (3257 ha) is beels (Table A.7). About 57% of the area (57,000 ha) is under water during the pre-monsoon period. There are over eight haor complexes within the project. The larger permanent water bodies are: Chardoar Beel, Chatal Haor, Baragop Beel, Piper Haor, Haitola Haor, Nalai Gang, Barasakhwa Beel, Gangajuri Haor, Kumaria Beel, Bara Beel, and Beri Beel. Most of the channels which flow to and drain the haor systems are the spill channels of the Kushiyara and Bijna Rivers. The more important channels are: Phumer Khal, Paharpurar Khal, Dair Khal, Ommarpurar Khal, Boalir khal, Rouailar Khal, Nagar Khal, Kausi Nadi, and Bardair Gang (Figure 6). Most of the khals are seasonal. The size of these water bodies is decreasing due to siltation and human encroachment.

Closed water bodies

In addition to the open beels and khals there are about 8,850 ponds and ditches which are used for fish stocking and other household purposes. The ponds have a total area of about 700 ha. Most of the ponds are inundated during the high monsoon floods (Table A.8).

2.4.5 Surface Water Availability

Surface water availability for irrigation (80% dependable low flow) for the months of January, February, and March is presented in Table 2.4. Available flow for the Kushiyara River for the critical month of March is about 44.0 m^3/sec. There is negligible flow in the Lungla and Karangi Rivers during the critical month of March and there is little opportunity for additional surface water irrigation from these rivers. For the Kushiyara River, the present irrigation use and navigation requirements restrict any large scale irrigation abstraction. Navigation along the Kushiyara has already changed from serving large mechanized vessels to small and medium sized vessels. There are some LLPs along both banks of the Kushiyara River.

Table 2.4: Surface Water Availability

River	Location	Decade	Low flow, 80% dependable (m3/sec)		
			January	February	March
Kushiyara	Sheola	I	78.75	62.31	52.74
		II	72.30	55.88	44.08
		III	65.97	56.91	56.57
Lungla	Motiganj	I	0.92	1.06	0.70
		II	0.61	0.67	0.69
		III	0.35	0.82	0.58
Karangi	Sofiabad	I	0.79	0.72	0.62
		II	0.76	0.67	0.55
		III	0.73	0.60	0.76

Note: Decade-10 day period.
Source: NERP

2.4.6 Ground Water

Based on MPO (WARPO) data the estimated usable ground water recharge within the project area is 148 Mm^3. Of this, about 108 Mm^3 is estimated as being accessible by DTW force mode technology. Suction mode STW technologies are not suitable due to aquifer constraints, but about 27 Mm^3 could be withdrawn by deep-set STW (Table 2.5). About 80% of the total ground water resource potential is located in Baniachong and Nabiganj thanas (Table A.9).

Table 2.5: Estimated Ground Water Recharge

Mode	Usable Recharge (Mm^3)	Available Recharge (Mm^3)
STW	1.10	0.97
DSSTW	37.40	27.20
DTW	148.00	108.40

Source: MPO (WARPO)

2.5 Land/Water Interactions

2.5.1 Siltation

Serious siltation occurs at the offtake of the Shaka Barak River and due to this, the river only flows during the peak pre-monsoon and monsoon seasons.

Serious siltation has also taken place at the offtake of the Bibiyana River and as a result the river only flows during peak pre-monsoon conditions and during the monsoon season. The major avulsion that occurred between 1952 and 1963 on the Bibiyana River, downstream of Sherpur, is an example of the kind of periodic channel switching that occurs as a result of channel aggradation. Substantial aggradation of the Kushiyara-Kalni channel bed has occurred between 1963 and 1988 in the reach downstream of Ajmiriganj. Most of this aggradation has developed since 1975. Office studies of historic data show that bed levels have risen by up to 5 m near Ajmiriganj. Independent estimates were obtained from residents of Ajmiriganj. Their estimates of channel infilling ranged from 4.5 m to 6.0 m over the last 15 to 20 years, which are consistent with the values obtained from the BIWTA sounding charts. Aggradation rates decline downstream from Ajmiriganj and bed levels have remained virtually unchanged over the last 30 years at Madna. Therefore, aggradation has developed in the form of a 50 km long "wedge" between Ajmiriganj and Madna (for details refer to the Specialist Study, *"River Sedimentation and Morphology, Draft Final, May 1993, NERP*).

Intensive siltation takes place in various khals and beels in Ajmiriganj, Nabiganj and Baniachong thanas: in the Old Kushiyara channel bed, Ratna River, Mokar Haor, Puber Haor and so on.

Siltation affects homesteads, roads, fishery resources and causes drainage congestion which has intensified flooding during both pre-and monsoon seasons.

2.5.2 River Erosion

River bank erosion and breaching of embankments of the Kushiyara River in the reach between Markuli to Ajmiriganj are more intense now and have occurred regularly in recent years. In the remaining reaches of the Kushiyara-Kalni River system there is less river erosion and breaching of embankments.

2.5.3 Crop Damage

Crops are damaged by floods, drainage congestion, hailstorms, cyclones, pests, and so on. Data on damage due to floods and drainage congestion was collected from the field and cross checked with the results from hydrologic analysis.

Crops damaged in Kushiyara-Bijna Interbasin area include local and high yielding varieties of boro rice in the reproductive phase, and local varieties of broadcast aman in the early vegetative growth phase. The crops are submerged in the pre-monsoon season when rain falls in the catchment and there is a sudden rise in water level. The extent of damage depends on the growth stage of the crop and the duration of submergence. When the crops are submerged by a sudden rise in flood levels, the farmers manage to collect the partially matured panicles of local and high yielding varieties of boro rice from underneath the water. There is a decrease in the yield level of crops in the damaged areas. Local varieties of broadcast aman seedlings are damaged when they are submerged before the plants are able to elongate with the gradual rise of flood levels.

Local varieties of transplanted aman rice are damaged by floods and drainage congestion in the monsoon season. The damage takes place mostly at the vegetative growth stage and lowers yield levels.

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2.6 Wetlands and Swamp Forest

2.6.1 Natural Wetlands

There are eight important wetlands situated within this project. Each of these wetlands consist of several perennial beels. The wetlands are: Puber Haor, Chatal Haor, Mokar Haor, Dabhanga Haor, Matikata Haor, Haitola Haor, Medarkandi Haor, and Abdullahpur Haor (Figure 7). The total area of permanent water bodies (beels) is about 3,257 ha, which includes the important wetlands and many other smaller beels.

The characteristics of these wetlands relate on their location. The wetlands which are located on the eastern side of the project, such as Puber Haor, are flat and shallow and have a small permanent water body. This provides a good habitat in the monsoon season for numerous submerged and rooted floating annual plant communities. But high human interference through encroachment of paddy fields inside the wetland makes the area unsuitable for both wild flora and fauna. The use of water from beels for winter irrigation lowers the water levels and exposes the land making it inappropriate for perennial wetland plants.

There are four major wetlands where flooding is more severe: Chatal, Mokar, Haitola and Medarkandi Haors. All of these haor complexes are large and include many perennial beels. The vast floodplains with deeper pockets of water provide a very diverse habitat for wetland flora and fauna. In the deeper areas, because of deep flooding and high wave action, floating plant communities can not survive in the monsoon season. But submerged plants grow very well particularly at the time of water recession. In the shallow floodplain floating plant communities grow profusely but sedge/meadow is the most important plant community here. The wetlands suffer from heavy human interference and almost all the possible land has already gone under rice cultivation.

There are three large haor complexes, the Dabhanga Haor, Abdullahpur Haor, and Matikata Haor which remain deeply flooded in the monsoon season and cannot support much natural vegetation. With the recession of water, plant communities rapidly start growing and spread over most of the area. The most important wetland plant community of the area is the sedges/meadow, which produce a large volume and many different species of valuable grasses. These grasses are grown on very low land, and at the border of the perennial water bodies where residual moisture remain throughout the dry season. Although human interference is less in this area, encroachment is a problem. Most of the land where water is available for irrigation is under rice cultivation.

Wildlife is rare in most of the area because of habitat degradation. All the larger mammals have disappeared. The most common wildlife now are smaller mammals like otters, rats, and cats. There are larger concentrations of waterfowl at the larger haor complexes, mostly on the western side.

2.6.2 Swamp Forest Trees

There are no major swamp forest plots within the project area, but there are many smaller forest patches with a few trees. Individual species from the forest patches can be found in homestead groves.

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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)	84,000
Homesteads	1,450
Beels	3,257
Ponds	700
Channels	4,950
Hills	-
Fallow[1]	3,953
Infrastructure[2]	1,690

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

Settlements
Villages are mainly found along the road sides in higher areas and along the levees of rivers, specially in the low-lying areas. Homesteads are constructed inside the flood plains where land elevation is higher. The more densely settled areas include the marketing centres, thana headquarters, river banks, and road sides. Settlements in the flood plain kanda tend to be sparsely scattered. In the south western haor areas where land elevation is very low, settlements are extremely sparse, especially in the west of Baniachong, Ajmiriganj, Mitamain, and Astagram thanas.

Flood Damage to Housing
Generally, homesteads located on higher lands are not damaged by floods. This is the case, for example, in the north-eastern part of the project area in Baniachong and Nabiganj thanas. Monsoon floods, however, damage many homesteads throughout the low-lying haor areas of the south-western part of the project area: in Baniachong, Ajmiriganj, Mitamain and Astagram thanas. Homesteads in this area are often threatened by erosion from monsoon wave action. From field studies many villages in this part of the project area were found to be badly damaged mostly from monsoon wave action.

Coping Strategies
Throughout most of the project area homestead platforms are raised to one meter or more to avoid monsoon flooding. In low-lying areas, homesteads are raised up to three to five meters to avoid flooding. To protect homesteads against monsoon wave action, residents construct seasonal protection walls around their homesteads using soil, bamboo, and local grasses. Some of the well-off households construct brick walls around their homesteads for protection. The monsoon flood waters remain in the area, especially at lower elevations, for a period of about five to six months starting from late May or early June. If there is severe flooding, villagers generally make platforms inside their houses and shift their belongings to safer places. In such situations, the poor suffer the most.

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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	16.5	15.7	13.2	45.9	2.0	6.7	100
Female	16.7	16.2	11.8	48.5	1.6	5.2	100
Total	16.6	16.0	12.5	47.2	1.8	5.9	100

Source: BBS, 1981 Population Census

3.1.2 Demographic Characteristics

The total population of the project area is estimated to be 517,000 of whom 255,400 are female. The gender ratio is calculated to be 102 (males to 100 females). The total households are estimated to be 89,500 within 700 villages. The population increased by 22.5% between 1981 and 1991.

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Too high - why?

The cohort distribution for males is: 32.2% are below 10 years of age, 45.9% are between 15 and 54 years of age, and 6.7% are above 60 years of age. The corresponding distribution for females is 32.9%, 48.5%, and 5.2% (Table 3.2).

The average population density is 515 persons per km^2, with density ranging from a maximum of 604 persons per km^2 in Nabiganj thana to 417 persons per km^2 in Astagram thana. The average household size in the area is estimated to be 5.8 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 services, sanitation, and pure drinking water facilities.

Literacy

In the project area the literacy rate is found to be varied. According to the 1981 census, the literacy of the population at 5 years of age and above varied from 11.0% in Astagram thana to 19.2% in Jagannathpur thana. The corresponding figures for females were 6.2% and 14.7% respectively for the same thanas. The rate appears to have slightly increased over the last 10 years. According to the 1991 census, the literacy rate for all people of Habiganj, Sunamganj and Kishoreganj districts are recorded as 18.87%; 17.20% and 16.42% 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 varies from 12.2% in Astagram thana to 29.3% in Jagannathpur thana. Attendance for females in this age cohort in these two thanas varies from 9.8% to 28.0% respectively. Attendance for all youths between the ages of five and 24 is 12.1% and 22.2% for these thanas while the corresponding attendance for females is 8.2% and 18.5%.

The situation is worse for the rural poor. They can not afford to send their children to school. Moreover, many villages, especially in Astagram, Mitamain and Ajmiriganj thanas, have no primary schools. The average number of primary schools per 10,000 population is estimated to be 5.4 for Habiganj district, while such figures are 5.6 and 4.1 for Sunamganj and Kishoreganj districts. (BANBEIS, 1990).

Access to Health Services
The district headquarters of Habiganj, Sunamganj and Kishoreganj each have hospitals, and 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 195,780 persons and one doctor for every 23,377 persons in the district of Habiganj. One hospital bed is meant for 5,866 people in the district. A similar situation prevails for the other two districts (Sunamganj and Kishoreganj) of the project area. Immunization coverage of children below two years of age is high for the project area expect for Astagram and Mitamain thanas. The rate varies from 27% in Mitamain thana to 60% in Ajmiriganj thana (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 Habiganj, DPHE[1] reports the availability of one working tube well for 110 persons. In 1990, 85% of the households had access to potable water in the district. There are less tube wells per person in Sunamganj and Kishoreganj 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.

Sanitation
Specific information on sanitation facilities are 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. Women generally use kutcha latrines or defecate at a fixed spot which is protected by bamboo mats or betel nut leaves. The villagers of the haor areas of Ajmiriganj, Baniachong, Astagram and Mitamain thanas generally defecate in running water during the monsoon months. Sanitary latrines are uncommon in the village environment, except for the very well-off and educated families.

3.1.4 Employment and Wage Rates
Village employment opportunities are mainly limited to agricultural activities. The major crop in the area is boro. Employment for men mainly consists of transplanting which occurs between January and February, and harvesting which occurs in late April and May. Employment during aman cultivation is mainly limited to the labourers living in the extreme south-east of the project area.

The wage rates for male agricultural labourers varies from Tk 25 to 50 with two meals per day during peak agricultural months. During months when there is no agriculture work, the daily wage rate varies from Tk 15 to 30 with two meals. Employment is also available for poor fishermen to catch fish in the jalmohals during the winter season. In most cases, the wages are

[1] DPHE, 1991-92

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a fixed percentage of the fish catch: 35% - 40% of the catch value are reportedly paid as wages for fishing labourers.

During the months when employment opportunities in agriculture are limited, some poor people migrate to their respective district headquarters to work as rickshaw pullers, construction workers, or sometimes in household activities. Some poor migrate to Chittagong district for agricultural work and a few migrate to the Chhatak-Bholaganj area to work on stone collection and carrying. Employment opportunities for women are very limited in the area. Some poor women are employed by the well-off farmers on a seasonal contract with wage rates varying from six to 12 maunds of rice for six to eight winter months. A few poor women are also employed by the Rural Maintenance Program of CARE. Sometimes, a few women migrate to towns to perform household work, but their numbers are very limited. Many villages have no such migrant woman labourers.

Migration to outside countries, particularly to the UK, is common in Jagannathpur and Nabiganj thanas. However, such migration is considerably less in other thanas of the project area.

There is in-migration into the project area, mainly from Mymensingh, Manikganj, Pabna, Comilla, and Barisal. They come to the project area and stay seasonally to work on harvesting of rice crops and earth work. Fishing labourers from Nasirnagar thana (Brahmanbaria district) and Lakhai thana (Habiganj district) also migrate to the project area, especially to Ajmiriganj and Baniachong thanas, during the winter months to fish in the jalmohals.

3.1.5 Land Ownership Pattern

Land ownership is extremely skewed in the project area. More than 49% of the households are landless (with cultivable land less than 0.2 ha). Among the landless, about 2.2% 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 a further nine percent up to 58%. 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 25.0%, 18.1%, and 7.8% respectively.

The project area has a substantial amount of uncultivable land, which includes the deeper wetlands, kanda and community pastures. The price of agricultural land varies from Tk 5,000 to Tk 50,000 per ker (0.12 ha) depending on the demand and 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, generally share out their lands to tenants for operation. The share cropping system is that one-half of the produce for local varieties is retained by the land owners but they provide no inputs. For HYV rice, the land owners provide 50% of the cost of the inputs. The leasing out of land in kind (chukti) is declining in the area. However, leasing out of land with advance cash (rangjama) is practised in some cases. The usual rate for such arrangements varies from Tk 500 to Tk 1,000 per ker (0.12 ha) and this is paid in advance to the land owner for one season. Landless people have very little access to land under this tenurial arrangement due to their inability to provide the cash after which they must still purchase agricultural inputs.

3.1.7 Fishermen

Fishing is an important activity in the project area, and competition over the fish resource is increasing every year. There are mainly two types of fishermen: traditional and non-traditional, who catch fish for generating an income. Traditional fishermen live on fishing and have been engaged in the profession for generations. The jalmohals are generally leased out to them through their cooperatives. The richer fishermen among them act as financiers and appropriate much of the profit from the catch while the poor catch fish on a regular basis and sell out their share in the lease for their survival. Poor traditional fishermen also work as fishing labourers. There are an estimated 5,000 to 7,000 traditional fisherman households in the project area. Additional information on fishing practices is given in Section 3.5.

The non-traditional fishermen are mainly an emerging group from the landless and poor agriculturists. They fish in open water especially during the monsoon months and sell their catch. Such non-traditional fishermen are increasing and now nearly 30-35% of the households, especially from the east area, are reportedly engaged in catching fish.

Local residents also catch fish but should not be referred to as "fishermen". They catch fish for their own family's consumption and do not sell the fish. Sometimes, the rich among them lease the jalmohals to earn a profit from the catch and they may also act as financiers for fishermen cooperatives.

3.1.8 Situation of Women

Women's role in agricultural production is important, especially in post-harvesting activities. 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 in activities like gathering wild vegetables and collecting fuel. The village women generally work in the post-harvesting activities of rice crops, especially drying, winnowing, parboiling and storing of rice. Most women prefer working on homestead gardening and raising poultry/duck in addition to other common household works.

3.1.9 People's Perception

General

Local people's perceptions 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 would solve these problems. These were collected through personal interviews, group discussions and meetings with various cross-sections of people during the relatively short field work in the project area. Opinions and suggestions were also sought at three seminars which were held at the district headquarters of Habiganj, Sunamganj and Kishoreganj. Participants at these one-day seminars included the Honourable Members of the Parliament, District and Thana level officials, Union Parishad Chairman, representatives from village level organizations and NGOs. The problems and suggestions from the field work and the seminars are described below.

Problems

Flooding and drainage congestion were described as the major problems of the project area. Pre-monsoon flash flooding is seen as the most serious problem and is widespread in the project area, except for the extreme north-eastern parts of both Baniachang and Nabiganj thanas. The flooding mainly damages rice crops. Boro is affected almost every year and is either partly or fully

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damaged in many haors and beels by the pre-monsoon flash floods during April and May. These flash floods generally enter the area through various channels and tributaries from the major rivers — the Kushiyara and Bijna. Sometimes water overspills the banks of the major rivers and inundates the low-lying boro fields. The situation is further aggravated in the lower pockets as a result of intensive rainfall during the same period. Local people described this damage as occurring on a regular basis and with increasing intensity in recent years. The major entry points for these flood waters were identified as Shaka Barak, Bibiyana, Old Kushiyara, Kaiyardhala, Sutki, and Ratna Rivers. Reportedly back flows of the Kushiyara-Kalni flood waters through the Ratna River cause extensive damage in the low lying boro fields.

Aus and t aman seed beds are damaged by pre- and early monsoon floods in the north-eastern part of the project area near Sherpur (Nabiganj thana) and Terapasha (Baniachong thana). During June to September t aman is sometimes affected in these areas by monsoon floods which over spill mainly the banks of the Kushiyara and Shaka Barak-Bijna Rivers, and their tributaries. The flood waters generally last for seven to ten days in the upper areas and there are three to four such occurrences reported in every monsoon period.

Drainage congestion is reported as the second most important problem in the interbasin, especially on both sides of the Bibiyana River between Enayetganj and Markuli, and in a part of Ajmiriganj, Mitamain and Astagram thanas. Due to sand and silt deposition along the left bank of the Kushiyara River and siltation of the Kushiyara, Bibiyana and Bijna-Ratna River systems, and other smaller internal rivers and channels, flood water can not drain out in time for the start of boro cultivation. This delays transplanting of boro (local and hyv).

Damage to homesteads by monsoon wave action is reported as a serious problem, especially in the villages of the southwestern part of the project area in Baniachong, Ajmiriganj, Mitamain and Astagram thanas. Many villages are being quickly eroded and entire villages are threatened.

Poor fishermen stated that the prohibition of open water fishing by powerful jalmohal lease-holders was a major problem for them. Local fishermen were found to take more care of a leased jalmohal to ensure the sustainability of their fishery resource. Fishermen considered that dewatering jalmohals to harvest all the fish was a major cause of declining fish production. They also stated that roads and embankments in the flood plains obstructed the movement of fish and reduced fish production. Concern was expressed about fish migration in the project area from the Kushiyara and the Ratna Rivers because of the closure of some channels and smaller rivers. Local fishermen were also concerned about the loss of fish habitats and large scale deforestation in the flood plains.

Local people expressed their desire for navigation routes between the haors and the rivers. They did, however, accept that there could be no boat access from the Kushiyara River into the project area, except at Enayetganj. But people want boat access from the other external rivers (Ratna, Bijna Rivers) into the project area and they want internal boat movement within the project. If navigation facilities are not provided at critical points, for example at Shaka Barak, Bibiyana, Old Kushiyara, Sutki mukh and on various internal rivers, then embankments would most likely be cut during the early monsoon months.

Suggestions

Numerous suggestions were put forward by local people. While some of the suggestions were specific to very localized problems many were important at a larger scale. The most common suggestions are:

- Dredge the Kushiyara River so as to increase draught for navigation and provide rapid drainage for flash flood waters.
- Re-excavate the Bijna/Gangajuri/Ratna River from the town of Madna up to the Kushiyara River for improved drainage of pre-monsoon flood waters. Re-excavation is also needed for the Sutki and Jhingari Rivers.
- Improve the banks of the Kushiyara, Bijna, Ratna and Sutki Rivers to stop overspilling of pre-monsoon flash flood waters into the haors. In the northern part of the project area bank improvement is needed to prevent monsoon flood waters entering the area.
- Prevent the entry of flash flood waters through the Bibiyana and Old Kushiyara Rivers and of the back flow of water through the Ratna River from the Kushiyara.
- Construct sluice gates at Kaiyer dhala and Raniar khal to stop the entry of flash floods
- Construct walls to protect the most vulnerable villages of Baniachong, Ajmiriganj, Mitamain and Astagram thanas from erosion by monsoon wave action.
- Lease of jalmohals only to local fishermen.
- Stop leasing out the rivers so that rapid siltation is avoided. At present leaseholders put tree branches (pile fishery: katha) in the rivers and this accelerates sedimentation in and around these areas.
- Allow poor and subsistence fishermen to catch fish in the flood plain.
- Conserve enough fish habitat for the normal production of fish. Plant water resistant trees, such as hizol, and koroch in the higher flood plains and along the river banks.
- Identify the duars in the area and protect them for use as fish shelters.
- Select a few suitable jalmohals for use as fish sanctuaries and preserve them so that fish production can be increased.
- Stop the dewatering and overfishing of jalmohals.
- Provide facilities for boat traffic so that navigation routes can be maintained but that embankments need not be cut. At the same time river banks should be

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developed to stop overspilling and the entry of water on to agricultural lands. For submersible embankments in the flood plain, facilities for boat traffic should be provided to allow early monsoon navigation.

3.1.10 Local Initiatives

People stated that it is their traditional practice to organize local people to counteract crisis which arise as a result of flash floods and drainage congestion. Their main activity is to construct dams on various localized canals to stop the intrusion of pre-monsoon flash floods and thereby to protect the boro crop. Local groups also assemble to re-excavate canals to expedite drainage. This is generally done on a voluntarily basis by the villagers around a particular canal which is threatening their property. More recently the Union Parishad also allotted cash or wheat for this purpose.

3.2 Water Resources Development

3.2.1 Flood Control & Drainage

The existing water development infrastructure in the project area includes the Sutki River Embankment Project, Sutki River FCD Project, Jhingari Nadi Drainage and Irrigation System, and the Bashira River Re-excavation (Figure 1). These projects are described below.

Sutki River Embankment Project: The project concept is to protect the boro crop from pre-monsoon flooding along the Sutki and Daman Khal right banks. Project works consist of 33.8 km of submersible embankment with a design crest elevation of about 9.15 mPWD. The project has a gross area of 12,146 ha. The Sutki River right embankment was constructed over three years from 1957-59. Additional planned flood control and drainage works were never constructed. Over the years, various embankment reaches have been re-sectioned under the FFW program. The project is partly achieving its objective of protecting boro crops from pre-monsoon flooding. However, some flood waters still enter the area through open khals this is reportedly causing minor flood damage. The provision of regulators on the khals would most likely reduce flood damage.

Sutki River FCD Project: The project objectives are twofold: to protect the area from flooding from the Ratna and Sutki Rivers to the south and west; and to provide irrigation water for the boro crop by retaining water in the khals and beels. BWDB works consist of a two vent regulator, and re-excavation of 58 km of channels to improve drainage. Locally constructed works consist of nine kilometers of submersible embankments, and some field irrigation channels. The project has a gross area of 1,417 ha. Farmers state that pre-monsoon floods enter the area overland from the north and east, and as such, the project concept for flood control is incomplete. Currently, BWDB, Habiganj Division, propose that additional works be carried out including the following: upgrading the existing embankment, construction of submersible embankment along the remainder of the project boundary, and improvement of the existing regulator. The additional interventions suggested by BWDB, Habiganj Division, appear reasonable.

Jhingari Nadi Drainage and Irrigation System: The project was conceived to improve the drainage of low-lying beels and to enhance water availability for winter season irrigation. The project has a gross area of about 4,260 ha. The Jhingari Nadi canal is about 11 km in length and connects the Old Kushiyara River in the north with Ratna River in the south. The canal was excavated with FFW assistance in 1974-78 under the Government's Canal Digging Program. Field studies in the area indicate that the project served the purpose for which it was intended.

Recently, the project has been studied under the Systems Rehabilitation Program and further improvement for the Jhingari Nadi is proposed. The new project has been designed for a larger catchment area of about 8098 ha. However, extensive siltation has taken place in the Ajmiriganj area (see Section 2.4) and drainage patterns have changed considerably. Now the Jhingari Nadi is one of the major drainage channels in the area and any re-excavation Jhingari Nadi should be closely coordinated with the overall development in the Kushiyara-Bijna Interbasin.

Bashira River Re-excavation: The project was conceived to prevent pre-monsoon flooding, to provide efficient controlled post-monsoon drainage, and provide water retention for irrigation. The project area is low-lying and includes several beels and khals. It is bordered to the south and west by the Kalni and Bashira Rivers. These rivers have high banks which do not overtop. Water, however, enters the project area through smaller channels; namely, the Matikata and Islampur Khals, and the boro crop is damaged. The project has a gross area of 7,150 ha. The project infrastructure includes two regulators, each having three vents (1.5m * 4.5m), and re-excavation of about 15 km of river channel. Construction started in 1981-82 and was completed in 1987-88. The project concept appears valid but the in-operability of the wooden fall-board arrangement at the regulators reduces the project's benefits. The regulator design needs to re-assessed and replaced by a more practical arrangement - possibly by using steel vertical lift gates.

3.2.2 Irrigation

Surface Water

Present surface water irrigation coverage by LLPs and traditional modes is about 33,100 ha, based on AST, 1991. There are about 950 LLPs operating in the project area with different discharge capacities: 720 of the LLPs have capacities equivalent to 57 lit/sec. The total area irrigated by LLPs is about 16,450 ha. Most of the surface water irrigation is in Nabiganj, Ajmiriganj and Baniachong thanas (Table A.10).

Ground Water

There is very little ground water used for irrigation. Based on Agriculture Sector Team (AST) 1991 data there are 39 STWs, and 36 DTWs in the project area. The total area irrigated from ground water supplies is about 1,740 ha, of which 450 ha are from STWs, and 1,290 ha from DTWs. Ground water abstraction is about 10.8 Mm3 based on MPO estimated ground water irrigation duty. According to AST information, ground water irrigation occurs mostly in Baniachong thana (Table A.10).

3.3 Other Infrastructure

Outside of the Kushiyara-Bijna Interbasin there is a National highway (under the jurisdiction of the Roads and Highway Department) which runs from Habiganj to Sylhet. Feeder roads connect Habiganj to Baniachong and Nabiganj. The total length of existing feeder roads within the project area is about 43 km of which about 34 km is metalled. The elevation of these roads are probably at about the average annual flood water level and suffer damage almost every year.

There are about 100 km of main village roads in the project area which connect all the thana centres. Most of these roads are not passable during the monsoon season due to flooding. The flooded roads are damaged annually, with an average damage rate estimated at about 15% of the capital cost. This translates into an average annual flood damage of Tk 2.0 million.

3.4 Agriculture

The hydrologic regime, particularly flooding, determines which crop production practices are used in the project area. Present cropping patterns reflect the farmer's efforts to adjust crop production practices with the hydrologic regime. The area flooded in excess of 1.8 m (F3 land type) constitutes 62% of the cultivated area, while another 24% is flooded between 0.9 to 1.8 m (F2 land type). Most of these areas are also flooded early in the pre-monsoon season and the soils retain residual moisture for a part of the rabi season. The dominance of such a semi-aquatic environment for most of the year, has led to the emergence of rice as the single most dominant crop on these land types. Local boro is the only crop grown on most of the F3 land type. It is planted into standing water which remains after the recession of flood waters from the area. Then irrigation water is provided at later stages wherever available. Elsewhere, farmers depend on pre-monsoon rains. High yielding varieties of boro rice are grown on very limited areas — only if a water supply for irrigation is assured. Local varieties of broadcast aman are the dominant crop on F2 lands. Most of this is grown as a single crop except some small areas where the timely recession of flood water in the post-monsoon season permits growing of rabi crops in the winter. Depending on irrigation facilities and the start of flooding, high yielding varieties of boro rice are grown mostly as a single crop, and partly in sequence with transplanted deep water aman rice.

About 14% of the cultivated area is flooded up to 0.9 m (F0 and F1 land types). Rice based multiple cropping is practiced on these lands including local and high yielding varieties of aus in the first kharif season, and local and high yielding varieties of transplanted aman rice in the second kharif season. Production of potatoes and high yielding varieties of wheat is dependent on when the preceding crop is harvested. Rabi crops are grown in the winter with residual soil moisture, and in sequence with rice in the kharif season. These rabi crops include various pulses, oilseeds, spices and vegetables. Cropping patterns, by land type are presented in Table 3.3.

The agricultural production system is closely linked with farm family needs, storage and marketing facilities. Most farmers sell their agricultural produce in the village market immediately after harvest when prices are normally low. Lack of storage facilities and the need for cash compel them to do this. Later they buy back the same produce for family consumption at higher prices. It is estimated that only 20 to 25 percent of the production actually enters commercial markets. Private traders handle most of this.

Homesteads are an integral part of the farming system. Homestead vegetation varies depending on the size of the homestead area and vulnerability to flooding. Trees, namely mango, betel nut, bamboo, banana and so on are common providing fruit, fuel, and building materials. Homesteads vulnerable to floods have fewer trees. Most of the vegetables consumed by the family are produced in the kitchen garden, adjacent to the homestead.

Present level of input use in Kushiyara-Bijna Interbasin is low for local varieties and moderate for high yielding varieties of crops. Yield levels of crops vary depending on the level of input use and flood vulnerability. Hence yield data under damaged and damage-free conditions were collected and used. Crop production data has been generated separately for damage-free and damaged areas and is presented in Table 3.4.

Table 3.3: Present Cropping Patterns

Cropping Pattern	F0	F1	F2	F3	Total Area (ha)
	Area (ha)	Area (ha)	Area (ha)	Area (ha)	
b aman-fallow			14000 (70)	2592 ((5)	16592
fallow-l boro				46656(90)	46656
fallow-hyv boro			2000 (10)	2592 (5)	4592
b aus-wheat		600 (5)			600
b aus-potato	8 (5)				8
b aus-fallow-rabi	16 (10)				16
b aus-lt aman-fallow	16 (10)	3120(26)			3136
b aus-lt aman-potato		480 (4)			480
b aus-lt aman-rabi		1200(10)			1200
b aus-hyv aman	8 (5)				8
b aus-hyv aman-potato	5 (3)				5
b aus-hyv aman-rabi	16 (10)				16
lt aman-fallow	40 (25)	3600 (30)			3640
lt aman-potato	6 (4)	600 (5)			606
lt aman-rabi	16 (10)	2400 (20)			2416
hyv aman-wheat	5 (3)				5
hyv aman-potato	8 (5)				8
hyv aman-rabi	16 (10)				16
b aman-rabi			3000 (15)		3000
b aman-hyv boro			1000 (5)		1000
Total	160	12000	20000	51840	84000

Numbers within parenthesis indicate percent of cultivated area under the respective land types.

Table 3.4: Present Crop Production

Crop	Damage free area			Damaged Area			Total Prod. (mt)
	Area (ha)	Yield (mt/ha)	Prod. (mt)	Area (ha)	Yield (mt/ha)	Prod. (mt)	
b aus	5469	1.25	6836	0	0	0	6836
b aman	17092	1.75	29911	3500	1.45	5075	34986
lt aman	7478	2.15	16079	4000	1.75	7000	23079
hyv aman	58	3.95	227	0	0	0	227
l boro	32156	2.25	72351	14500	1.75	25375	97726
hyv boro	3092	4.55	14069	2500	3.25	8125	22194
Paddy			139473			45575	185048
wheat	605	2.05	1240				
potato	1107	12	13286				
pulses	1000	0.85	850				
oilseeds	3332	0.75	2499				
spices	333	2.25	750				
vegetables	1999	3.75	7497				

Source: NERP

3.5 Fisheries

3.5.1 Floodplain fishery

There are more than 100 important seasonal and permanent beels and channels within the project area, of which the following are the most renowned for fish production: Chatal haor, Baragop Beel, Piper haor, Haitola haor, Doba Beel, Dhalai Beel, Bibiyana River, Barasakhwa Beel, Gangajuri haor, Bara Beel, Beri Beel, Kodalia fishery, Old Kushiyara River, and so on. During the monsoon season, water from the Kushiyara and Bijna Rivers flows into the project area through open khals, spill channels and by overtopping the river banks. In most cases beels are interlinked to each other by narrow channels which allows fish better movement for spawning and grazing.

Except for a few jalmohals (such as Beri Beel which is under NITIMALA, Nabiganj), most of the large and renowned jalmohals are leased by a very few rich influential persons, usually for a period of three years. They generally reside outside the area and appropriate the profits from the catch. This system deprives the local fishermen of access to the fisheries resources. Neither is there much opportunity to serve as labourers for the final catch as fishermen from outside the project area are generally hired for this purpose. Sometimes rich people have obtained the lease of the jalmohals by showing "shadow fishermen organizations".

Conflicts and tension are common over the issue of fishing the jalmohals in the area, particularly between farmers and fishermen. The jalmohal leaseholders construct and maintain water retention dams on the beels' drainage canals, which prevents the timely boro cultivation in the peripheral zone of the beels. Annual beel fishing in mid-winter is also common and results in beels being completely drained to maximize the catch. Neither of these practices are in the interests of the farmers.

It was reported that leaseholders 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 leaseholders' control over the area needs to be further clarified as this will have a significant bearing on the operability of any proposed intervention.

3.5.2 Species present in the area

Of the 155 fish species in the region, about 60-70 species inhabit the project area. For several reasons, some important species like Mohashoal, Nanid, Pangas, Angrot, and Berkul are now almost extinct in the region. At present, Catla, Mrigel, and Ghagla are rare species. The most common fish species are listed in the Table 3.5.

3.5.3 Duar fishery

Duars, which are an indispensable part of a typical floodplain fishery, act as a refuge for the large mother fish during the winter season. These fish then migrate to a suitable spawning ground for breeding when water levels begin to rise. There are 36 duars in and around the project area, of which 29 duars are in the Kushiyara River, six duars are in the Bheramona/Kalni River and one duar is in the Mora Kushiyara River (Table A.11)

Table 3.5 Major Fish Species in the Kushiyara Flood Plain

Large Fish	Small Fish
Catla, Rui, Mrigel, Kalibaus, Ghonia, Ilish, Boal, Air, Bagair, 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, Poa, Chanda, Golda chingri, Icha .

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3.5.4 Sources of fish and breeding

It is generally understood that early rain, thunder, flooding, temperature, grassy or rocky land influence the spawning of fresh water fish. If conditions are favourable, during the pre-monsoon and early monsoon season, fish migrate into shallow areas, usually from the beels to adjacent grassy areas, to rivers, to canals, and vice-versa. During this period migrations are usually made against the current. Localized breeding migrations are seen for the Boal, Ghonia, Pabda, Fali, Koi, Singi, Magur, Puti, Lati, Shoal, and Gazar species and some other smaller varieties fish in the Dabhanga haor, and Ajmiriganj area. Other than these, there are a number of smaller fish and large catfish spawning within the project area. The spawning grounds most well known to the local people are at Baragop and the Jalsuka area. It is reported that Baushir khal, Roailar khal, Koiar dhala, Paharpur Khal, and Old Kushiyara Rivers are the major in-migration fish channels to the project area.

It is generally considered that perennial water bodies with shallow floodplains which contain reeds are the potential breeding grounds for many species. The project area is still rich for "zeol mach". Larger Koi, Magur, Singi, Batashi, and Pabda are plentiful in the beels and channels. Within the project area (except for river duars and a few deep beels) species composition for capture fisheries is dominated by miscellaneous species (65-70%), followed by carps (10-15%), and catfish (10-15%).

The giant fresh water prawn, Golda Chingri (M. rogenbergii), is found in the rivers and floodplains of the Ajmiriganj, Nabiganj, Baniachong, Sullah, and Derai thanas (atleast 10% of the monsoon flooded area). The prawn has a high value for export and incountry consumption. Adult prawns migrate downstream to spawn in estuaries and the sea. Juveniles move back into the rivers to grow and mature. Duars also act as brood Galda Chingri refuge.

Ilish (Hilsa ilisha) is found in the Kushiyara, Bardair, and Ajmiriganj areas of the project (about five percent of the flooded area). The adults migrate from the sea far up the rivers to spawn. The Jatka (young) are caught around the Bardair of Ajmiriganj .

3.5.5 Production trends

According to NERP studies, fish abundance is directly related to the flood duration, water depth and access to the flood lands. Fish production in the project area appears to have declined by about 20-30% over the last five years. The identified causes of fish decline are outlined below:

- Siltation of beels and rivers. Water depth and water hectare-months are declining. Beels in the Mokar haor near Nabiganj, Mora Kushiyara near Ajmiriganj, and Kodalia fishery near Jalsuka have been seriously affected by siltation.

- Overfishing and loss of fish habitat.

- Reduction of reproductive fish stock due to the indiscriminate use of some fishing gear (current jal, kona ber jal, and so on).

- Increased fish mortality due to fish diseases caused by water pollution in the beels, particularly during the months of December and January.

- Construction of local dikes on the spill channels of the Kushiyara River and the regulator on the Shaka Barak have restricted fish migration to and from Bara haor, Mokar haor, and Gungajuri haor during flooding (at the time of spawning migration).

- Rapid deforestation (of trees and reeds) on the floodplains which has reduced fish food organisms and breeding places.

- Reduction of fish habitat by encroachment of agriculture onto the fish producing beels.

- Leasing of smaller beels, short term leasing, and the lack of security have encouraged overfishing through complete dewatering of beels. Previously most of the smaller beels were controlled by the villagers, and part of the overwintering stock was maintained in the beels.

- Lack of proper extension services for the pond owners to develop culture based fish farming in the existing ponds.

While no real estimates have been made of overall fish production for the project area, the estimated production is about 6450 tonnes per year (see Table 3.6).

3.5.6 Fishing practice

Floodplain
Open water fisheries are the major source of fish in the area (floodplain 57%, Beels 27%, Riverain 8%, and ponds 8%). Subsistence fishing occurs mainly during the flooding period and large-scale beel and duar fishing takes place from December to March. Except for a few pile fisheries, most beel and duar fishing is carried out on an annual basis.

The most common fish production method in the area is katha. Tree branches and bushes are placed on the bed of the rivers and beels to increase fish food supply and provide shelter for fish. During the dry season, fish stay in the katha and are easier to catch. Hizal, koroch, Am, Bot, Jarul, and Shawra tree branches are used in the area for katha. In all cases bamboo stakes are used to fence the katha to prevent it being swept away. Kathas are installed when the water recedes (August and September) and are harvested in January to March.

Closed Water
Pond fish culture practices are being developed mainly through extension programs. At present most pond owners in the project area release an uncounted number of fingerlings into their ponds without undertaking other basic management activities such as predatory and weed fish eradication, aquatic weed eradication, and regular application of feed and fertilizer. Monitoring the growth and health of the fish is not done. Fish are usually harvested during the dry season.

3.5.7 Present Fisheries Resource Development

Fish processing & marketing

A small portion of the catch is processed and exported. There is one processing plant in the project area: the Ajmiriganj Fish Industries Ltd, at Ajmiriganj. The plant started operation in 1972. The processing plant has a freezing capacity of four tonnes per day. The ice plant has a capacity to produce ten tonnes of ice per day. The plant exported 262 tonnes of fish in 1992, of which about 70% was harvested in the project area. There are four ice plants in the project area which are used for fisheries.

Table 3.6: Present Fish Production

Types of water body	Area (ha)	Rate of Production (kg/ha)	Total Production (mt)
Beel	3257	410	1335
Floodplain	83,840	44	3689
Pond	700	800	560
Channel/river	4950	175	866
Total			6450

Source: BFRSS

Sun-dried (Sutki) and fermented fish (Sidal) are the most common forms of processed fish produced in Ajmiriganj, Nabiganj, and Baniachong. Both the products are marketed to other parts of Bangladesh from November to May.

3.6 Navigation

Kushiyara River, which follows the north-western boundary of the basin, is navigable year-round. It is classified by the BIWTA as a Class I navigation route. The important places/landing centres are Sherpur, Enayetganj, Markuli, Ajmiriganj, and Madna. The Shaka Barak-Bijna-Ratna River was previously navigable from its mouth near Sherpur to its outfall near Madna.However, siltation has taken place in many sections of the river and there is very little water for navigation in the upstream section during the winter months. In the downstream section, the river remains navigable year-round. Siltation has taken place at the upstream sections of the Bibiyana and the Old Kushiyara Rivers and they are not navigable in the dry season. There is too little flow in the Sutki River for winter navigation. However, all these rivers serve as important navigation routes in the monsoon season. Some of the internal rivers, including the Sutki River, and a few local channels become navigable during the pre-monsoon period and are used for the transportation of boro rice.

The entire village road communication system in the project area is submerged during the monsoon months and boats are the only means of transportation. At present small and medium-sized engine boats are commonly used for about six months the year. Many of the residents of the area, especially in the south-western area, perform their daily works outside their homes using small-sized country boats during the monsoon months.

Previously water transportation was the major form of communication in the project area, and all the major rivers were navigable during the winter months. In recent years, the water transport network has been disrupted due mostly by siltation in the rivers, channels, and flood plains.

3.7 Wetland Resources Utilization and Management

The most important use of natural wetland products is as a thatching material. Mostly its use is confined to the deeply flooded areas. There are two different uses: one is for matting for the protection of homesteads from wave action, and the other is for the roof and panels of houses and as mats. The species used for protecting the homesteads is *Hemarthria protensa* (chilla) and the species mostly used for other purposes are *Vetiveria zizanioides* (binna), *Sclerostachya fusca* (ikor), *Phragmites karka* (khagra) and *Clinogyne dichotoma* (murta). These species generally grow on the borders of the perennial beels. The growing area is estimated very roughly at about 1,000 ha and yields are estimated at about Tk. 150 $ha^{-1}year^{-1}$. As a result, the gross estimated total value could reach Tk. 0.15 million $year^{-1}$. The estimated employment in gathering this material is about 0.002 million md $year^{-1}$, requiring 2 md ha^{-1}.

The next important use is fodder. The people of the western area are dependent on the wetland products for cattle feed, particularly during the monsoon season as flood waters cover most of the grazing land at that time. People from the shallowly flooded area also depend of plants for green fodder. Plants such as *Nymphaea* sp. (shapla), *Nymphoides* sp. (chandmela) and other available grasses are commonly used. Most of the people collect their own requirement by themselves and quantification of the real economic value is difficult to estimate. Estimation is done mostly on the replacement value and on the data collected in other projects. The plants mostly grow on F3 land which remains fallow in the summer. The estimated area is about 55,000 ha, the estimated yield is about Tk. 40 ha^{-1}, and the estimated gross total value is about Tk. 2.2 million $year^{-1}$. The estimated employment in gathering the plants is about 0.055 million md $year^{-1}$, resulting 1 md ha^{-1}.

Another important use of these resources is fuel wood. However fuel wood around the homesteads is becoming more scarce. Swamp forest trees other than Hizal are the most demanded fuel wood in these wetlands. Other woody shrubs and grasses are also used for fuel. The saplings of swamp forest trees are damaged due to the scarcity of fuel wood.

Other uses of the wetlands are:

- Food material. Mostly from *Nymphaea* sp. (shapla) and *Aponogeton* sp. (ghachu).
- 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.

4. PREVIOUS STUDIES

There have been no previous studies. There was, however, a project identified called the Kushiyara Left Embankment Project, which would impact on much of the proposed project area was conceived by Moulvibazar Water Development Division-II, BWDB in 1991. The project is located in the eastern part of the Kushiyara-Bijna Interbasin Project and is bounded by the Nabiganj-Kazirgaon road to the west, Shaka Barak River to the southeast and the Kushiyara River to the north.

The project concept was to provide full flood control, drainage and irrigation to facilitate hyv boro and aman cultivation. The proposal includes 39 km of full flood embankment along the periphery of the project area, re-excavation of 10 km of drainage channels, and installation of five drainage regulators.

The Project Report was submitted in the standard format of BWDB, (Proforma A1) to the Chief Engineer, Northeastern zone, Dhaka for its inclusion in the Second Small Scale Flood Control, Drainage and Irrigation Project. The project has not yet been approved for implementation.

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5. WITHOUT-PROJECT TRENDS (NULL OPTION)

Certain trends will be occurring in the area. These trends provide some indication of what the future in the project area will be like if no intervention is provided:

- Net population growth: About 1.8% per year. This is below the National average. The future population growth rate will be down from the yearly growth rate of 2.06% experienced over the past 10 years. By the year 2000 the population would be 622,000 and by the year 2015 the population would be 815,000.

- Openwater fisheries production: to assess project fish impacts (FW production minus FWO production), some assumption must be made about FWO trends. Observations of past fish production indicate that it is declining by 1-3% per year overall. Conversely, estimates of future production taking into account interventions to improve biological fisheries management suggest that great increases in fish production are possible. If the FWO trend is assumed to be negative, project negative impacts on fish production will be of significantly smaller magnitude than if the FWO trend is assumed to be positive. Lacking any way to decide between these two scenarios, it is assumed that FWO production will be equal to present production.

- Food grain production growth: 2.7 % per year. Current trends in agricultural production would continue in the absence of any intervention in the Kushiyara-Bijna Interbasin area. There would be no change in area under different land types except that siltation would occur on some F3 land type. The area flooded by less than 0.3 m is very limited and the area of high yielding varieties of aman would not expand. Local varieties of transplanted aman area would be restricted to the limited area under F1 land type. Local boro would continue to be dominant on F3 lands. But continued siltation may lead to some of the local boro rice being replaced by broadcast aman due to a lack of water in the dry season. Farmers confirmed that they were growing local varieties of broadcast aman in these areas mainly due to a shortage of water in the dry season.

  There would only be a marginal expansion of irrigation facilities as there is limited water available in the dry season. For these newly irrigated lands high yielding varieties of boro would replace local boro and broadcast aman in some areas. The high yielding varieties of boro rice would continue to be exposed to damage by pre-monsoon floods. Before making any investments, farmers would use their judgement in selecting sites with the least possibility of flood damage.

  Future cropping patterns, assuming no intervention in Kushiyara-Bijna Interbasin, are presented in Table 5.1.

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Table 5.1: Cropping Patterns under Future Without Project Condition

Cropping Pattern	F0	F1	F2	F3	Total Area (ha)
	Area (ha)	Area (ha)	Area (ha)	Area (ha)	
b aman-fallow			12600 (63)	2592 (5)	15192
fallow-l boro				44064 (85)	44064
fallow-hyv boro			3000 (15)	5184 (10)	8184
b aus-wheat		600 (5)			600
b aus-potato	8 (5)				8
b aus-fallow-rabi	16 (10)				16
b aus-lt aman	16 (10)	3120 (26)			3136
b aus-lt aman-potato		480 (4)			480
b aus-lt aman-rabi		1200 (10)			1200
b aus-hyv aman	8 (5)				8
b aus-hyv aman-potato	5 (3)				5
b aus-hyv aman-rabi	16 (10)				16
lt aman-fallow	40 (25)	3600 (30)			3640
lt aman-potato	6 (4)	600 (5)			606
lt aman-rabi	16 (10)	2400 (20)			2416
hyv aman-wheat	5 (3)				5
hyv aman-potato	8 (5)				8
hyv aman-rabi	16 (10)				16
b aman-rabi			3400 (17)		3400
b aman-hyv boro			1000 (5)		1000
Total	160	12000	20000	51840	84000

Numbers in parenthesis indicate percent of cultivated area under the respective land types.

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Table 5.2: Crop Production Under Future Without Project Condition.

Crop	Damage free area			Damaged Area			Total Prod. (mt)
	Area (ha)	Yield (mt/ha)	Prod. (mt)	Area (ha)	Yield (mt/ha)	Prod. (mt)	
b aus	5469	1.25	6836	0	0	0	6836
b aman	16092	1.75	28161	3500	1.45	5075	33236
lt aman	7478	2.15	16079	4000	1.75	7000	23079
hyv aman	58	3.95	228	0	0	0	228
l boro	29564	2.25	66519	14500	1.75	25375	91894
hyv boro	6684	4.55	30412	2500	3.25	8125	38537
Paddy			148234			45575	193809
wheat	605	2.05	1240				
potato	1107	12	13286				
pulses	1060	0.85	901				
oilseeds	3532	0.75	2649				
spices	353	2.25	795				
vegetables	2119	3.75	7947				

The analysis of historical data shows that yield levels for individual varieties have not changed over the period of record. Most increases in production have been due to changes in variety. Without any change in the flood regime, levels of input use are not expected to change, and damage to different crops would continue. This would include local and high yielding varieties of boro and broadcast aman in the pre-monsoon season. Damage to local and high yielding varieties of transplanted aman through drainage congestion, specially on F1 land types, would continue. Crop production under future without-project conditions are presented in Table 5.2.

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6. WATER RESOURCES INFRASTRUCTURE DEVELOPMENT OPTIONS

6.1 Summary of Problems

The main problems of the area are:

- Floods and seasonal inundation over a major part of the area. Flooding of crops during the pre-monsoon and monsoon seasons causes yield reduction and limits the cropped area to the higher lands. In addition to the losses in agriculture, floods cause substantial damage to homesteads and roads;

- Major channel avulsions can take place. There was a major channel avulsion that occurred between 1952 and 1963 on the Bibiyána River down stream of Sherpur. This was due to channel aggradation in Kushiyara River.

- Severe siltation has taken place in the Bibiyana channel bed and many smaller channels. This siltation affects fisheries and causes drainage congestion, which increases flood risk; and

- Channel aggradation in Kushiyara River together with increased flood discharges in recent years cause frequent overtopping and breaches in the river banks and increased damage to crops and infrastructure.

6.2 Water Resources Development Options

Three options were considered for water resources development in the project area:

- partial flood control with submersible embankments;
- full flood control with high embankments; and
- a combination of partial and full flood control embankments.

Each of these options include drainage development (with nine drainage regulators), partial protection flood protection along the Bijna River, and extension of Sutki River flood embankments up to Baniachong-Nabiganj road.

6.2.1 Partial Flood Protection with Submersible Embankments (Option 1)

The project concept which was considered was to provide protection to boro crops from pre-monsoon flooding for a gross area of 100,000 ha by constructing submersible embankments along the left bank of the Kushiyara River from Sherpur to Ajmiriganj (Figure 8).

The submersible embankment crest elevation required would be 8.92 m PWD at Sherpur, 8.30 m PWD at Markuli and 6.09 m PWD at Ajmiriganj (all include a freeboard of 0.90 m). Design crest levels were established using 1:10 year return period water levels (refer Table A.4). The average height of embankment in the reach between Sherpur to Markuli is around 1.2 m while in the section from Markuli to Ajmiriganj it is over 1.7 m (Table A.12).

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The proposed plan protects boro crops, but it does not protect the monsoon crops particularly along the reach from Sherpur to Enayetganj where substantial areas are planted to monsoon crops. This area is densely populated. There is a difference in water levels of about one meter between pre-monsoon levels (1:10 year) and monsoon levels (1:20 year). During a people's participation meeting at Habiganj in April, 1993 (reference *Proceedings of the Habiganj Seminar, April, 1993, NERP*) and during field studies, local people requested that full flood embankments be provided along the left bank of the Kushiyara River.

The proposal was not studied further as it did not provide protection for monsoon crops or for the homesteads situated on higher lands.

6.2.2 Full Flood Protection (Option 2)

Full flood protection against flooding from the north could be provided to the area by constructing flood embankments along the left bank of the Kushiyara-Kalni River from Sherpur to Ajmiriganj (Figure 9).

Design crest levels of flood embankments at Sherpur, Markuli and Ajmiriganj would be 10.78 m PWD, 9.75 m PWD and 9.59 m PWD, respectively, including a free board of 1.5 m for a 1:20 year return period. Average height of flood embankments is about 2.8 m in the reach between Sherpur and Markuli while from Markuli to Ajmiriganj it is over 4 m.

Average water levels for various return periods with and without the Kushiyara-Kalni full flood embankments up to Markuli and Ajmiriganj are presented in Table 6.1. The table illustrates that full flood embankments beyond Markuli provide only marginal flood control benefits. For an average flood (1:2 year flood) average water levels are reduced by only 4 cm from 7.37 to 7.33 m PWD. For a flood with a 1:20 year return period water levels are reduced by 8 cm. Full flood control embankments beyond Markuli increase the cost of embankments by 56% and increase land acquisition costs by 17%. In addition, the maintenence of 4 m high embankments in the deeply flooded area will be costly. Hence Option 2 with full flood embankments extending to Ajmiriganj was not considered worthy of further study at pre-feasibility level.

Analysis of smaller units, particularly Area A1 in the northeastern corner (Figure 9), shows that substantial benefits could be achieved by providing full flood embankments up to Markuli (Table 6.2). These proposed full flood embankments would also protect the densely populated area along the Kushiyara River bank (homesteads and infrastructure). Optimization of embankments was reviewed (see Option 3 below).

6.2.3 Combined Full and Partial Flood Protection (Option 3)

The project concept considered in this option is to protect boro crops throughout the area and to protect monsoon crops over an optimized area. This option includes full flood control embankments in the eastern part of the project area; partial flood control embank-

Table 6.1: Peak Water Levels

Embankment Configuration	Return Periods	
	1:2	1:20
Without Embankment	7.55	8.18
Embankment up to Markuli	7.37	8.04
Embankment up to Ajmiriganj	7.33	7.94

Note: Levels in m PWD
Source: NERP

ments in the western part; and drainage improvements. Of the three options, this option was considered most appropriate and was selected for further analysis. The option is described in more detail and analyzed in Chapter 7 of this document.

Table 6.2: Flooded Areas for Area A1 (ha)

Embankment Condition	1:2 Year Return Period				1:20 Year Return Period			
	0-0.3 m	0.3-0.9 m	0.9-1.8 m	>1.8 m	0-0.3 m	0.3-0.9 m	0.9-1.8 m	>1.8 m
Without	200	1600	3700	3900	50	780	3700	5600
With	1700	3400	2600	1700	400	1600	4600	2800

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7. PROPOSED FLOOD CONTROL AND DRAINAGE PROJECT

7.1 Rationale

This plan provides for flood control and improved drainage. It will protect boro crops from pre-monsoon flooding on a gross area of about 57,000 ha. It will increase the flood free cultivable area from 3000 ha to about 6000 ha during the monsoon season. The plan also provides for the expansion of open water fisheries by re-activating silted channels as well as mitigating potential negative impacts on fisheries through the installation of regulators. Supplemental irrigation will be provided during the monsoon season along the left bank of the Kushiyara River. Roads and homesteads located along the left bank of the Kushiyara River will be protected from river flooding.

7.2 Objectives

The objectives of the project are:

- to reduce flood damage to boro and monsoon crops;
- to promote expansion of hyv rice crops onto the lower lands by reducing flood depths on these lands, improving internal drainage, and reducing the risk of early flooding;
- to promote expansion of hyv monsoon crops onto the higher lands by reducing the risk of flooding and providing irrigation inlets along the Kushiyara left bank for supplemental irrigation;
- to reduce flood damage to homesteads and infrastructure by river floods; and
- to increase dry season water surface area in the Bibiyana River, Kodalia Fishery and so on, through the installation of regulating structures to facilitate expansion of fishery resources.

7.3 Description

Protection against flooding from the Kushiyara River is provided by: 1) full flood embankments to prevent over bank spill from Sherpur to Markuli; and 2) submersible embankments from Markuli to Ajmiriganj to prevent pre-monsoon over bank spill. It is planned to leave the Kalni River reach unembanked from Ajmiriganj to Madna for navigation and fish migration. Development of the left bank of the Kushiyara River also includes the installation of regulating structures at the offtake of the Bibiyana River, Kaiyerdhala, Paharpur Khal and so on to improve fishery resources. Irrigation inlets are provided at strategic locations for hyv monsoon crops.

Protection against flooding from the Shaka Barak-Bijna River is provided by: 1) a control structure at the Shaka Barak River; and 2) submersible embankments and drainage structures along the Bijna River at strategic locations downstream of Terapasha to prevent pre-monsoon over bank spill. The project also includes extension of the existing Sutki River right embankment from its north end up to the Baniachong-Nabiganj road (Figure 10).

The project consists of:

- 48.5 km of full flood embankments
- 33 km of submersible embankments
- 9 drainage regulators
- 5 irrigation inlets
- re-excavation of 56 km of drainage channels

7.3.1 Flood Protection

Embankments
To provide flood protection for the area a combination of full flood and submersible embankments designed for 1:20 and 1:10 year return periods, respectively, are proposed.

The average heights of embankment along the Kushiyara-Kalni River for submersible and full flood embankments are 1.72 m and 2.8 m, respectively. The proposed cross section for both the submersible and full flood embankments for the Kushiyara-Kalni, Bijna, and Sutki Rivers is 4.27 m crest width, with side slopes of 1(v):2(h) on the country side and 1(v):3(h) on the river side.

Design embankment crest elevations are shown in Table 7.1. Design details are provided in Table A.12.

The alignment of Kushiyara-Kalni River embankment has been shown along the Kushiyara River based partly on the discussions held at Habiganj Seminar. There is ample scope to construct the embankment along the Bibiyana River. However an embankment along the Bibiyana River will not protect homesteads on the right bank of the Bibiyana. It is recommended that the proposed embankment alignment be further reviewed during feasibility level studies. The possibility of using the existing road from Sherpur to Enayetganj as a road-cum-flood embankment should also be further explored during feasibility level studies.

Table 7.1 Design Embankment Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Kushiyara-Kalni		
Sherpur	0.0	10.78
Markuli	44.0	9.75
Ajmiriganj	70.0	6.09
Bijna River		
Terapasha	0.0	7.14
Downstream of Terapasha	7.0	6.92
Sutki River Embankment	0.0-4.5	9.05

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 7.2 and 7.3.

7.3.2 Drainage

Following completion of the project, the drainage requirements of the project area will be greatly reduced since the present flood spills from the Kushiyara-Kalni, Shaka Barak-Bijna Rivers will be decreased, and consequently the outflow discharge will be smaller.

The existing natural drainage system of khals and beels, with some improvements, will be used for drainage of the project area. The project basin internal rainfall runoff will be evacuated through the two main drainage collectors of the project: the Bijna-Gangajuri-Ratna system in the lower basin and the Singli-Lokhchara-Jhingari-Sutki Nadi system in the upper basin.

Table 7.2 Pre-Monsoon Depth of Flooding (by 1:10 Year Flood before 15 May)

Flood Depth (m)	Gross Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	26,000	74,000
0.30-0.90	24,000	20,000
0.90-1.80	30,000	5,000
>1.80	20,000	1,000
Total	100,000	100,000

[a] These figures do not reflect cultivable land acquired for infrastructure. Production impacts of land acquisition are documented in Section 7.8.

Channels

The improvement works of the Bijna-Gangajuri-Ratna system include 11 km of re-excavation of existing channels at strategic locations around Terapasha, Baniachong road, and below Jhingari outfall. The improvement works in the upper basin include 25 km of re-excavation of the existing channels; mainly the Jhingari, Lokhchara, and Singli (Figure 10).

Table 7.3 Monsoon Depth of Flooding (by 1:5 Year Max Annual Flood)

Flood Depth (m)	Gross Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	3,000	6,000
0.30-0.90	7,000	15,000
0.90-1.80	19,000	23,000
>1.80	71,000	56,000
Total	100,000	100,000

[a] These figures do not reflect cultivable land acquired for infrastructure. Production impacts of land acquisition are documented in Section 7.8.

To eliminate water logging and improve local drainage, it is proposed to re-excavate about 20 km of lateral khals: Paharia Khal, Kairdhala and others. The Paharia Khal and Kairdhala will also be used for flushing, and their sections should be designed to match the discharge capacities of the regulators.

The design parameters of the main channels are: 1(v):1.5(h) side slopes; a longitudinal bed slope of 15 cm/km, and an elevation of 1.5 m PWD at the outfall of the Ratna River. The channel is designed to convey the annual flood flow generated by a 5-day basin rainfall with 1:10-year return period. Based on these parameters, preliminary bed widths are: Jhingari Nadi: 23 m, Lokhchara: 15 m, and Ratna below Jhingari Nadi: 60 m. For cost estimating purposes it is assumed that the volume of the re-excavation works is equivalent to about 50% of the required

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channel section. These are very preliminary designs which are to be updated during feasibility studies.

7.3.3 Structures

Regulators
There are three existing regulators in the project area: one is in good condition and the other two are inoperable. The two- vent (1.5 x 1.8 m) flushing and drainage regulator on the Baganir Bundh is in good operational condition (Sutki FCD Project); the other two regulators each have three-vents (1.5 x 4.5 m) and are on Matikata and Islampur Khals and are inoperable.

Construction of nine new regulators are proposed on major khals, mainly to allow fish passage: one six-vent (1.5 x 1.8 m) flushing regulator on the Shaka Barak River; one four-vent (1.5 x 1.8 m) flushing cum drainage regulator on the Bibiyana offtake; three two-vent (1.5 x 1.8 m) flushing cum drainage regulators on Old Kushiyara, Paharpur Khal, and Kaiyardhala; and four one-vent (1.5 x 1.8 m) drainage regulators at Roail Khal, Boalir Khal, Terapasha, and Markuli.

Irrigation Inlets
Five inlet structures are proposed along the Kushiyara River to provide supplemental irrigation in the northeast corner of the project area.

7.3.4 Expected Benefits and Achievement of Objectives

While the benefits expected from the project relate mainly to agriculture, there would also be a reduction in flood damage to homesteads and infrastructure such as roads.

Protection from floods in the monsoon season would bring about significant changes in area for different land types. The area under F0, F1 and F2 land types would increase with a corresponding reduction in area under the F3 land type. This would provide a wider range of options to farmers in choosing crops and enable them to increase the area under local and high yielding varieties of transplanted aman on F0 and F1 land types.

The F2 land type would continue to be dominated by broadcast aman with a potential increase in area under rabi crops because of drainage improvements. Protection from pre-monsoon floods would enable farmers to harvest local and high yielding varieties of boro rice. Local varieties of boro rice would still be dominant on F3 land, but some of this is expected to be replaced by high yielding varieties of boro rice in areas having irrigation facilities.

In making future projections it is assumed that future without project percentages of each cropping pattern would apply to the new area under F0 and F1 land types. So with an increase in area under these land types, the same percentage cropping pattern would be adopted over the larger areas. In F2 land type, the potential for irrigation development has been considered in projecting the hyv boro area. Cropping patterns under future with project conditions are presented in Table 7.4.

Protection from floods would reduce the damage presently incurred in different types of rice whose yield levels are expected to increase to at least the level other farmers are obtaining under damage-free conditions. In this case, historical yield data were considered and yields obtained under damage-free conditions were used as the future yield level. But it may not be possible to eliminate flood damage from such a large area. So it has been assumed that damage to different

Table 7.4: Cropping Patterns under Future With Project Condition

Cropping Pattern	F0	F1	F2	F3	Total Area (ha)
	Area(ha)	Area(ha)	Area(ha)	Area(ha)	
b aman-fallow			9200 (40)		9200
fallow-l boro			2300 (10)	37264 (85)	39564
fallow-hyv boro			5290 (23)	6576 (15)	11866
b aus-wheat		735 (5)			735
b aus-potato	105 (5)				105
b aus-fallow-rabi	210 (10)				210
b aus-lt aman	210 (10)	3822 (26)			4032
b aus-lt aman-potato		588 (4)			588
b aus-lt aman-rabi		1470 (10)			1470
b aus-hyv aman-fallow	105 (5)				105
b aus-hyv aman-potato	63 (3)				63
b aus-hyv aman-rabi	210 (10)				210
lt aman-fallow	525 (25)	4910 (30)			4935
lt aman-potato	84 (4)	735 (5)			819
lt aman-rabi	210 (10)	2940 (20)			3150
hyv aman-wheat	65 (3)				65
hyv aman-potato	105 (5)				105
hyv aman-rabi	210 (10)				210
b aman-rabi			4600 (20)		4600
b aman-hyv boro			1610 (7)		1610
Total	2100	14700	23000	43840	83640

Note: Numbers within parenthesis indicate percent of cultivated area under the respective land type

crops would continue though on a smaller scale. Future crop production for the with project condition is presented in Table 7.5. Cereal production is expected to increase annually by about 25,600 tonnes (13%) from 195,000 tonnes (FWO) to 220,600 tonnes as a result of the project, inclusive of the impacts of land use changes (see Section 7.8). Non-cereal production would increase to about 11,700 tonnes which is a 46% increase. This increase is mainly due to: shifts from broadcast aman to local transplanted aman, and local boro to hyv boro; and an increase in area under rabi crops resulting from drainage improvements in the post-monsoon season.

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Table 7.5: Crop Production under Future With Project Condition

Crop	Damage free area			Damaged Area			Total Prod. (mt)
	Area (ha)	Yield (mt/ha)	Prod. (mt)	Area (ha)	Yield (mt/ha)	Prod. (mt)	
b aus	7518	1.25	9398	0	0	0	9398
b aman	13910	1.75	24343	1500	1.45	2175	26518
lt aman	10994	2.15	23637	4000	1.75	7000	30637
hyv aman	756	3.95	2986	0	0	0	2986
l boro	39064	2.25	87894	500	1.75	875	88769
hyv boro	12976	4.55	59041	500	3.25	1625	60666
Paddy			208260			11675	218973
wheat	798	2.05	1636				
potato	1680	12	20160				
pulses	1478	0.85	1256				
oilseeds	4925	0.75	3694				
spices	493	2.25	1108				
vegetables	2955	3.75	11081				

7.3.5 Mitigation Measures Incorporated

To minimize the negative impacts on fisheries, particularly in the Kodalia fishery, and at Matikata and Mokar Haors, regulators are being incorporated to facilitate passage of fish. These regulators would be located at Old Kushiyara, Kaiyardhala, Paharpur Khal and Bibiyana offtake. Improvements to current structure designs would need to be made to ensure the functionality of some of these regulators for their intended purpose.

Also, to ensure appropriate post-monsoon drainage and to maintain a water linkage between the Kushiyara-Kalni River and the various wetlands in the lower half of the project area, the southern lower area is left unembanked and no structures are planned where the project area drains into the Kushiyara-Kalni River. In combination with the regulators mentioned in the previous paragraph, this is expected to ensure that the integrity of the wetlands are maintained. Afforestation is also proposed along the toe of the existing embankments and lowland forestry is proposed for the Kodalia fishery complex.

7.4 Operation and Maintenance

Under this development plan, operation and maintenance requirements would involve operating the flushing/drainage regulators provided for fish passage. In addition, maintenance of the flood embankments and the drainage channels would be required to assure effective flood control and drainage. An Environmental Management Plan, detailing actions necessary to achieve acceptable environmental impacts, will need to be prepared and costed as part of the feasibility study. An operators handbook would need to be prepared as part of the project design process.

7.5 Organization and Management

During the early part of the feasibility study process, a client group would need to be organized to oversee project development. These client groups would be composed of representatives from the local farming community, fishing community, and would include 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 being 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 and these designs, in the end, would require the approval of the client groups. The 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 but would be responsive to the client group described above. The general tasks include completion of final designs, preparation of tenders, pre-qualification of contractors, contract awards and construction supervision. The general management of BWDB activities would be under the Executive Engineer stationed in Habiganj. 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.

In summary, the organization and management of this project is partly dependent 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.

Bangladesh Rural Development Board (BRDB) is responsible for assisting with command area development through farmers' training and by organizing farmers 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.

7.6 Cost Estimate

Total project costs are estimated at Tk 365.1 million.

The estimates of land requirement and 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: land which was single cropped was estimated at Tk 120,000 per ha; land that could be double cropped was Tk 300,000 per ha; and, land suitable for homesteads and gardens (including high ridges along the rivers) was Tk 500,000 per ha. Earthwork costs are based on BWDB Schedule of Rates for Sylhet indexed to June 1991 prices. Structure costs are based on parametric costs developed for the Region, and are also indexed to June 1991 prices in accordance with the FPCO Guidelines for Project Assessment.

The summary of total costs is presented in Table 7.6 with details provided in Table A.13.

Table 7.6 Capital Cost Summary

Item	('000 Tk)
Structures	45,300
Embankments	48,200
Channels	47,600
Bridges	-
Buildings	2,500
Land Acquisition	110,400
BASE COST	254,000
Physical Contingencies (25%)	63,500
SUBTOTAL	317,500
Study Costs[1] (15% of Subtotal)	47,600
TOTAL	**365,100**
Net Area (ha)	83,640
Unit Cost (Tk/ha)	4,365

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

7.7 Project Phasing and Disbursement Period

Four 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 one and be completed in year two. Land acquisition should commence in year one, be implemented in phases preceding construction, and completed in year three. Construction activities should start in year one and be completed in year three. An itemized implementation schedule is shown in Table 7.7.

Table 7.7 Implementation Schedule

Activity	Year (% Completion)			
	0	1	2	3
Preconstruction Activities				
Feasibility Study	100			
Engineering Investigation	70	30		
Detail Designs		70	30	
Land Acquisition		30	50	20
Construction Activities				
Construction of Embankments		20	30	50
Excavation of Channels		30	30	40
Construction of Structures		20	40	40
Construction of Bridges				
Project Buildings		20	50	30

7.8 Evaluation

7.8.1 Environmental

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

Land Use

Land use changes are summarized in Table 7.8. A total of 368 ha of land (about 0.4% of the project gross area) will be required for embankments, drains, regulators, and project buildings. Of this:

- 358 ha will be taken from the cultivated area. Assuming average yields and that all is under rice, this corresponds to incremental cereal production foregone of about 790 tonnes per year or about 3% of total incremental cereal production. This impact is incorporated into the economic analysis.

- 10 ha will be taken from the homestead area. This is 0.7% of the total homestead area, which implies that 617 households or about 3500 persons will be displaced. Also, homestead agricultural production from these sites will be lost. Roughly estimating homestead agricultural production at Tk 1000 per decimal or Tk 200,000 per ha, this amounts to Tk 2 million per year.

Agriculture
The project is expected to facilitate annual cereal production to increase from 195,000 tonnes (FWO) to 220,600 tonnes (FW), an increase of 25,600 tonnes (13%), inclusive of the impacts of land use changes described above.

The cereal production increase implies a per person increase in cereal availability from 655(FWO) to 741 (FW) gm per person per day, an increase of +13% (Table 7.9), allowing 10% for seed, feed, and waste, and 65% for conversion of paddy to rice. Current Bangladesh average consumption is 440 gm per person per day.

Non-cereal production is expected to increase from 25,575 tonnes (FWO) to 37,300 tonnes (FW) (+46%). This results from a 3,360 ha increase in area cultivated to non-cereals from 8,170 ha to 11,530 ha and implies an increase in the availability of non-cereals from 86 (FWO) to 125 grams per person per day (Table 7.9).

Table 7.8: Changes in Land Use

Use	Change in area (ha)
Cultivated	-358
Homesteads	-10
Beels	-
Ponds	-
Channels	-
Hills	-
Fallow[1]	-
Infrastructure[2]	-

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

Openwater Fisheries Production[1]
The project is expected to impact on fisheries in four ways: some obstruction to migration, the floodplain will be reduced, the depth of the main drainage channels will be increased, and the dry season water surface area will be increased. The sign and magnitude of these impacts is provided in Table 7.9.

The proposed embankments will obstruct fish migration but since the lowest access routes are left open, the impacts will be much less severe than cases where an area is completely encircled by embankments. The rationale being that most important channels are 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).

There will be a reduction in the seasonally flooded area of the project by about 2300 ha (2.7%) during the monsoon season (Table 7.9). This is expected to reduce annual fisheries production by 101 tonnes.

The increase in depth of the main drainage channel will have a positive impact on fisheries production since it will improve the overwintering habitat and provide better migration routes. This combined with an increase in dry-season surface water area in the Bibyana River and other natural and artificial areas is expected to off-set fisheries losses due to the reduction in floodplain.

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[1] The model used to estimate impacts on fisheries is described in Annex D.

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Table 7.9: Fish Production Indicators

Regime	FWO (2015)		FW (2015)			
	Area (ha)	Production ('000 kg)	Area (ha)	Area Equivalent	Production Impact ('000 kg)	Net Value ('000 Tk)
Flood Plain	83840	3689	81540	81540	-101	-3330
Beels	3257	1335	3582	3582	+133	7959
Channels /River	4950	866	6935	6935	+347	22331
Net Project	84000	5890	84000		+379	26960

In summary, the project is expected to have a positive impact on fisheries with a net increase of 379 tonnes per year. The water linkage between the Kushiyara River and Kodalia Fishery, Mokar, and Matikata haors will be reactivated as a result of excavating the silted channels and by installing regulators for fish passage as required. These areas are considered to be spawning grounds for carp. As indicated above, this is expected to result in an annual fish production increase in beels and river channels. This is expected to off-set the losses resulting from the reduction in the floodplain and disruptions to spawning migration associated with construction of the embankments.

The changes in fish production are projected to result in a slight increase in fish availability from 20 to 21 grams per person per day (Table 7.10).

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. There are about 89,500 homesteads in the area, and the average plinth level is at about the 1:5 year flood level. About 30% of homesteads are affected by flooding of 20-30 cm in the 1:10 to 1:20 year floods. The estimated annualized economic value of reduced flood damage is Tk 17 million.

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

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	944	972	741	655
Non-Cereals	126	164	125	86
Fish	30	28	21	20

Wetland Habitats and Grazing Area

Impacts are difficult to quantify, but a general impression is given by Table 7.11, 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. While it is clear that animals do graze on such areas, productivity per unit area is not known.

- "Winter wetland". Defined as 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". Defined as 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 >0.3 m and would support submerged, free-floating, rooted floating, and sedge/meadow plant communities.

Table 7.11: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	64	840	+776	
sc/wf F1	6720	8232	+15120	
sc/wf F2	12600	9200	-3400	
Fallow Highland	2500	2500	0	
Total	21884	20772	-1112	-5

Land Type	Winter Wetland			
sc/wf F3	2592	0	-2592	
F4, Beel, Channel	9660	9660	0	
Total	12252	9660	-2592	-21

Land Type	Summer Wetland			
wc/sf F1	0	0	0	
wc/sf F2	3000	5290	+2290	
wc/sf F3	49248	43840	-5408	
F4, Beel, Channel	12160	12160	0	
Total	64408	61290	-3118	-5

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.

The impact of the project would be to decrease winter grazing area by 5%, decrease winter wetland area by 21%, and decrease summer wetland area by 5%.

Economic and employment impacts of the project on wetland plant and animal production can only roughly be 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 60 thousand per year. Assuming 0.5 person days (ha yr)$^{-1}$ for harvesting, the employment impact would be -2900 person days per year.

Transportation/navigation
Transportation will remain largely unchanged. However, people living along the Kushiyara River will get road transport facilities during the monsoon season. The total length of existing roads in the project is 135 km of which 120 km is inundated every year. The project would make 18 km of these roads flood-free (up to the 1:20 year flood). Assuming a capital cost of Tk 190,000/km and 15% flood damage, the annual benefit of flood protection is Tk 2.0 million.

Higher Kushiyara flood levels
Kushiyara flood levels could increase by not more than 0.10 m at Markuli. This could affect areas outside the project, most likely un-embanked haors to the south. Studies show that with the Kushiyara dredging program, pre-monsoon water levels at Markuli would fall by about 1.5 m (see Draft *Northeast Regional Water Management Plan,* NERP, September, 1993).

7.8.2 Social
The key areas of social impact (or lack thereof) for this project are described below. Additional information is given in Annex C, Initial Environmental Evaluation.

Employment
There will be an overall increase in employment of 1.82 million person-days per year. This is composed of:

- an increase in owner-labour employment of +0.94 million pd yr^{-1}, 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 +0.88 million pd yr^{-1}, composed of changes in the following areas:

  - Agricultural hired labour: +0.966 million pd yr^{-1}, of which about 10% is for post-harvest processing traditionally done by women hired in (mainly by larger farmers) for the purpose.

  - Fishing labour[1]: -0.08 million pd yr^{-1}; in addition to this, there would be 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): -0.003 million pd yr^{-1}. Fodder and building material is gathered mainly by men. Food, fuel, and medicine is gathered mainly by women.

Displacement impacts due to land use changes
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.

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[1] It is estimated that one person day is required: to catch 0.5 kg of fish on the floodplain, 8 kg of fish in the beels, and 3 kg of fish in the rivers. Hence, a slight reduction in employment despite an overall increase in fish production.

Two mitigation options bear consideration. Embankments could be constructed with berms at strategic locations to support homesteads. Alternatively, provision could be included for the construction of raised housing platforms to facilitate relocation. 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.

Conflicts

Improved drainage will encourage farmers to extend cultivation further into the deeper haor areas. This will bring them into conflict with fishermen who will find the fishing area reduced. This conflict will affect the way the regulator is operated and will have a direct bearing on the extent to which some of the crop production benefits are realized.

Equity

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

- Landowners, in proportion to landholdings, benefit directly from investment in agriculture production. This is the main benefit (73% in economic terms) of the project and its distribution is *regressive*.

- Leaseholders, in proportion to the leases, benefit directly from investments in fisheries. This benefit amounts to about 19% of the net incremental agricultural output. Its distribution is also *regressive*.

- Homesteads in the northeast part of the project and along the Bibiyana River will be protected from monsoon flooding. *Progressive*.

Who loses?

- Families involved in gathering wetland products. These families are mainly landless and tend to be 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 <u>except</u> wetland gathering. Reduced homestead flood damage will disproportionately favour women, given that most women still spend most of their lives within the homestead. By the same token, the adverse effects of acquisition of 10 ha of homestead land (617 households or 1760 women) may fall mainly on the women in those households.

Qualitative Impact Scoring

The qualitative criteria shown in Table 7.12 are scored on an 11 level scale of -5 to +5. Scoring of those criteria that are impacts (some are not, like "responds to public concerns") is shown in Table 7.12. The scoring procedure is analogous to that used in the FAP 16 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 7.12: 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	0	0
Regional Biodiversity	-1	0	0	1	0	0	-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	1	0	0	-1
Conflicts	-1	1	1	0	0	0	-2
Socioeconomic Equity	-1	0	0	0	0	0	0
Gender Equity	1	1	0	0	1	1	3

7.8.3 Economic

The project has an economic rate of return of 49%, which compares well to the required rate of 12% as prescribed by government. It is a relatively high investment project, at Tk 365 million or Tk 4,347 per hectare, and it covers a large geographic area (100,000 ha gross). The rate of return, however, is quite sensitive to increases in capital costs (a 20% increase in capital costs would reduce the rate of return to 43%). Another sensitive variable is the timing of the benefits: a delay in benefits by two years would reduce the ERR to 31%. Fisheries benefits are also sensitive: a 20% reduction in estimated impacts (20% increase in fish losses) would reduce the ERR by 6%.

The foreign costs associated with the project are low, at 6% (excluding FFW contributions). Donor funding considerations would clearly need to include funding some local costs.

The major benefit of the project relates to increased rice production, mostly resulting from shifts from broadcast aman to local transplanted aman and from local boro to hyv boro. Average crop yields would increase as a result of reduced flood damage, and cropping intensity would remain almost constant. Non-cereal production would increase by 46%. Floodplain fish production would increase by 6% over future without-project production. The value of the increased fisheries output amounts to about 19% of the value of increased agricultural output. About 17% of project benefits would result from reduced homestead flooding. A small amount of disbenefits would result from loss of food, shelter, and tree products that are currently harvested from the seasonal wetlands. A summary of salient data in provided in Table 7.13.

It is anticipated that the established crop marketing system will handle incremental 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 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.

7.8.4 Summary Analysis

From a multi-criteria perspective (Table 7.14), the project is attractive:

- Benefits derive from increased food (rice and fish) production.
- The net employment impact is positive, and is about equally split between employment for owners and jobs for hired labourers.
- Rate of return is acceptable.
- Increased economic returns to land owners.
- Reduced flood damage to homesteads and roads.
- Substantial increase in non-cereal production.
- Gender equity of impacts is somewhat progressive.
- Project responds to some public concerns.

The negative aspects of the project would be:

- Conflicts between farmers and fishermen would continue; though these could be mitigated to a degree through an appropriate community participation process.
- Kushiyara flood levels would increase somewhat.
- A number of households would lose their homestead land to project land acquisition.
- The project has a high dependency on central government for implementation.

Knsh-Bijna

Table 7.13: Summary of Salient Data

Economic Rate of Return (ERR)	49			
Capital Investment (Tk million)	365			
Maximum O+M (Tk million / yr)	8			
Capital Investment (Tk/ha)	4,347			
Foreign Cost Component (%)	6			
Net Project Area (ha)	83,640			
Land Acquisition Required (ha)	368			

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (Tk million / yr)	100			
Cropping Intensity		1.2	1.2	1.2
Average Yield (tonnes/ha)		2.1	2.2	2.5
Average Gross Margins (Tk/ha)		12048	12355	12971
Owner Labour (md/ha)		117	118	121
Hired Labour (md/ha)		28	30	37
Irrigation (ha)		9636	13368	19402
Incremental Cereal Prod'n (' 000 tonnes / yr)	26			
Incremental Non-Cereal (' 000 tonnes / yr)	12			
Incremental Owner Labour (' 000 pd / yr)	940			
Incremental Hired Labour (' 000 pd / yr)	966			

FISHERIES IMPACTS		Flood plain	Beels	Channel/ River
Incremental Net Econ Output (Tk million / yr)	+18.9	-2.3	+5.6	+15.6
Impacted Area (ha)		2300	+325	+1385
Average Gross Margins (Tk/ha)		1540	28700	12250
Remaining Production on Impacted Area, %		50%	100%	100%
Incremental Fish Production (tonnes / year)		-101	+133	+347
Incremental Labour ('000 pd / yr)	-80	-200	+10	+110

FLOOD DAMAGE BENEFITS				
Households Affected		26836		
Reduced Econ Damage Households (Tk M / yr)	17			
Roads/Embankments Affected -km		135		
Reduced Econ Damage Roads (Tk M / yr)	2			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	-0.06			
Wetland Incremental Labour ('000 pd / yr)	-3			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	-4.42			
Persons Displaced by Homestead Acquisition	3500			

Table 7.14: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	49
EIRR, Increase Capital Costs by 20%	per cent	43
EIRR, Delay Benefits by Two Years	per cent	31
EIRR, Decrease in Fishery by 20%	per cent	43
Net Present Value	Tk	549465

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	26	13
Incremental Non-Cereal Production	tonnes	12	46
Incremental Fish Production	tonnes	379	6
Change in Floodplain Wetland/Fisheries Habitat	ha	2300	3
Homesteads Displaced Due to Project Land Acquisition	homesteads	617	0.7
Homesteads Protected From Floods	homesteads	26800	30
Roads Protected From Floods	km	18	15
Increase in Kushiyara Flood Levels	m PWD	0.1	1
Owner Employment	million pd/yr	+0.94	51
Hired Employment (Agri+Fishing+Wetland)	million pd/yr	+0.88	49

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

ANNEX A

TABLES

TABLE A-1: METEOROLOGICAL DATA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature Max. (°C)	25.4	28.1	32.1	33.5	32.6	31.7	32.0	32.2	32.1	31.2	29.1	26.5
Min. (°C)	9.0	11.4	16.5	21.1	23.0	24.4	25.1	24.9	24.4	21.7	15.7	10.5
Mean (°C)	17.5	19.6	24.4	27.2	27.8	28.2	28.5	28.6	28.3	26.6	22.4	18.8
Humidity (%)	85	78	73	75	81	87	88	89	89	88	87	78
Sunshine (hr/day)	7.9	8.1	7.3	7.1	6.9	5.0	4.2	4.7	4.4	6.4	8.1	8.1
Wind speed (kph)	3.0	4.0	5.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	6.0
Evapotranspiration (mm/month)	105.6	124.4	162.4	157.1	153.4	124.9	125.0	130.6	121.5	128.4	114.5	102.6
Rainfall (mm) Mean monthly	9	42	76	223	387	516	328	341	249	157	44	6

Source: BMD; Station Srimangal except Evapotranspiration which is for Sylhet station.

Table A.2: Area - Elevation and Storage Volume

Elevation (m PWD)	Area (ha)	Storage (ha-m)
2.29	101.46	0.00
2.50	101.46	21.31
3.00	2942.34	782.25
3.50	8928.47	3749.95
4.00	20393.43	11080.43
4.50	39163.49	25969.66
5.00	53469.33	49127.86
5.50	67876.63	79464.35
6.00	79240.12	116243.54
6.50	88980.27	158298.64
7.00	95575.16	204437.49
7.50	98923.33	253062.12
8.00	100140.85	302828.16
8.31	100242.31	333887.55

Table A.3: Flood Discharges at Various Return Periods (m3/sec)

River	Station and No	Return Period (Years)						
		2	5	10	20	25	50	100
Annual Monsoon Floods								
Kushiyara	Sherpur - 175.5	1570	1947	2147	2309	2355	2482	2590
Langla	Motiganj - 192	55	83	102	121	128	148	168
Karangi	Sofiabad - 138	85	137	191	266	296	414	580
Khowai	Shaistaganj-158.1	191	320	478	723	829	1274	1975
Pre-monsoon Floods								
Kushiyara	Sherpue - 175.5	1570	1947	2147	2309	2355	2482	2590
Langla	Motiganj - 192	39	66	85	103	109	128	147
Karangi	Sofiabad - 138	32	47	53	57	58	60	62
Khowai	Shaistaganj- 158.1	110	155	178	196	200	213	224

Table A.4: Flood Water Levels for Various Return Period (m PWD)

SL	River	Station	Return Period (Years)			
			2	5	10	20
1	Kushiyara	Sherpur	9.00	9.15	9.22	9.28
2		Markuli	7.54	7.82	8.01	8.20
3		Ajmiriganj	7.29	7.68	7.90	8.09
4		Inathganj	8.49	8.68	8.79	8.90
5	Lungla	Terapasha	7.53	7.58	7.74	7.99
6	Ratna	Baniachong	6.96	7.20	7.43	7.61
	Average (1-6):		7.48	7.75	7.94	8.12
7	Kushiyara	Madna	7.10	7.52	7.74	7.92
8	Khowai	Habiganj	8.80	9.52	9.99	10.48
9	Lungla	Motiganj	8.67	8.88	8.99	9.08
10	Karangi	Sofiabad	11.90	12.11	12.19	12.25
	Pre-monsoon Flood					
1	Kushiyara	Sherpur	7.18	7.73	8.02	8.25
2		Markuli	5.67	6.3	6.56	6.74
3		Ajmiriganj	4.12	4.69	4.92	5.08
4		Inathganj	6.67	7.24	7.52	7.74
5	Lungla	Terapasha	7.14	7.44	7.73	7.83
6	Ratna	Ratna(40km)	5.48	5.78	6.09	6.28
	Average (1-6):		5.38	5.84	6.11	6.28
7	Kushiyara	Madna	3.2	3.59	3.83	4.04
8	Khowai	Habiganj	8.23	8.94	9.24	9.46
9	Lungla	Motiganj	8.22	8.62	8.79	8.9
10	Karangi	Sofiabad	10.23	11.16	11.58	11.88

Table A.5: Mean Monthly Discharges (m3/sec)

Month	Gauge 175.5 KUSHIYARA at Sherpur			Gauge 192 LUNGLA at Motiganj		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	139.5	730.5	1340.4	0.8	6.7	33.4
May	627.0	1561.2	3240.3	3.3	15.2	26.3
June	573.2	1785.1	3227.3	5.5	19.5	37.0
July	1387.1	2015.0	2525.5	4.0	15.8	30.6
Aug	1386.5	2036.5	2593.5	5.3	13.6	28.4
Sept	1241.3	1967.7	2511.7	5.1	12.0	27.0
Oct	890.5	1652.1	2386.5	0.4	10.3	27.0
Nov	247.9	683.7	1143.2	0.3	3.7	8.6
Dec	133.3	261.5	426.3	0.1	1.9	3.4
Jan	88.8	173.1	325.9	0.5	1.3	2.2
Feb	71.3	135.9	255.3	0.5	1.4	2.5
Mar	61.5	211.0	579.4	0.7	2.5	8.9

TABLE A.5 (Cont'd): Mean Monthly Discharges (m3/esc)

Month	Gauge 138 KARANGI at Sofiabad			Gauge 332 KHOWAI at Shaistaganj		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	0.4	3.7	15.3	7.3	23.4	78.4
May	1.0	14.3	83.9	8.3	53.2	275.5
June	2.1	20.5	46.0	11.1	66.4	116.1
July	3.6	15.1	32.9	29.8	62.1	148.1
Aug	4.2	15.1	40.6	28.9	60.6	146.5
Sept	4.5	12.3	23.4	23.3	56.0	118.1
Oct	1.6	8.2	33.7	8.9	45.1	140.1
Nov	0.7	2.8	12.2	5.6	21.1	46.8
Dec	0.5	1.6	3.9	6.2	14.5	29.8
Jan	0.3	1.1	1.9	7.5	11.0	20.6
Feb	0.4	1.0	2.1	5.8	10.0	16.9
Mar	0.2	1.3	6.0	5.4	11.0	30.6

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TABLE A.6 : Mean Monthly Water Levels (m PWD)

Month	Gauge 270 KUSHIYARA at Markuli			Gauge 175.5 KUSHIYARA at Sherpur		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	2.12	3.76	5.82	2.74	4.63	6.30
May	3.34	5.10	6.48	5.10	6.28	7.99
June	4.47	6.23	6.89	4.67	7.31	8.70
July	6.55	7.08	7.77	7.31	8.30	8.88
Aug	6.78	7.21	7.92	7.65	8.39	8.97
Sept	6.38	6.94	7.63	7.46	8.20	8.77
Oct	5.56	6.26	6.95	6.31	7.49	8.31
Nov	3.42	4.70	5.98	3.57	5.10	6.47
Dec	2.29	3.26	4.51	2.56	3.56	4.37
Jan	1.87	2.60	3.60	2.18	2.89	3.50
Feb	1.62	2.30	3.34	1.97	2.58	3.22
Mar	1.61	2.58	4.09	1.99	3.05	4.19

TABLE A.6 (Cont'd): Mean Monthly Water Levels (m PWD)

Month	Gauge 271 KUSHIYARA at Ajmiriganj			Gauge 272 KUSHIYARA at Madna		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	1.98	2.84	4.32	1.87	2.27	3.02
May	2.67	3.90	5.16	2.42	3.11	4.20
June	3.78	5.39	6.44	3.05	4.64	6.09
July	5.68	6.69	7.60	4.94	6.31	7.38
Aug	6.20	6.93	7.79	5.77	6.69	7.61
Sept	6.04	6.66	7.66	5.66	6.43	7.50
Oct	4.86	5.76	6.52	4.24	5.44	6.34
Nov	2.75	3.86	5.06	2.41	3.32	4.11
Dec	1.62	2.54	3.65	1.80	2.09	2.70
Jan	1.52	2.03	3.01	1.32	1.63	1.92
Feb	1.40	1.85	2.75	1.23	1.49	1.96
Mar	1.52	2.03	3.00	1.31	1.66	1.96

Source: NERP (FAP 6)

TABLE A.7:WATER BODIES IN THE KUSHIYARA-BIJNA BASIN

Thana	Beel area (ha)	Thana	Beel area (ha)
Ajmiriganj	452	Habiganj	8
Astagram	196	Jagannathpur	48
Bahiachong	1900	Mitamain	46
Sullah	9	M.Bazar	2
Derai	64	Nobiganj	533
Total Area: 3,257 ha			

Source: Inception report- Haor Development Project, CIDA, 1989.

Table A.8: CLOSED WATER BODIES IN THE PROJECT AREA

Thana	Area in project (%)	Total number of ponds	Combined pond area (ha)	Average pond size (ha)	Pond concentration (nos/km2)
Ajmiriganj	92	1494	116	0.07	7.55
Astagram	11	290	32	0.11	8.79
Baniachong	79	3584	276	0.07	9.11
Derai	2	74	6	0.08	8.83
Habiganj	1	22	2	0.09	8.90
Jagannathpur	7	234	18	0.07	8.54
Mitamain	10	181	20	0.11	7.78
M.Bazar	1	32	2	0.06	9.23
Nabiganj	71	2916	226	0.07	9.33
Sullah	1	23	2	0.08	9.02
Total		8,850	700	0.07	

Source: BFRSS, 1986

TABLE A.9: GROUND WATER AVAILABILITY AND USE
(Mm^3)

Thana	Portion in Project	Useable Ground Water by Technology			Available Ground Water by Technology			Present Ground Water Use (1991)			Ground Water Available after Present Use (1991)		
		STW	DSSTW	DTW	STW	DSSTW	DTW	STW	DTW	Total	STW	DSSTW	DTW
Mitamain	0.1	0	0.62	2.6	0	0.35	1.46	0.03	0	0.03	0	0.32	1.43
Astagram	0.11	0	1.15	3.82	0	0.64	2.14	0.89	0	0.89	0	0	1.24
Baniachong	0.79	0.87	13.43	42.9	0.75	11.57	36.94	1.46	6.78	8.24	0	3.32	28.7
Ajmiriganj	0.92	0	2.22	20.24	0	1.99	18.13	0	0	0.00	0	1.99	18.13
Nabiganj	0.71	0	18.89	75.12	0	11.82	47	0.56	1.08	1.64	0	10.18	45.36
Derai	0.02	.05	0.18	0.48	0.04	0.13	0.35	0	0	0.00	0.04	0.13	0.35
Jagannathpur	0.07	0.22	0.90	2.89	0.18	0.75	2.4	0	0.02	0.02	0.18	0.73	2.39
Total		1.14	37.39	148.04	0.97	27.24	108.41	2.94	7.88	10.82	0.22	16.67	97.59

TABLE A.10: PRESENT (1991) IRRIGATION STATISTICS

Thana	Portion in Project	STW		DSSTW		DTW		MOSTI		LLP		Traditional
		(ha)	Number	(ha)	Number	(ha)	Number	(ha)	Number	(ha)	Number	(ha)
Ajmiriganj	0.92	0	0	0	0	0	0	0	0	4149	258	5497
Baniachong	0.79	240	14	0	0	1112	30	0	0	8005	447	4693
Nabiganj	0.71	91	11	0	0	175	6	1	1	2183	161	3866
Derai	0.02	0	0	0	0	0	0	0	0	83	5	325
Jagannathpur	0.07	0	0	0	0	3	0	0	0	156	15	800
Austagram	0.11	116	14	0	0	0	0	0	0	1046	52	1240
Mitamain	0.1	4	1	0	0	0	0	0	0	828	36	248
Total		450	39	0	0	1290	36	0	0	16450	974	16669

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TABLE A.11: DUARS AROUND THE PROJECT AREA

Name of Duar	Approximate Dry Season Depth (m)	Baramaach occurred*	Chotomaach occurred*
RIVER: KUSHIYARA			
Perkular duar	16*	LC,MC	B,Ch,Ca,L
Kamarkheda	15*	As above.	As above.
Hossainpur	15*	As above.	As above.
Mirkhalir duar	17*	LC,MC,C	As above.
Digholbag 4**	14,16,18,32*	As above.	As above.
Atghor	19*	As above.	As above.
Bara Pechi**	16*	As above.	As above.
Jalalpurar duar	14*	LC,MC	As above.
Kaittar duar**	14*	As above.	As above.
Bagakhalir duar**	25*	LC,MC,C	As above.
Alokdir duar	19*	As above.	As above.
Pilegaor duar	18*	As above.	As above.
Ranigangar duar**	22*	As above.	As above.
Alampurar duar	18*	as above.	As above.
Balichata	17*	As above.	As above.
Bagmaynar duar	19*	As above.	As above.
Roailar duar**	31*	As above.	As above.
Mohiskonar duar	15-16	As above.	As above.
Baushir duar	15-16	As above.	As above.
Galishalar duar	12-13	As above.	As above.
Markulir duar	12-13	As above.	As above.
Pratappurar duar	11-12	As above.	As above.
Bherar duar	12-13	As above.	As above.
Matidora	11-12	As above.	As above.
Badalpurar duar	11-12	As above.	As above.
Pirispurar duar	11-12	As above.	As above.
River: BHERAMONA/KALNI			
Bardair duar	6-7	LC,MC	B,L,Ca,G
Chondir duar	7-8	As above.	As above.
Kanchanpurar duar	10-11	LC,C,MC	As above.
Kalimpurar duar	9-10	As above.	As above.
Ichapurar duar	10-11	As above.	As above.
Adampurar duar	10-11	As above.	As above.
River: MARA KUSHIYARA			
Kodaliar duar (Jalsuka)	8-9	C,LC,MC	B,L,Ch,Ca

* Echo sounding data (all other depths from interviewing with fishermen).

** Duars proposed for fish sanctuaries.

B:Bacha; C:Chital; Ca:Chapila; Ch:Chela; G:Golda Chingri; LC:Large catfish; MC:Major carp. (Source: NERP, 1992)

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Table A.12: Design and Volume Estimates; Kushiyara-Bijna Interbasin

Distance (km)	Ground Elevation (m PWD)	Design Height (m PWD)		Embankment Height (m)		Volume (m3)	
		Pre-monsoon (1:10)	Monsoon (1:20)	Pre-monsoon (1:10)	Monsoon (1:20)	Pre-monsoon (1:10)	Monsoon (1:20)
0.0	5.6	6.09	9.59	0.54	4.04	0	0
1.0	5.2	6.18	9.60	0.98	4.40	4770	62511
2.0	4.8	6.26	9.60	1.47	4.81	9094	72728
3.0	4.9	6.35	9.61	1.40	4.66	11262	76324
4.0	5.3	6.43	9.61	1.09	4.27	9243	69088
5.0	5.2	6.52	9.62	1.33	4.43	8834	65960
6.0	4.9	6.60	9.63	1.72	4.74	12372	72255
7.0	5.0	6.69	9.63	1.71	4.66	14646	75302
8.0	5.1	6.77	9.64	1.64	4.51	14178	72129
9.0	4.9	6.86	9.65	1.94	4.73	15725	73145
10.0	5.3	6.94	9.65	1.60	4.31	15456	70498
11.0	5.2	7.03	9.66	1.81	4.44	14536	66520
12.0	5.6	7.11	9.66	1.46	4.02	13732	62850
13.0	5.6	7.20	9.67	1.61	4.08	12478	58329
14.0	5.6	7.28	9.68	1.63	4.03	13499	58479
15.0	5.2	7.37	9.68	2.18	4.49	17388	63733
16.0	5.3	7.45	9.69	2.11	4.35	20623	67731
17.0	5.0	7.54	9.69	2.50	4.66	23196	69968
18.0	5.7	7.62	9.70	1.91	3.99	21793	65527
19.0	5.6	7.71	9.71	2.06	4.06	18349	57740
20.0	5.6	7.79	9.71	2.14	4.07	20014	58635
21.0	6.0	7.88	9.72	1.92	3.77	19054	55147
22.0	6.3	7.96	9.73	1.64	3.41	15615	47590
23.0	6.0	8.05	9.73	2.06	3.75	16608	47380
24.0	6.6	8.13	9.74	1.51	3.12	15789	44369
25.0	6.0	8.22	9.74	2.20	3.73	16831	44161
26.0	6.3	8.30	9.75	2.01	3.46	20134	47762
Average Height				1.71	4.18		
Total Volume						395221	1625861

Note: Distance 0.0 km is located at Ajmiriganj; 26.0 km is located at Markuli

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Table A.12(Cnn'd): Design and Volume Estimates; Kushiyara-Bijna Interbasin

Distance (km)	Ground Elevation (m PWD)	Design Height (m PWD)		Embankment Height (m)		Volume (m3)	
		Pre-monsoon (1:10)	Monsoon (1:20)	Pre-monsoon (1:10)	Monsoon (1:20)	Pre-monsoon (1:10)	Monsoon (1:20)
26.0	6.3	8.30	9.75	2.01	3.46	0	0
27.0	6.3	8.31	9.77	1.97	3.43	18399	44373
28.0	6.7	8.33	9.80	1.58	3.05	15552	40153
29.0	6.4	8.34	9.82	1.96	3.44	15536	40328
30.0	6.7	8.36	9.84	1.67	3.16	16090	41396
31.0	6.7	8.37	9.87	1.72	3.21	14431	39016
32.0	7.0	8.38	9.89	1.43	2.93	12951	36797
33.0	7.0	8.40	9.91	1.44	2.96	11267	34255
34.0	7.1	8.41	9.94	1.30	2.83	10578	33269
35.0	6.6	8.43	9.96	1.84	3.37	13033	37413
36.0	6.7	8.44	9.98	1.73	3.27	15548	41737
37.0	7.0	8.46	10.01	1.50	3.05	13420	38496
38.0	7.1	8.47	10.03	1.36	2.92	11213	35045
39.0	7.1	8.48	10.05	1.40	2.98	10673	34318
40.0	7.0	8.50	10.08	1.45	3.03	11176	35350
41.0	7.4	8.51	10.10	1.16	2.75	9862	33237
42.0	7.4	8.53	10.12	1.17	2.77	8365	30815
43.0	7.3	8.54	10.15	1.22	2.82	8665	31518
44.0	7.0	8.55	10.17	1.50	3.12	10490	34860
45.0	7.4	8.57	10.19	1.18	2.81	10322	34730
46.0	7.3	8.58	10.22	1.32	2.96	9272	33109
47.0	7.6	8.60	10.24	1.00	2.64	8371	31617
48.0	7.4	8.61	10.27	1.20	2.85	7716	30625
49.0	7.6	8.62	10.29	1.00	2.66	7705	30768
50.0	7.6	8.64	10.31	1.04	2.71	6942	29531
51.0	7.8	8.65	10.34	0.87	2.55	6387	28617
52.0	7.3	8.67	10.36	1.34	3.04	7934	31611
53.0	7.7	8.68	10.38	0.96	2.66	8329	32544
54.0	7.6	8.69	10.41	1.13	2.84	7202	30676
55.0	7.7	8.71	10.43	1.02	2.74	7473	31363
56.0	7.6	8.72	10.45	1.13	2.85	7461	31514
57.0	8.1	8.74	10.48	0.59	2.33	5681	28037
58.0	7.7	8.75	10.50	1.09	2.84	5520	27906
59.0	7.7	8.77	10.52	1.05	2.80	7422	31956

to

Table A.12(Cnn'd): Design and Volume Estimates; Kushiyara-Bijna Interbasin

Distance (km)	Ground Elevation (m PWD)	Design Height (m PWD)		Embankment Height (m)		Volume (m3)	
		Pre-monsoon (1:10)	Monsoon (1:20)	Pre-monsoon (1:10)	Monsoon (1:20)	Pre-monsoon (1:10)	Monsoon (1:20)
60.0	8.0	8.78	10.55	0.75	2.52	5922	29136
61.0	8.1	8.79	10.57	0.74	2.51	4581	26602
62.0	8.0	8.81	10.59	0.81	2.60	4821	27262
63.0	8.2	8.82	10.62	0.64	2.44	4459	26637
64.0	8.3	8.84	10.64	0.51	2.31	3296	24250
65.0	8.2	8.85	10.66	0.64	2.46	3288	24385
66.0	8.4	8.86	10.69	0.47	2.30	3178	24273
67.0	8.7	8.88	10.71	0.18	2.01	1722	20867
68.0	8.5	8.89	10.73	0.41	2.25	1517	20518
69.0	8.3	8.91	10.76	0.58	2.43	2733	23691
70.0	8.5	8.92	10.78	0.47	2.33	2922	24298
Average Height				1.15	2.80		
Total Volume						379425	1398899

Note: Location at distance 26.0 km is Markuli; location at distance 70.0 km is Sherpur

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Table A.13: Estimated Capital and O & M Costs

Item of Works	Quantity	Unit	Unit Price (tk)	Capital Cost (mtk)	O&M (%)	O&M Costs (mtk)
Full Flood Embankment	1714000	m^3	24.27	33.3	6	2.00
Partial Embankment	578600	m^3	24.27	11.2	10	1.12
Fine Dressing and Turfing	1626800	m^2	2.27	3.7	1	0.04
Drainage Channel Re-excavation	2025000	m^3	23.5	47.6	3	1.43
Regulators:						
Six Vent (1.52m*1.63m)	1	unit	9000000	9.0	2	0.18
Four Vent (1.52m*1.63m)	1	unit	7000000	7.0	2	0.14
Two Vent (1.52m*1.63m)	3	unit	5000000	15.0	2	0.30
One Vent (1.52m*1.63m)	4	unit	3500000	14.0	2	0.28
Inlet Structures (.45m dia)	5	unit	550000	0.3	2	0.01
Land Acquisition	368	ha	300000	110.4		-
Project Buildings	500	m^2	5000	2.5	3	0.08
BASE COST:				254.0		5.6
Physical Contingency 25%				63.5		1.39
SUB_TOTAL:				317.5		6.96
Engg & Admin 15%				47.6		1.04
TOTAL:				365.1		8.00
NET AREA (ha):				83640		
UNIT COST (Tk/ha):				4365		

ANNEX B

FISHERIES MODEL

ANNEX B: 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 desireable (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 =

$$[M * Q * (R_1 * P_{RO})] + [M * Q * (B_1 * P_{BO})] + [M * (W_1 * P_{WO})]$$

Thus,

Impact = FW - 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 project are shown in Table B.1. 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.

Table B.1: Fisheries Parameters

Var	Value	Stnd value?	Comments
M	1.0	0.8	Migration routes rehabilitated; water linkages with Kushiyara River re-activated
Q	1.0	0.8	Water quality is expected to improve since drainage system will be re-activated
R_0	4950		
R_1	6935		Bibiyana River provided with regulators; drainage channels improved.
B_0	3257		
B_1	3582		Siltation reduced; beel bunding provided.
W_0	83840		
W_1	81540		
P_{RO}	175	175	
P_{BO}	410	410	
P_{WO}	44	44	
A_M	—	100000	There is no "mother fishery" in this area.

ANNEX C

INITIAL ENVIRONMENTAL EXAMINATION

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ANNEX C: INITIAL ENVIRONMENTAL EXAMINATION

C.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.

C.2 Alternative 1: Proposed FCD Project

C.2.1 Project Design and Description (Step 1)

As in Section 7.3, Project Description.

C.2.2 Environmental Baseline Description (Step 2)

As in Chapter 2, Biophysical Description, and Chapter 3, Settlement, Development, and Resource Management.

C.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.

C.2.4 Bounding (Step 4)

Physical:

Gross area: 100,000 ha.
Impacted (net) area: 83,640 ha.
Impacted area outside project: Kushiyara water level might increase five to ten centimetres during the pre-monsoon season. During feasibility studies, these impacts need to be assessed.

Temporal:

Preconstruction: years 0 through year 3 (see Table 7.7).
Construction: year 1 through year 3 (see Table 7.7).
Operation: year 3 through year 20.
Abandonment: after year 20.

Cumulative impacts:

With other floodplain infrastructure: With Kushiyara Dredging Project water levels at Markuli will fall by about 1.5 metres during the pre-monsoon season and about 0.2 metres during the monsoon season.
With pre-existing no-project trends. Described in Chapter 5.

C.2.5 Field Investigations (Step 5)

Field investigations were limited to seven to ten days of informal reconnaissance by a multi-disciplinary team.

C.2.6 Impact Assessment (Step 6)

At this level of detail, a screening matrix (Table C.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 7.8.

C.2.7 Quantify and Value Impacts (Step 7)

Quantification and evaluation of impacts is documented in Section 7.8 and Tables 7.8, 7.9, and 7.13 through 7.15.

C.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. Documented in Section 7.3.

Compensation. Mandated requirements for land acquisition must be adhered to. Beyond this, consideration should be given to:

- In-kind rather than cash compensation for households whose homestead land is taken.

- Compensation for persons other than landowners who are impacted negatively by land acquisition and construction/infrastructure-related land use changes. Example: project implementation could be made contingent upon successful resettlement of squatters displaced from embankment/structure sites under local initiative; local communities could work with NGOs to accomplish this.

Monitoring. There is a need to define monitoring needs and methodologies at regional, institutional (BWDB), and projects 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). Once the flood protection is operational, investment in agriculture will likely rise. This increases the total amount of farmers' assets that are at risk should an extreme flood event occur or the embankment fail for any reason. Currently in Bangladesh, these risks are borne by individual investors (in this case farmers). Unsustainable solutions (such as government subsidy of crop insurance) should be avoided however.

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 and DOE, probably through an Environmental Cell within BWDB linked to DOE. 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.

Environmental Screening Matrix

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										

Environmental Screening Matrix

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											

ANNEX D

FIGURES

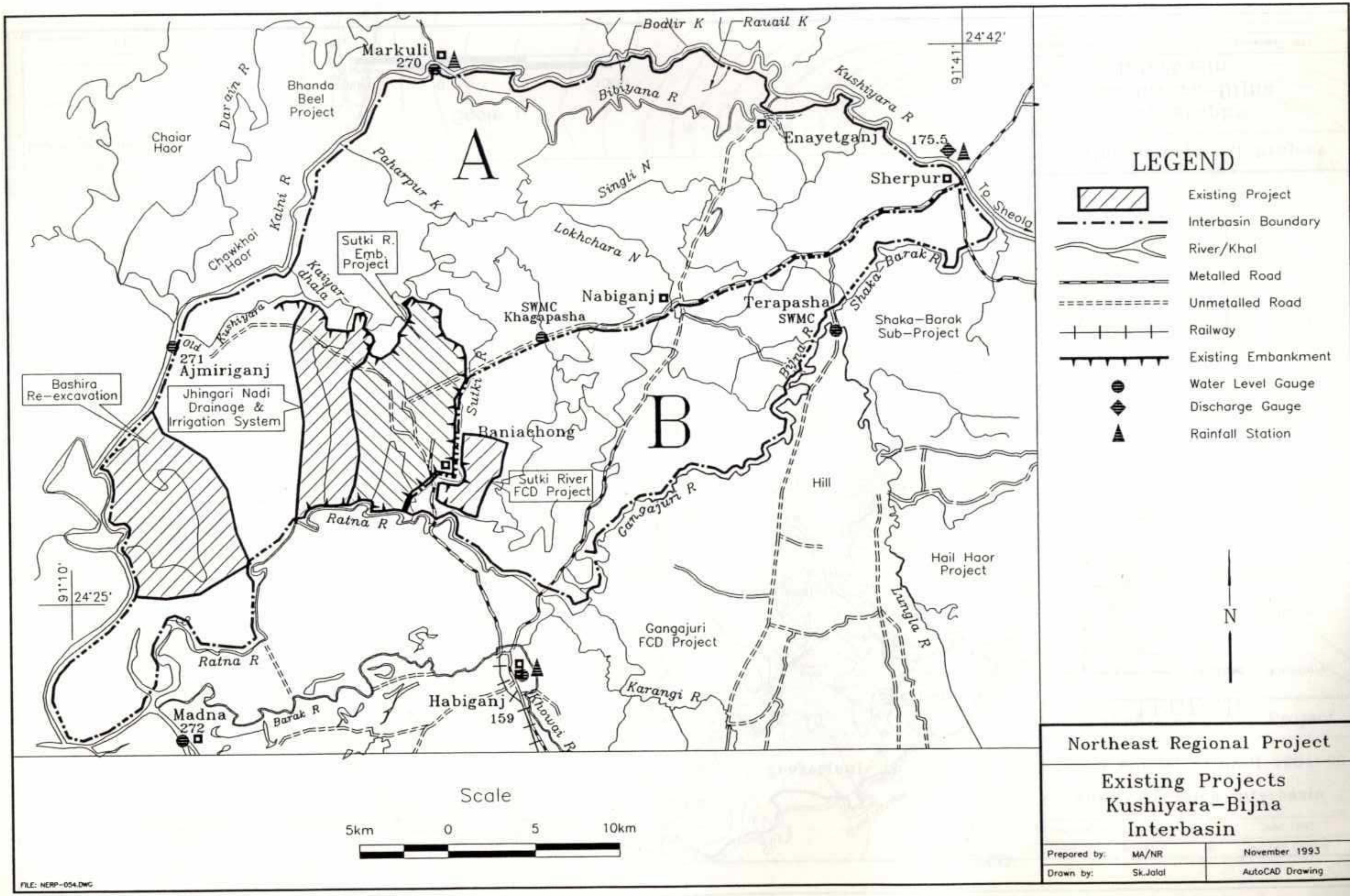

Markuli
270
Bodlir K
Rauail K
24°42'
91°41'
Bhanda Beel Project
Chaiar Haor
Darain R
Kushiyara R
Bibiyana R
Enayetganj
175.5
Sherpur
To Sheola
A
Paharpur K
Singli N
Kalni R
Lokhchara N
Chowkhai Haor
Sutki R. Emb. Project
Kaiyar-dhala
Old Kushiyara
271
Ajmiriganj
SWMC
Khagapasha
Nabiganj
Terapasha
SWMC
Shaka-Barak R
Shaka-Barak Sub-Project
Bijna R
Bashira Re-excavation
Jhingari Nadi Drainage & Irrigation System
Sutki R
Baniachong
B
Sutki River FCD Project
Gangajuri R
Hill
Ratna R
Hail Haor Project
91°10'
24°25'
Lungla R
Gangajuri FCD Project
Ratna R
Habiganj
159
Khowai R
Karangi R
Madna
272
Barak R
LEGEND
Existing Project
Interbasin Boundary
River/Khal
Metalled Road
Unmetalled Road
Railway
Existing Embankment
Water Level Gauge
Discharge Gauge
Rainfall Station
N
Scale
5km 0 5 10km
Northeast Regional Project
Existing Projects
Kushiyara-Bijna
Interbasin
Prepared by: MA/NR
November 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-054.DWG

Figure 1

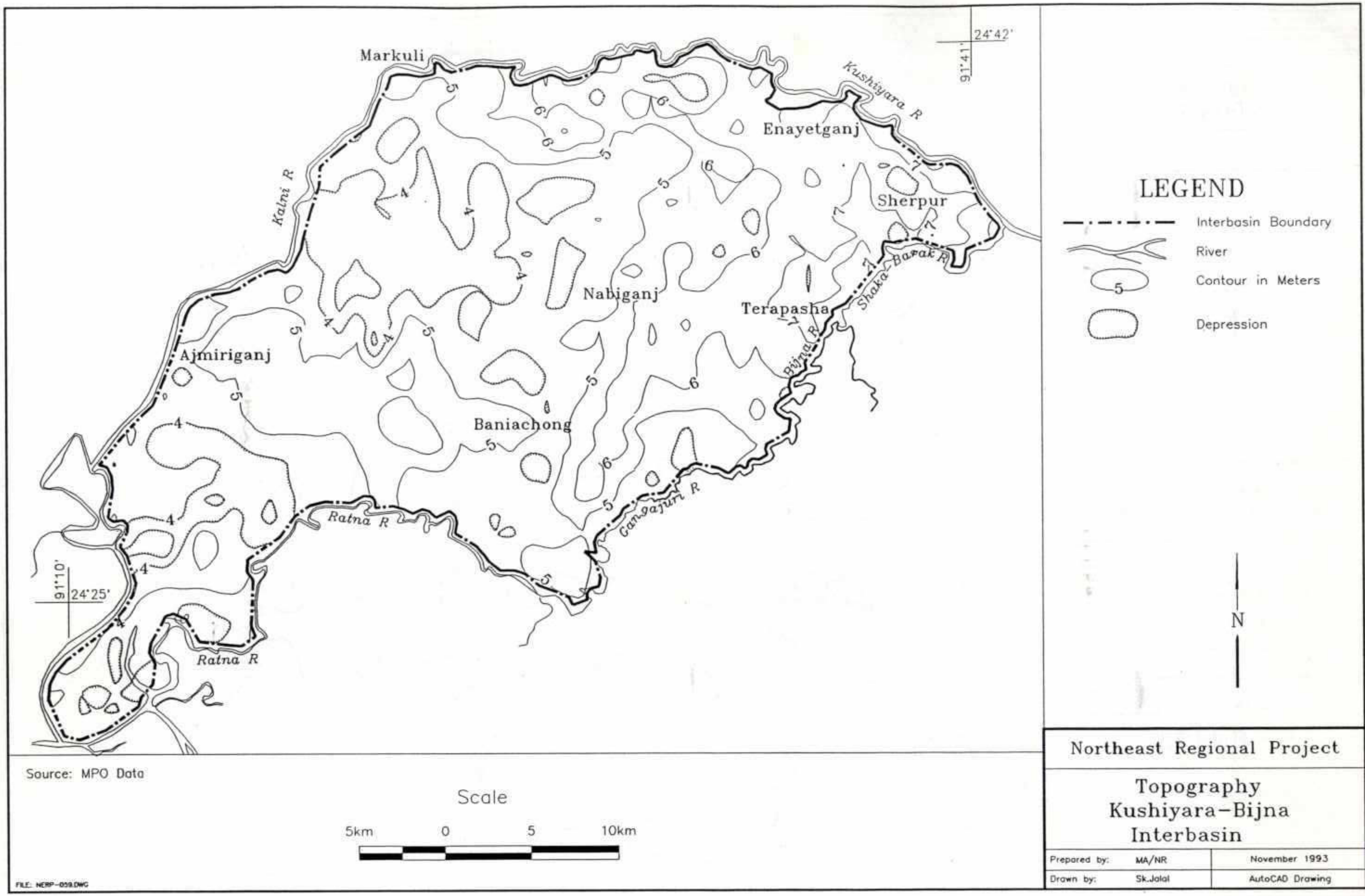
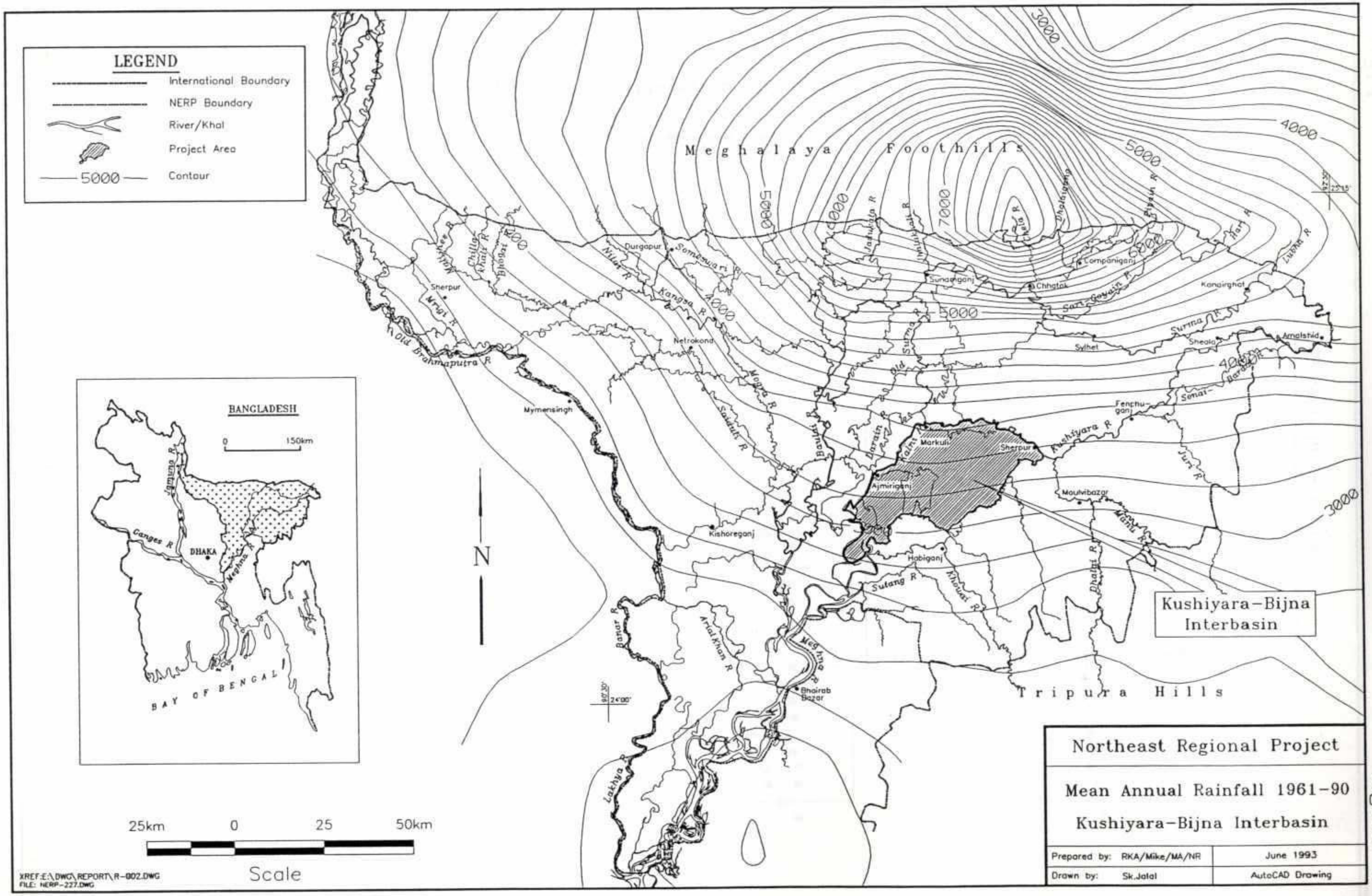

Markuli
Enayetganj
Sherpur
Terapasha
Nabiganj
Baniachong
Ajmiriganj
Kushiyara R
Kalni R
Ratna R
Ratna R
Gangajuri R
Bijna R
Shaka-Barak R
24°42'
91°41'
91°10'
24°25'
LEGEND
Interbasin Boundary
River
Contour in Meters
Depression
N
Source: MPO Data
Scale
5km 0 5 10km
FILE: NERP-059.DWG
Northeast Regional Project
Topography
Kushiyara-Bijna
Interbasin
Prepared by: MA/NR
November 1993
Drawn by: Sk.Jalal
AutoCAD Drawing

Figure 2

Figure 3


LEGEND
International Boundary
NERP Boundary
River/Khal
Project Area
5000
Contour
Meghalaya Foothills
Tripura Hills
Kushiyara-Bijna
Interbasin
BANGLADESH
150km
DHAKA
BAY OF BENGAL
Ganges R
Jamuna R
Meghna R
25km
0
25
50km
Scale
N
Sherpur
Durgapur
Somesuari R
Kangsa R
Netrokona
Mymensingh
Old Brahmaputra R
Kishoreganj
Sunamganj
Chhatak
Companiganj
Kanairghat
Sylhet
Sheola
Amalshid
Fenchuganj
Kushiyara R
Markuli
Sherpur
Ajmiriganj
Habiganj
Moulvibazar
Manu R
Dhalai R
Juri R
Sonai-Bardal
Khowai R
Sutang R
Meghna R
Bhairab Bazar
Arial Khan R
Banar R
Lakhya R
Baulai R
Darain R
Old Surma R
Mogra R
Surma R
Sari Goyain R
Piyain R
Hari R
Lubha R
Dhalai R
Jadukata R
Nitai R
Mrigi R
Bhogai R
Chillakhali R
3000
4000
5000
6000
7000
Northeast Regional Project
Mean Annual Rainfall 1961-90
Kushiyara-Bijna Interbasin
Prepared by: RKA/Mike/MA/NR
June 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
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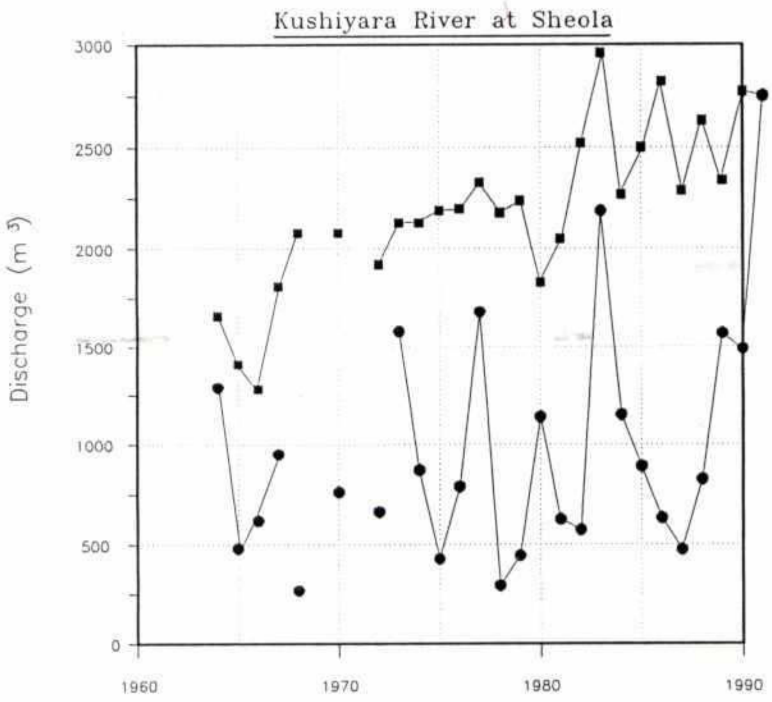
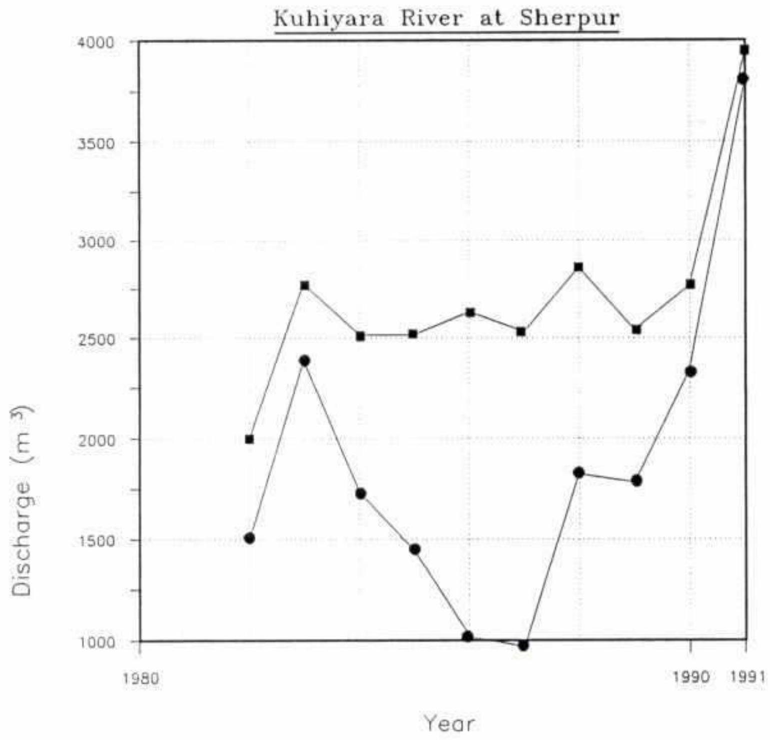
FILE: NERP-227.DWG

Figure 4





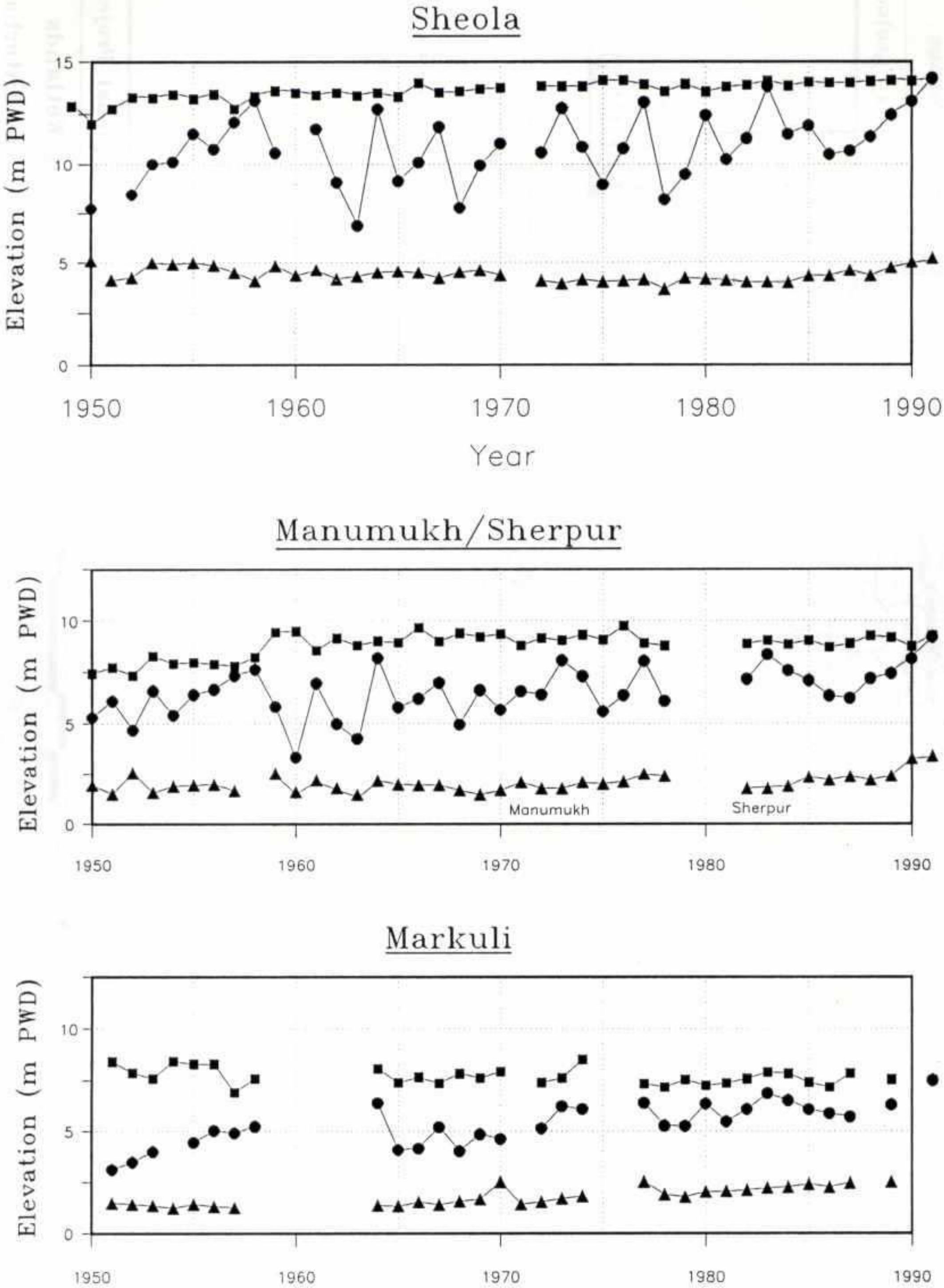
Legend:
- ■ Annual Maximum
- ● Maximum in Pre-monsoon

Note:
Pre-monsoon season is period from March 1 - May 15

FILE: NERP-689.DWG

Northeast Regional Project	
Annual Discharges Kushiyara River Kushiyara-Bijna Interbasin	
Prepared by: Dave G. Mclean	May 1993
Drawn By: Mamun	AutoCAD Drawing

Figure 5

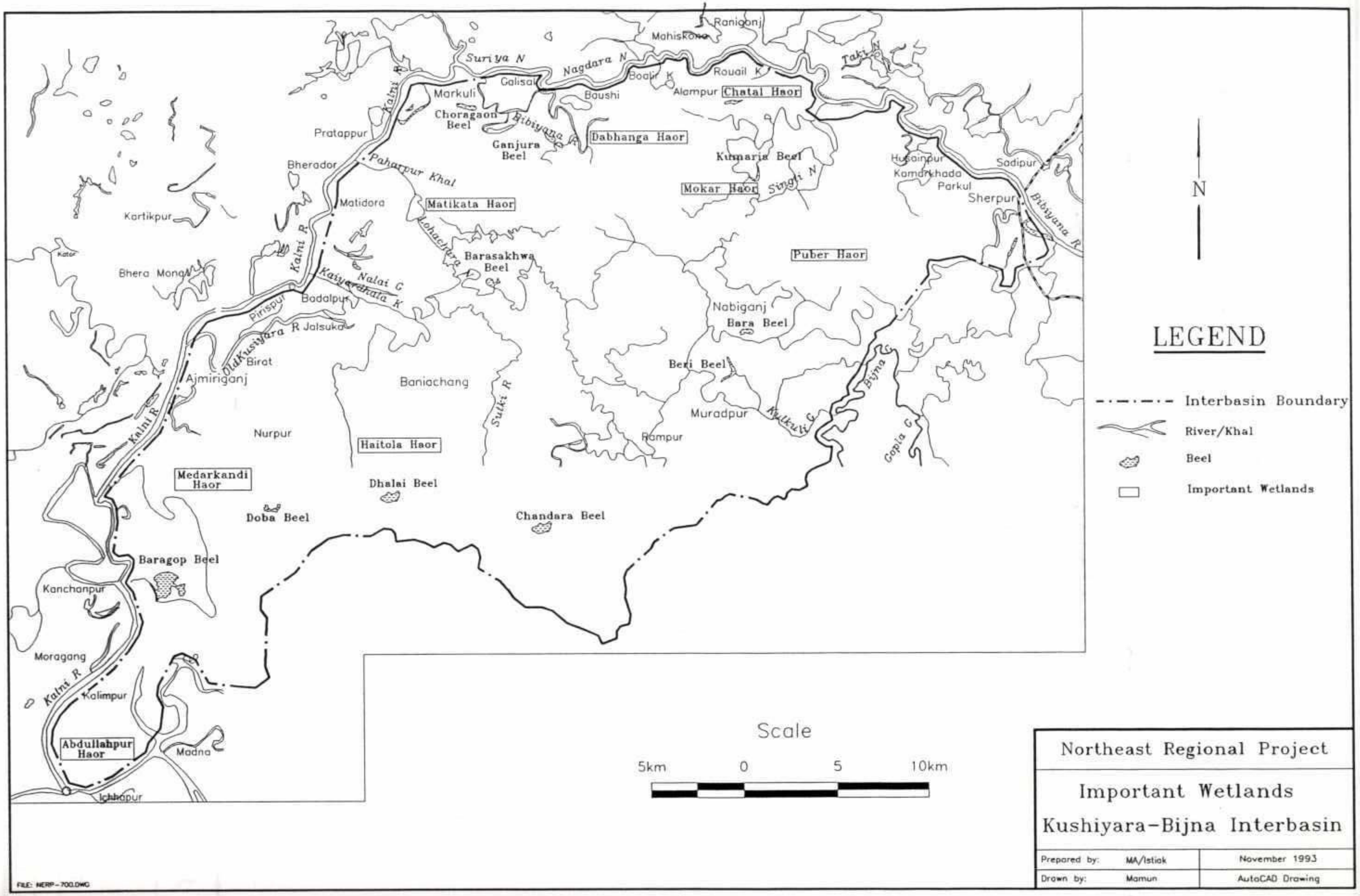


Legend:
- ■ Maximum Annual
- ● Maximum Pre-Monsoon
- ▲ Minimum Annual

Northeast Regional Project			
Annual Water Levels Kushiyara River Kushiyara-Bijna Interbasin			
Prepared by:	Dave G. Mclean	May 1993	
Drawn By:	Mamun	AutoCAD Drawing	

FILE: NERP-688.DWG

Figure 6



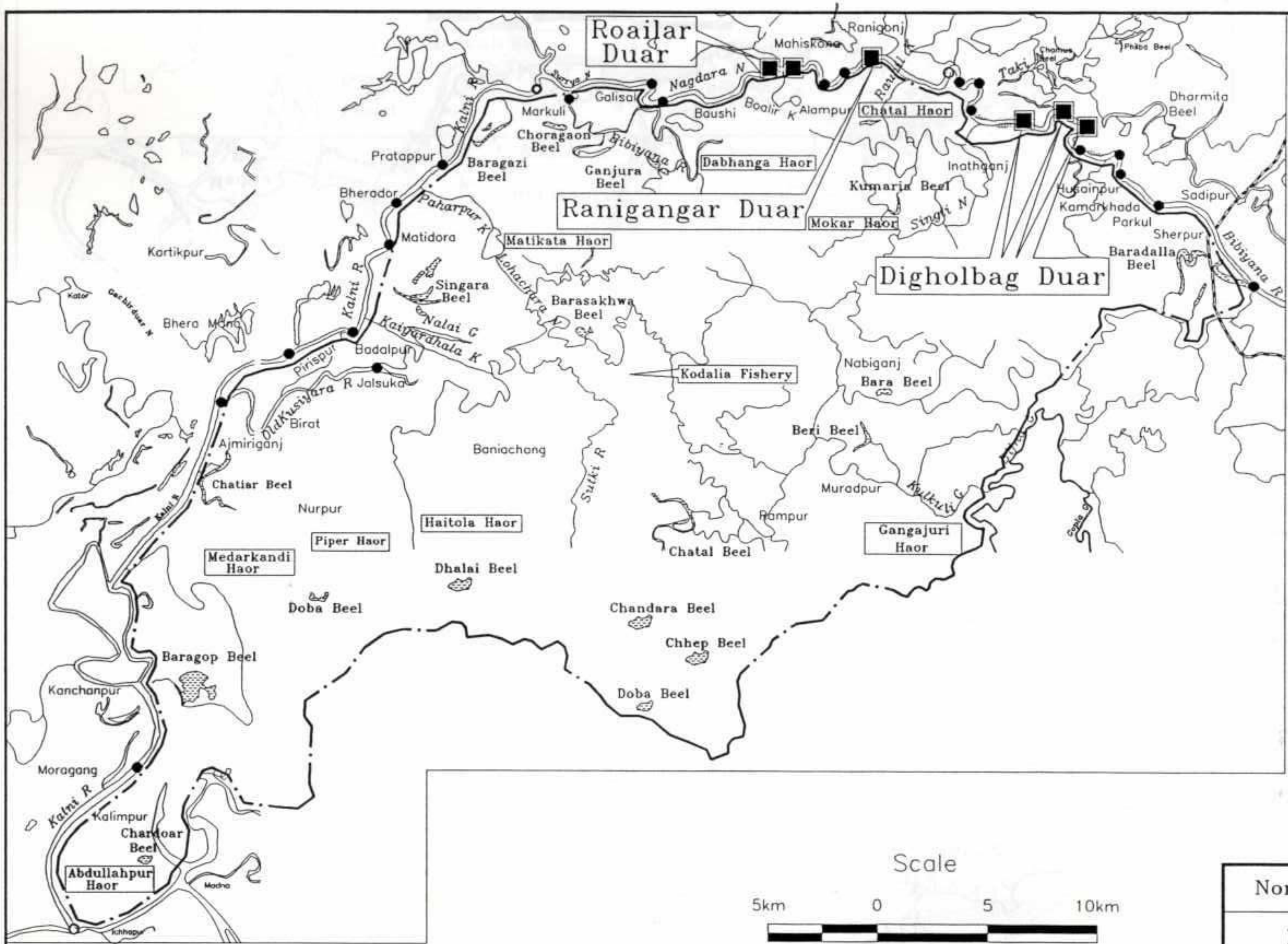
Northeast Regional Project

Important Wetlands

Kushiyara-Bijna Interbasin

Prepared by:	MA/Istiak	November 1993	
Drawn by:	Mamun	AutoCAD Drawing	

Figure 7



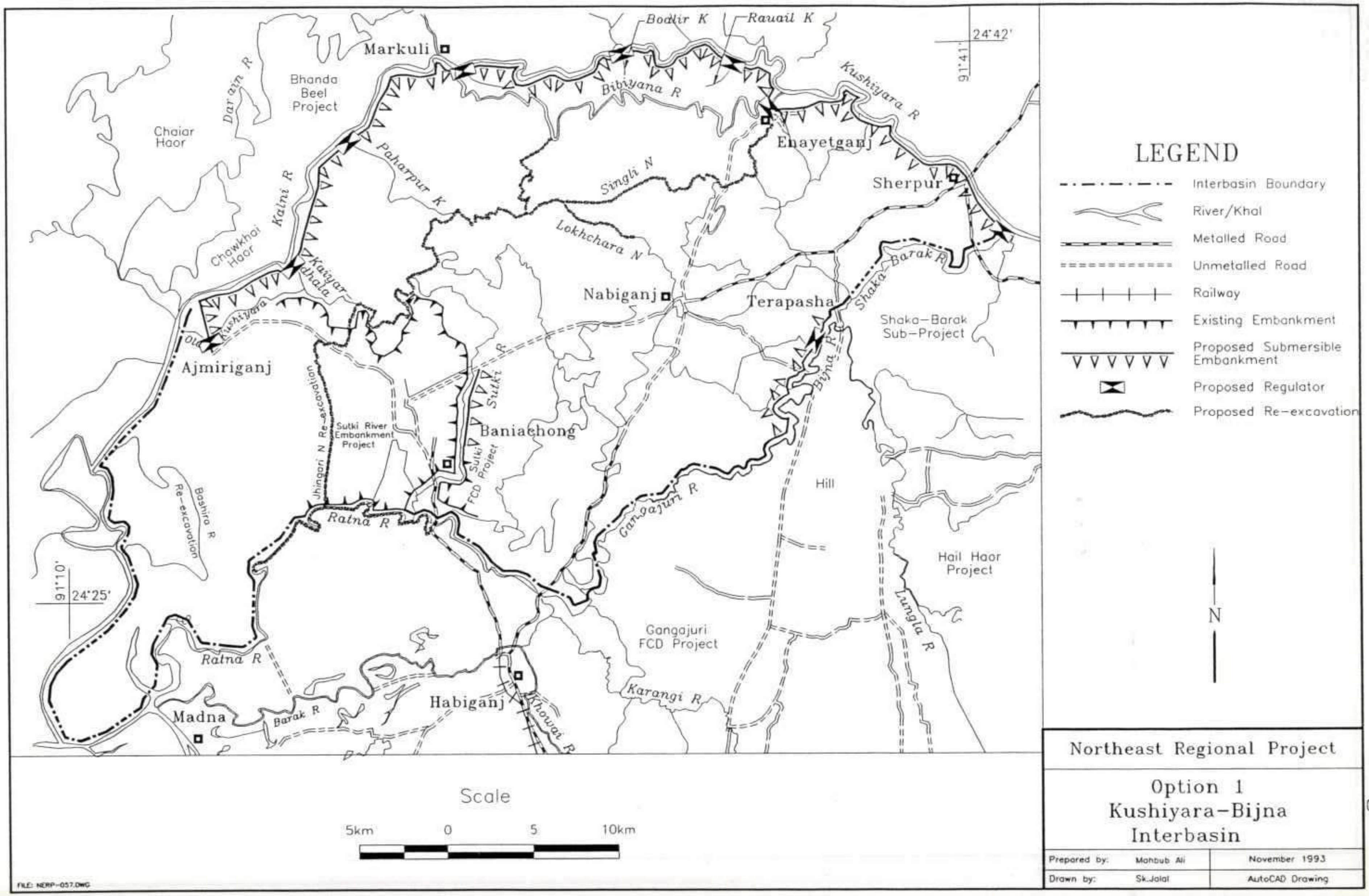
Northeast Regional Project

Fishery Resources

Kushiyara-Bijna Interbasin

Prepared by:	Mahbub Ali	November 1993
Drawn by:	Mamun	AutoCAD Drawing

FILE: NERP-690.DWG



LEGEND
Interbasin Boundary
River/Khal
Metalled Road
Unmetalled Road
Railway
Existing Embankment
Proposed Submersible Embankment
Proposed Regulator
Proposed Re-excavation
Markuli
Bodlir K
Rauail K
Bibiyana R
Kushiyara R
Enayetganj
Sherpur
Bhanda Beel Project
Chaiar Haor
Darain R
Kalni R
Chowkhai Haor
Paharpur K
Singli N
Lokhchara N
Nabiganj
Terapasha
Shaka Barak R
Shaka–Barak Sub–Project
Kaiyar dhala
Old Kushiyara
Ajmiriganj
Jhingari N Re-excavation
Sutki River Embankment Project
Sutki R
Baniachong
Sutki FCD Project
Bijna R
Gangajuri R
Hill
Hail Haor Project
Bashira R Re-excavation
Ratna R
Gangajuri FCD Project
Lungla R
Karangi R
Habiganj
Khowai R
Madna
Barak R
91°41'
24°42'
91°10'
24°25'
N
Scale
5km
0
5
10km
Northeast Regional Project
Option 1
Kushiyara–Bijna
Interbasin
Prepared by:
Mahbub Ali
November 1993
Drawn by:
Sk.Jalal
AutoCAD Drawing
FILE: NERP-057.DWG

Figure 8

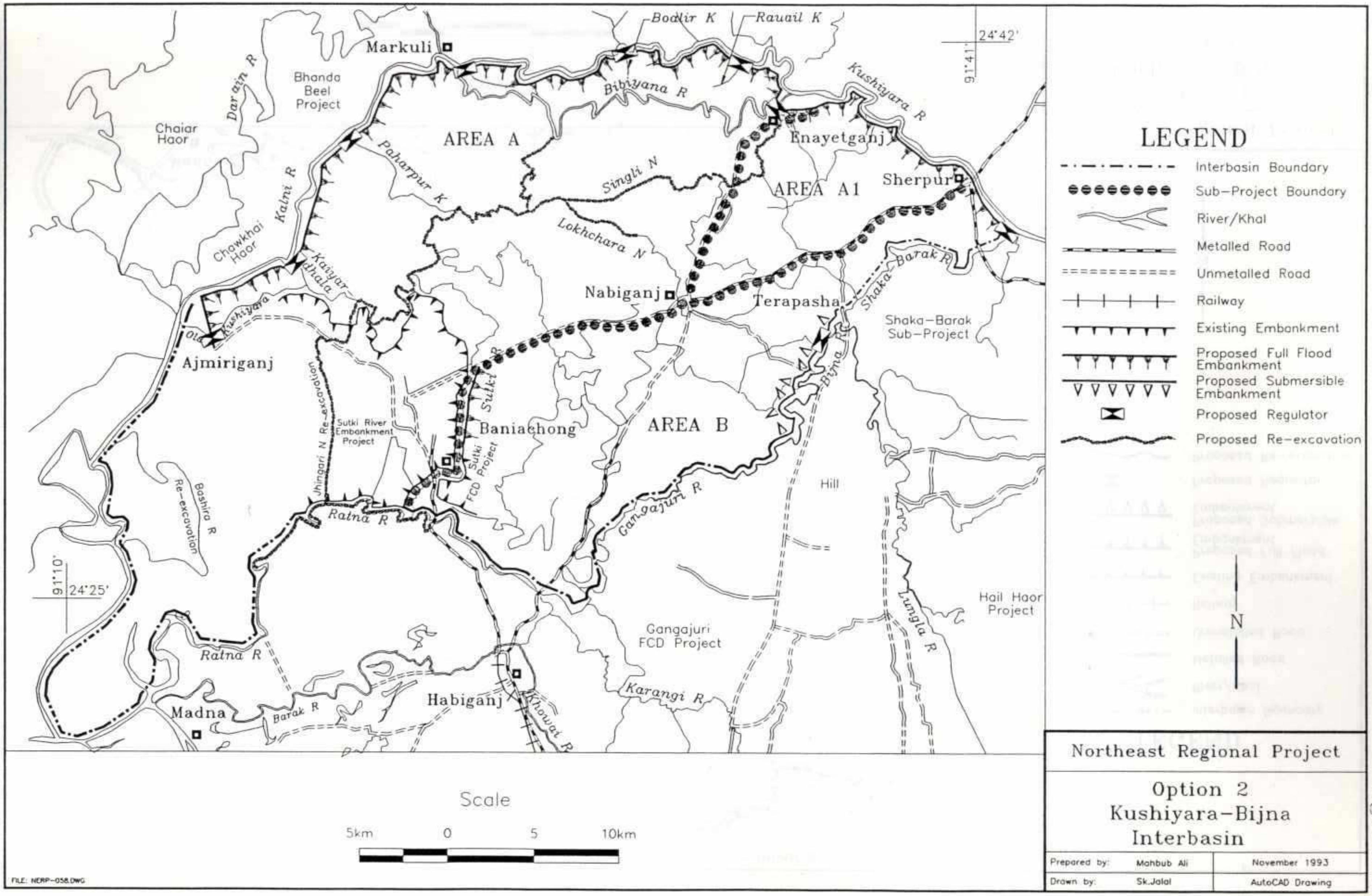

LEGEND
Interbasin Boundary
Sub-Project Boundary
River/Khal
Metalled Road
Unmetalled Road
Railway
Existing Embankment
Proposed Full Flood Embankment
Proposed Submersible Embankment
Proposed Regulator
Proposed Re-excavation
N
Markuli
Bhanda Beel Project
Chaiar Haor
Darain R
Chowkhai Haor
Kalni R
Kaiyar thala
Old Kushiyara
Ajmiriganj
Bodlir K
Rauail K
Bibiyana R
Kushiyara R
AREA A
Paharpur K
Singli N
Lokhchara N
Enayetganj
AREA A1
Sherpur
Nabiganj
Terapasha
Shaka-Barak R
Shaka-Barak Sub-Project
Bijna R
Sutki R
Baniachong
AREA B
Sutki River Embankment Project
Jhingari N Re-excavation
Sutki FCD Project
Bashira R Re-excavation
Ratna R
Gangajuri R
Hill
Hail Haor Project
Lungla R
Gangajuri FCD Project
Karangi R
Habiganj
Khowai R
Madna
Barak R
91°41'
24°42'
91°10'
24°25'
Scale
5km 0 5 10km
Northeast Regional Project
Option 2
Kushiyara-Bijna
Interbasin
Prepared by: Mahbub Ali
November 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-058.DWG

Figure 9

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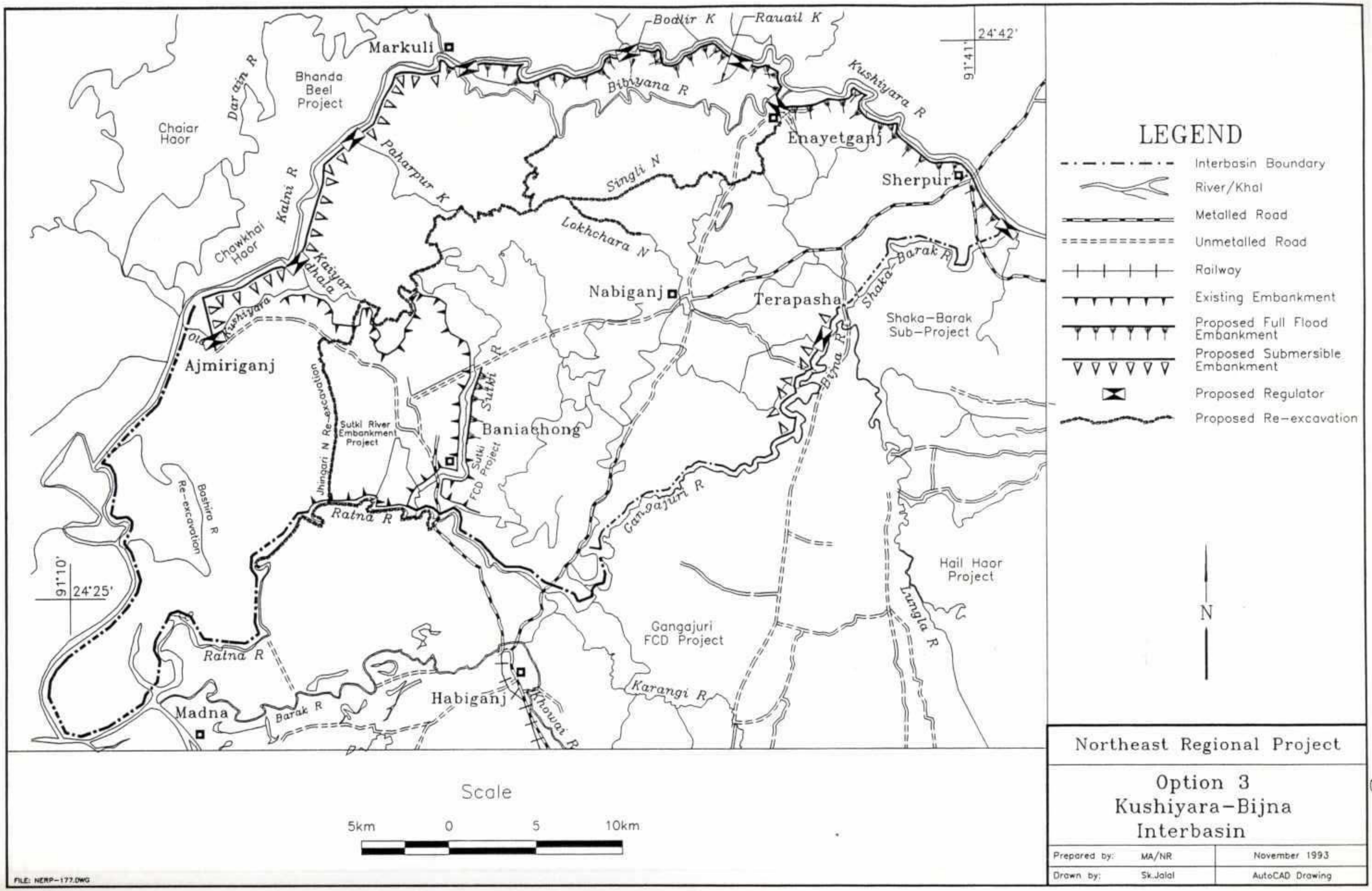

Figure 10