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)

PRE-FEASIBILITY STUDY

UPPER SURMA-KUSHIYARA PROJECT

April 1993

Shawinigan Lavalin (1991) Inc.
Northwest Hydraulic Consultants

in association with

Engineering and Planning Consultants Ltd.
Bangladesh Engineering and Technological Services
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ACRONYMS AND ABBREVIATIONS

BBS	Bangladesh Bureau of Statistics
BFRSS	Bangladesh Fisheries Resource Survey System
BRDB	Bangladesh Rural Development Board
BWDB	Bangladesh Water Development Board
DAE	Department of Agricultural Extension
DPHE	Department of Public Health Engineering
EIA	environmental impact assessment
EIRR	economic internal rate of return
EMP	Environmental Management Plan
EPWAPDA	East Pakistan Water and Power Development 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	Pakistan Water Department
RCC	reinforced concrete
SLI	SNC-Lavalin International

US \$1 = Tk 38

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1. INTRODUCTION

1.1 General Information

BWDB Division:	Sylhet
District:	Sylhet
Thana(s):	Beanibazar, Golapganj, Kanaighat, Zakiganj
MPO Planning Area:	26
Gross Area:	49,200 ha
Net Area:	33,600 ha

1.2 Scope and Methodology

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

1.3 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 Chapters 7 and 8 provide analyses of the two best options. Chapter 9 flags outstanding issues which need to be addressed if either of the initiatives is moved on to feasibility. The annexes consist of detailed information to support the main body of the report.

2. BIOPHYSICAL DESCRIPTION

2.1 Location

The Surma-Kushiyara Project covers a gross area of 49,200 ha in the northeastern part of Sylhet district, between latitude 24° 43' and 25° 02' North, and longitude 91° 59' and 92° 30' East. The project area is confined by the Surma and Kushiyara Rivers from the bifurcation of the Barak River in the east to the hills between Golapganj and Manikkona near Fenchuganj in the 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 40.6 C in May and the lowest at 8.9 C in December and February. The lowest monthly temperature is in January, when the mean is 18.7 C and the highest monthly temperature is in July, when the mean is 28.8 C.

Rainfall distribution shows a general pattern of gradual increase from south to north. Average annual rainfall in the area ranges from about 3000 mm in the south near Fenchuganj to about 5000 mm in the north near the outfall of Lubha into the Surma River. Mean monthly rainfall varies from 9.2 mm in January to 916.5 mm in June, and mean annual rainfall is 3833.7 mm. Potential evapotranspiration is lowest in December at 102.6 mm/month and highest in March at 162.4 mm/month.

2.3 Land (Physiography)

2.3.1 General Description

The Surma-Kushiyara Project area consists of two topographically distinct sub-areas: a saucer shaped plain of the Sada Khal basin in the eastern part of the area, and hills plus the old Kushiyara (Kura Gang) floodway in the western part.

The area is dotted with beels and laced with a dense network of internal khals. Most of the khals originate from the surrounding Surma and Kushiyara Rivers, and drain into the main drainage channels of the area, the Sada Khal and the Kura Gang, (each of which have several names along their courses). Several of the khals pass through beels and supply them with fresh water from the rivers during the monsoon.

The ground elevations of the area vary from about 6.5 m to above 17 m PWD. The high ridges along the river banks are about 3 m to 4 m above the lowlands in the interior part of the basin.

The locations of low-lying and hilly areas within the project are shown in Figure 1. The project basin elevation versus cumulative area relation is given in Table A.3 and graphically presented for the area upstream from the Sheola-Charkhai Road (Area A) in Figure 2, and for the area downstream from the Sheola-Charkhai Road (Area B) in Figure 3.

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2.3.2 Soils

Soils in the Surma-Kushiyara project area were developed from alluvial sediments laid down by the Surma and Kushiyara Rivers. Heavy clay soils occur in the deeply flooded basins. Silty clay soils occur on low, smoothed-out ridges and basin edges. Silty clay loams are found primarily on ridges while medium texture soils (loam to silt loam) occupy the highest topographical positions.

The finely textured soils (silty clays and clays) are poorly to very poorly drained, grey to dark grey in colour and have low available moisture holding capacity. Moderately fine textured (silty clay loam) and medium textured (silt loam) soils are olive brown to grey in colour, imperfect to poorly drained and have high to moderately high available moisture holding capacity. The natural fertility of these soils is moderate and they are capable of producing fairly good crops.

2.4 Water (Hydrology)

2.4.1 Runoff Patterns

The hydrological regime of the Surma-Kushiyara basin is governed by the Surma and Kushiyara Rivers, distributaries of the Barak River.

The Barak River is about 400 km long and has a drainage basin of 25,263 km^2 which is located in India. The upper part of the basin is hilly with mountains reaching 3000 m above sea level. The river descends to about 30 m PWD in the flood plain before it enters Bangladesh at Amalshid, where it bifurcates into the Surma to the north and into the Kushiyara to the south.

The Surma and Kushiyara Rivers, which flow on the higher ridges, define the natural boundaries of the project basin. As the interior part of the basin is below the banks of the rivers, the rivers dominate the flooding and also control drainage from the project area.

The Kushiyara River does not have any tributaries within the project boundary (the Sonai River channel in India has been closed), and all the discharge of the river comes from the Barak.

The Surma has three right bank tributaries, the Baliachara, the Gumra, and the Lubha Rivers. The Baliachara and the Gumra Rivers have small catchments (132 km^2 total), and as they pass through a large flood plain before joining the Surma their floods are moderate. The Lubha River has a catchment of about 724 km^2, most of which is in the Cachar Hills of Assam in India. It carries high peak flash floods which discharge into the Surma at Bandarbari about 40 km downstream from Amalshid. During the monsoon, following rainstorms, the Lubha flood inflows cause the current in the Surma to reverse in the entire reach from Bandarbari to Amalshid. This condition can last for several hours.

The Surma and Kushiyara Rivers are in their flood stage between April and November and water enters the area at this time through open khals and by overbank flow.

2.4.2 Flooding

The Surma-Kushiyara Project area experiences two types of floods: the pre-monsoon flash floods occurring from March to May, and normal monsoon floods occurring between June and October. In some years, flash floods may also appear during the post-monsoon period from October to December.

Most of the pre-monsoon floods (up to 1:10-year before 15 May) are within the riverbanks but water can enter the project area through several open spill channels.

During the construction of the Surma embankment all left bank spill channels were closed. Subsequently, several khals are being reopened and closed annually. The Kakura Khal, which was also closed has been opened and now remains open.

According to local residents, the Kakura Khal used to be a small channel and the Surma water would enter the khal only during high river stages. Since the embankments were constructed, flow in the Kakura Khal increased and its channel is eroding at high rate. Presently this khal is the main source of pre-monsoon floods in the lower parts of the project area near Sheola and Erali Beel.

The estimated inflow through the Kakura Khal is about 200 m^3/s. Since the Sada Khal is silted downstream of the Sheola Road Bridge, the inflow from the Kakura Khal causes flooding of the lands in the upper part of the basin. In the post-monsoon the Kakura Khal drains back into the Surma River.

In addition to the open khals, during the monsoon, the Surma left embankment is breached or cut by the public in several places. Some cuts are made to facilitate navigation across the Surma-Kushiyara basin and other are made by farmers, apparently to bring silt into the low beel areas.

Five khals remain open on the Kushiyara River: Jagirdari, Napit, Kharati (an outfall of the Sada Khal), Aval and Karam Khal. The offtakes of these khals are partly silted and they serve as Kushiyara high water spill channels during the monsoon season. Other Khals are closed or completely silted.

Intensive siltation in the lower section of the Sada Khal, coupled with flood inflows from the Surma through the Kakura Khal prevent drainage and intensify basin flooding during the pre-monsoon and monsoon seasons.

At present the project is embanked along the entire Surma boundary and along the Kushiyara from Amalshid to Chandrapur. However, due to the existence of the open khals (mainly the Kakura Khal) the middle and lower part of the area is subjected to pre-monsoon flooding. During the monsoon between June and October), about 80% of the project area is flood affected. During this period, the Surma and Kushiyara Rivers stages are close to or above their banks. Also during this period, most of the flood inflow into the basin is from the Surma, and during peak floods, the two rivers are interconnected through the Kakura-Sada and other khals.

2.4.3 Drainage

Water levels in the Surma and Kushiyara Rivers remain above the basin level for most of the monsoon season, which restricts gravity drainage.

Drainage from the project is effected through the centrally located Sada Khal in the upper part of the basin and through the Kura Gang (an old Kushiyara channel) in the lower part of the project. The Sada Khal basin has a dense network of khals and beels which retain as well as drain local runoff into the Sada Khal. However, the outfall of the channel is partially silted and most of its monsoon discharge flows across the floodway into the Kura Gang which empties into Damrir Haor near Fenchuganj.

At the end of monsoon when the Kushiyara and Surma stages fall rapidly, the water accumulated in the project basin drains back into the rivers; initially through several of the open khals and later on only through the Kakura and the Sada Khals. Since the lower section of the Sada Khal is silted, towards the end of the drainage period the part of the basin upstream from the Charkhai-Sheola road drains only to the Surma through the Kakura Khal. As a result, post monsoon drainage is slow.

2.4.4 Water Bodies

Open water bodies
About 65% (22,850 ha) of the project area is seasonally inundated to a depth of greater than 0.3 m of which 3% (700 ha) is perennial beels. The larger permanent water bodies are: Anwa Gang, Balai Haor, Chechua Beel, Chatal Beel, Chapti Beel, Chunnia Beel, Dubail Beel, Dubag Beel, and Erali Beel. Sada Khal and Kura Gang are the two major drainage systems in the area. Most of the khals which drain into these systems are spill channels of the Surma and Kushiyara Rivers. Most of the khals in the Surma-Kushiyara basin are seasonal. The size of these open water bodies is decreasing due to siltation.

Closed water bodies
In addition to the open beels and khals there are over 10,000 ponds and ditches used mainly for fish production. There are 4594 ponds in the project area covering about 355 ha of land, and more than 6000 ditches suitable for seasonal fish production. More than half of homesteads in on high land have ponds.

2.4.5 Surface Water Availability

The Surma and Kushiyara Rivers are the external source of water in the Surma-Kushiyara Project area. During the rainy season, spills from these two rivers augment the discharge in the Sada Khal and in the Kura Gang which are the main drainage collectors of the upper and lower part of project area respectively. Towards the end of the dry season the internal khals dry up.

Surma River
Within the project boundary, the Surma River conveys a part of the Barak River discharge and the discharges of its right bank tributaries; the Lubha, Gumra, and Baliachara Rivers. The Gumra and Baliachara are small streams which are dry during winter season.

At the bifurcation, the channel bed of the Surma is higher than that of the Kushiyara, and as a result the inflow from the Barak into the Surma is lower. It varies from about 40% of the Barak discharge at high stages to nothing at the low stages.

In an average year, during the dry months between January and March, there is no flow in the Surma between Amalshid and the outfall of the Lubha River. The dry season flows in the Surma measured at Kanaighat Station No. 266 originate mostly from the Lubha River.

The mean monthly discharges in the Surma River recorded at Kanaighat range from a 2.7 m^3/s minimum in March to a 1960.3 m^3/s maximum in August. For details on water levels and discharges refer to the tables in Annex A.

Kushiyara River
Starting at the bifurcation point, the Kushiyara River has a higher bed slope and is much deeper than the Surma River. The distribution of the Barak flow into the Kushiyara ranges from about 60% during high river stages to about 100% during low river stages.

The Kushiyara does not have any branches within the project boundary, since the left bank Sonai River channel in Karimganj in India has been closed. All the Kushiyara right bank khals within the project are spill channels. The Sada Khal (Kharati Khal at the outfall) and the Kura Gang convey spill waters of the Surma and Kushiyara Rivers and local basin runoff.

There are three hydrometric stations on the Kushiyara within the project: Station No. 172 at Amalshid, Station No. 173 at Sheola, and Station No. 174 at Fenchuganj. Long-term stage and discharge data are available at Sheola, and stage data are available at Amalshid and Fenchuganj.

The mean monthly discharges in the Kushiyara River recorded at Sheola range from a 37.0 m^3/s minimum in March to a 2188.1 m^3/s maximum in August. The water level and discharge data are presented in Annex A.

Sada Khal
The Sada Khal, which has different names at various locations, is the main drainage collector of the upper basin of the Surma-Kushiyara Project. It originates as Rahimpur Khal at the eastern end of the basin and falls into the Kushiyara as Kharati Khal about 10 km downstream of Sheola Bridge. During the rainy season it carries the inter-riverine rainfall runoff and the combined flood spills from the Surma and Kushiyara Rivers. During the rising river stages, when water from the rivers enters the basin, the Sada Khal does not drain into the Kushiyara through its outfall (the Kharati Khal), but rather is diverted over the floodplain into the Kura Gang which empties into Damrir Haor at the western end of the project. As river levels begin falling, the basin drains back to the rivers through the open khals. However, due to siltation of the channel downstream of the Sheola Bridge, late post-monsoon drainage (through the end of December) from the Sada Khal basin is into the Surma via the Kakura Khal.

A gauging station was installed in the Sada Khal at the road crossing at Sheola in 1952. Water level and discharge data for the wet months from June to November are available until 1977. The highest flow was 1970.6 m^3/s, recorded on 4 August 1964 at a stage of 13.05 m PWD, and the highest stage was 14.06 m PWD recorded in 1966. The Sada Khal water records represent a combined flow of the local runoff and the spills from the Kushiyara and Surma Rivers. The water data from the Sada Khal Station No. 173A are provided in Annex A.

2.4.6 Ground Water

The area is a part of the Upper Meghna Valley alluvium. Sediments carried by the Surma and Kushiyara Rivers have gradually built up the land. The deposits are predominantly fine textured silts and clays which have poor water bearing capacity. Therefore, there is a limited possibility of locating a good aquifer at a shallow depth.

Seven exploratory bore holes were drilled within the Surma-Kushiyara basin in 1965 as part of the Upper Kushiyara Project feasibility investigation. The results of the boring (Table A.13) show that the upper soil strata contains mostly clay and silt. This indicates that there may not be sufficient ground water potential to support a reliable tube well irrigation system.

There is, however, sufficient ground water to meet domestic requirements. Department of Public Health Engineering (DPHE) installed over 2000 hand tube wells in the area by 1990. Findings of the field investigations conducted in the area in 1992 under the FAP 16 Environmental Study reveals that most of the HTWs have adequate water supply during the dry months of March and April. Many wells, however, are not in an operating condition (ISPAN, 1992).

2.5 Land/Water Interactions

2.5.1 Siltation

Serious siltation occurs at the offtakes and outlets of the khals which flow into and out of the Kushiyara River.

There is no siltation associated with khals originating in the Surma River. This may be attributed to the fact that the Surma has a higher water profile than does the Kushiyara. The corresponding velocities are also higher and prevent sediment deposition at the offtakes of the Surma's distributaries. The sediments carried with the flows from the Surma are deposited in the beels and in lower reaches of the basin drains.

Intensive siltation takes place in various khals and beels. These include Rahimpur Khal upstream and downstream of the regulator, offtakes and upper sections of Senapati, Muskendar, Shiker Mohal Khal, Dubail Beel, July and Urban Beel. Also, the lower section of the Sada Khal and its outfall (Kharati Khal) have seriously infilled with sediment. With the exception of the Sheola Khal, all of the Kushiyara right bank khals downstream from Sheola are partly or completely silted at their outfalls.

Water flows from the rivers into the basin, and siltation of the khals and beels in the upper part of the project area impacts on fisheries. Siltation of the khals in the lower part of the project causes drainage congestion and intensifies flooding, primarily during the pre-monsoon season.

2.5.2 River Erosion

River bank erosion and breaching of the embankments occur along both the Kushiyara and Surma River. Erosion rates are generally low and occur due to progressive migration of the river's meander pattern. This process is driven by secondary currents in the channel which deposit sediment on the convex side of the meander bend and scour material from the outer (concave) side of the bend. As a result, local sloughing and slow bank retreat are occurring at virtually each of the sharp bends in the rivers. Erosion rates on the Kushiyara and Surma Rivers are limited by the cohesive nature of the banks and the low velocities of the river.

The highest rates of bank erosion have occurred near Amalshid at the point where the Barak River divides to form the Surma and Kushiyara Rivers. According to available historic maps, the location of the bifurcation appears to have shifted considerably over the last 40 years. This shifting has produced erosion rates of 15 m/year on the Surma and Kushiyara Rivers. Recent surveys have shown that the banks are continuing to retreat in spite of temporary protective works that have been constructed.

2.5.3 Crop Damage

Flood damages agricultural crops almost every year. Because of poor drainage, flood water remains in the fields for long periods. This delays seedbed preparation and transplanting of both aman and boro. As a result, some lowlands and medium-lowlands remain fallow. During April and May, flash floods often destroy the early growth of aus and broadcast aman. These floods can also damage standing boro prior to harvesting. Transplanted aman is affected by seasonal floods and by late flash floods.

At present, due to the inadequate drainage and flooding the agricultural potential of the project area is not fully utilized. Part of the cultivable land remains fallow, and the present crop production is low due to flood damage.

2.6 Wetlands and Swamp Forest

2.6.1 Natural Wetlands

There are two very important wetlands situated within this project. The most important is *Balai Haor* consisting of four perennial beels (Dubail, Jugni, Khagra, and Singaikuri) with a combined area of about 300 ha. The haor is situated in between Sada Khal and Kushiyara river and on the west side of Atgram Zakiganj by-pass road. It is a medium sized, flat-shallow wetland which is a very good habitat for numerous submerged and rooted floating plants. It also acts as an important stopover for large numbers of migratory waterfowls — particularly ducks. In terms of wildlife, the threatened Smooth Indian Otter still inhabits this haor. *Rana temporalis*, a very rare amphibian is also reported in this wetland. This wetland meets at least three of the criteria for wetlands of international importance under the Ramsar Convention: criterion 1(d), it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region; criterion 2(b), it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna; and criterion 3(b), it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity and diversity.[1]

The second most important wetland is *Erali Beel* with an area of about 320 ha. The main beel has two sister beels — Boomail beel and Chatal beel which are near and are connected by Kura Gang. Erali Beel is relatively small in size but deep and is surrounded by small hills. There are three small islands inside the beel created by those hills. These islands and the surrounding hills have a unique mixed plant community consisting both wetland and hilly plants. This beel is also a preferred stopover for migratory birds and the very rare Hen Harrier was observed in this beel[2]. The small islands serve as a nesting ground for freshwater turtles. This area is also populated by some other smaller mammals including otters, fishing cats, and civets.

2.6.2 Swamp Forest Trees

There is no swamp forest within this project area, but individuals of these species can be found in homestead groves.

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[1] Montreux Proceedings, Vol I, Annex I, Rec. C.4.2 (Rev)

[2] Dr. D. Scott and S.M.A. Rashid, Ornithology Main Survey, NERP, 1992

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)	33,600
Homesteads	1230
Beels	713
Ponds	800
Channels	490
Hills	4537
Fallow[1]	4900
Infrastructure[2]	2930

[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 levees of the Surma-Kushiyara Rivers and along various road sides. Exceptions are along the hills of Golapganj and the Beanibazar area. The river banks and Sylhet-Zakiganj road sides are densely settled, while settlements tend to be more sparsely scattered along the foot of the hills. While settlements are also found along the various roads, they are extremely sparse in areas where the land elevation is very low.

Flood Damage to Housing
Generally, there has been very little monsoon flood damage to the villages, except erosion of homesteads at certain levels along the Kushiyara River. More recently, however, many villages along the Kushiyara as well as along the interior sides are reporting damage to homesteads as a result of flash floods between July and September. The damage mainly results from overbank Kushiyara flow and from water intrusion through the breaches. Obviously, the lower the elevation at which homesteads are placed, the worse is the risk of flooding.

Coping Strategies
Homestead platforms are usually raised up to one meter to avoid monsoon flooding. Wave action which erodes homestead platforms in some areas of the region is almost non-existent here. Flood waters from the monsoon flash floods usually recede from the homesteads within two or three days. If there is severe flooding, villagers generally make platforms inside their houses and shift their belongings to a safer place. In such situation, the poor suffer the most.

3.1.2 Demographic Characteristics

The total population of the project area is estimated to be 376,000 of whom 184,300 are female. The gender ratio is calculated to be 104 (males to 100 females). The total households, are estimated to be 60,200 within 470 villages. The population increased by 27.7% between 1981-91 in the district of Sylhet.

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	16.4	15.9	14.0	45.6	2.0	6.1	100.00
Female	17.5	16.9	13.6	46.2	1.3	4.5	100.00
Total	16.9	16.4	13.7	45.7	1.6	5.6	100.00

Source: BBS, 1981 Population Census

The cohort distribution for males is: 32% are below 10 years of age, 45% are between 15 and 54 years of age, and 6% are above 60 years of age. The corresponding distribution for females is 35%, 46% and 4% (see Table 3.2).

The average population density is 764 persons per km^2, with density ranging from a maximum of 893 persons per km^2 in Golapganj to 456 persons per km^2 in Kanaighat. The average household size in the area is estimated to be 6.25 persons.

3.1.3 Quality of Life Indicators

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

Literacy

In the project area the literacy rate is found to be extremely varied. According to the 1981 census, the literacy of the population at 5 years of age and above varied from 14% in Kanaighat thana to 28% in Beanibazar thana. The corresponding figures for females were 6% and 21% respectively for the same thanas. The rate appears to have increased over the last 10 years. According to the 1991 census, the literacy rate for all people of Sylhet district is recorded as 25% for both male and female.

According to the 1981 census, school attendance in the project area for all children 5 - 9 years of age varies from 22% in Kanaighat thana to 40% in Beanibazar thana. Attendance for females in this age cohort in these two thanas varies from 16% to 37% respectively. Attendance for all youths between the ages of 5 and 24 is 18% and 32% for these thanas while the corresponding attendance for females is 10% and 26%.

The situation is worse for the rural poor. They can not afford to send their children to school. Moreover, many villages, especially in Kanaighat, and Zakiganj thanas, have no primary schools. The average number of primary schools per 10,000 population is estimated to be 5.5 for Sylhet district (BANBEIS, 1990).

Access to Health Services

The district headquarters of Sylhet has a medical college with a hospital 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 162,190 persons and one doctor for every 9915 persons in the district of Sylhet. One hospital bed is meant for 2351 people. Immunization coverage of children below two years of age is quite high for the project area. The rate varies from 45% in Zakiganj thana to 65% in Golapganj thana (1990).

Rural Water Supply

Detail information on access to rural water supply for drinking purposes are not available for the project area. However, for the rural areas of the district of Sylhet, DPHE[1] reports the availability of one working tube well for 134 persons. In 1990, 59% of the households had access to potable water in the district. 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 banana or betel nut leaves. 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 t aman; employment for men is mainly limited to transplanting which occurs between August and September and harvesting which occurs in late November and December. Employment during boro cultivation is limited to the labourers living in low-lying villages.

The wage rates for male agricultural labourers varies from Tk 40 - 50 with or without a meal per day during peak agricultural months. During months when there is no agriculture work, the wage rate varies from Tk 25 - 35. It is reported that during the monsoon months, some labourers work on sand and stone carrying activities. They are usually involved in transporting these materials from the quarries at the Sarigoyain and Lubha rivers to various construction and sale centres throughout Sylhet district. The average daily income from this activity varies from Tk 60 - 100. During months when employment opportunities in agriculture are limited, some poor people migrate to Sylhet city to work as rickshaw pullers, as construction workers, or sometimes in household activities. Employment opportunities for women is very limited in the area, except for the Rural Maintenance Program of CARE, where a few poor women are employed. Women generally migrate to Sylhet city to perform household works, 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 Golapganj and Beanibazar thanas. However, such migration is less in other thanas of the project area.

[1] DPHE, 1991-92

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There is in-migration into the project area, mainly from Mymensingh and Noakhali. They come to the project area and stay seasonally to work on harvesting of rice crops and earth work.

3.1.5 Land Ownership Pattern

Land ownership is extremely skewed in the project area. Nearly half of the households are landless (with cultivable land less than 0.2 ha). Among the landless, about 1.5% have no homesteads of their own. If the definition of landless includes landholdings up to 0.4 ha, the number of households included increases by an additional 10%. 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 26%, 19% and 5% respectively.

The project area has little uncultivable land except for the deeper wetlands. As such, there are no community pastures in the area. The price of agricultural land varies from tk 15,000 to tk 40,000 per ker (0.12 ha) depending on the quality of the land and the intensity with which it can be cropped.

3.1.6 Land Tenure

Owner operation is common in the area. A few large land owners, particularly from Golapganj and Beanibazar thanas, share out their lands to tenants for operation. The share cropping system is that one-half of the produce is retained by the land owners but they provide no inputs. The leasing out of land in kind (chukti) is almost nonexistent in the area. However, leasing out of land with advance cash (pattani) is practised in some cases. The usual rate for such arrangements varies from tk 500 to tk 2000 per ker (0.12 ha) and this is paid in advance to the land owner for one year. 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

Traditional fishermen in the project area are very small in number. However, fishing is now practised as a profession by many poor people, particularly during monsoon months when they can fish in open water. Such non-traditional fishermen are increasing and they are larger in number in the low lying beel areas. Additional information on fishing practices and so on is given in Section 3.5.1.

3.1.8 Situation of Women

The strict gender division of labour in farming households entails the high dependance of men and women in agriculture production. Women's contribution, however, tends to be be less recognized. In Konaighat, Jaintiapur, and Gowainghat thanas, female seclusion is enforced more strictly than elsewhere in Sylhet. While in the city of Sylhet, women move with some freedom, their movement elsewhere in the District is highly restricted. Some poor women are reportedly working outside their homes in the CARE Road Maintenance Program. Others collect wild vegetables, fuel, and even catch fish with small fishing traps. These activities, however, tend to lower their families prestige. Education levels in the project area are also very low for both females and males and contraceptive acceptance is low. It is important to recognize that an accurate reading of women's situation in the context of the proposed project will require an extra effort since these women are not easily accessible — particularly by male outsiders.

Was there any attempt made by the consultant to send some female sociologist to them?

3.1.9 People's Perception

General

Local people's perception of their problems were solicited. These were related mainly to water and its impact on their livelihood and their suggestions as to the nature of interventions which solve these problems. These were collected through personal interviews, group discussions and meetings with various cross-sections of people during the relatively short (7 - 10 day) field work in the project area. These are described below.

Problems

Flooding, both pre- and monsoon, was described as a major problem of the area. This flooding mainly damages rice crops. Boro and aus are affected by pre-monsoon floods between April and May and accumulated rainfall. These flash floods enter through various breaches/canals from the Kushiyara river. There are also a number of smaller pockets so affected throughout the project area.

Monsoon flash floods during July and September damage t aman, particularly in Zakiganj and Kanaighat thanas. The flood waters enter from the Kushiyara and the Surma Rivers overtopping roads and embankments and last for 3 to 5 days in the upper areas. There are 2 to 3 such occurrences reported in every monsoon period.

Drainage congestion is another important issue as perceived by the farmers, particularly around the lower beels, where boro is grown. Similar congestion problems are reported by farmers from other localities of the area. This is because of silting up of the internal drainage canals as well as the rivers. In this context, Rahimpur khal and Sada khal are mentioned as a major problem since they have silted up in many places. Silting of the Surma and the Kushiyara Rivers was also referred to as a serious cause of flooding in the area.

Erosion of the Kakura khal is also mentioned as a serious problem of the area.

Subsistence and poor fishermen stated that the prohibition of open water fishing by jalmohal leasees was for them a major problem. This practice was attributable to the influential and powerful leasees. The fishermen cooperatives under the New Fisheries Management Policy generally did not adopt this practice. It was also noted that where the leases were taken by local fishermen, much more care was taken to ensure the sustainability of the resource. Fishermen considered that the major problem for fisheries was overfishing though they also stated that roads and embankments in the flood plain also reduced fish production. Concern was expressed that fish migration into the project area would be reduced if a project was constructed which closed the Sadar and Rahimpur Khals.

People generally expressed the need for the water transportation network. If a proposed project did not provide for this transport, there would be a need to cut embankments during the early monsoon months.

Suggestions

Numerous suggestions were put forward by local people. However, some suggestions are meant for very small and localised issues. The most common are:

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- Re-excavate the Sada khal and Rahimpur khal to the extent necessary for internal navigation and drainage purpose.
- Develop the entire Kushiyara right bank and Surma left bank to protect intrusion of flood water into the project area.
- Dredge the Surma and the Kushiyara rivers.
- Construct sluice gate at Kakura khal with provision for boat passage.
- Lease jalmohals only to local fishermen.
- Allow poor and subsistence fishermen to catch fish in the flood plain.
- Conserve sufficient fish habitat, particularly in the kanda, for normal production of fish.
- Retain adequate provision for fish movement from the rivers to the beels.
- Any structures on the Sada and Rahimpur Khals should allow provision for navigation.

3.1.10 Local Initiatives

Information on specific local initiatives to avert flood-related problems in the project area were not collected during the field visit. However, 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 congestions. The main activity is to construct dams on various localised canals to stop the intrusion of pre-monsoon flash floods to save the boro crop. They would also assemble to re-excavate canals for quick 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 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 flood embankments along the Surma and Kushiyara Rivers, three flushing/drainage regulators, and river bank protective works at the Amalshid bifurcation and at Zakiganj town.

Surma Embankment

Construction of the Surma left embankment, locally called the "Surma Dyke", begun in the early 1950s. The main purpose of the embankment was to protect homesteads along the river. Records of design or construction of the first embankment are not available, but the 1960 irrigation maps show a continuous embankment from Sylhet to Charkhai. Construction of the section from Charkhai to Amalshid was begun in 1963 and continued until completion in 1985. In 1973 the SARM Upper Kushiyara Project Feasibility Report was accepted by BWDB, and the remaining portion of the embankment was constructed according to the design criteria set out in the Feasibility Report. The 1973 design was for protection of the area with embankments designed for 1:10-year return period flood. The proposed cross-section of the embankment was: 4.27 m crest width and side slopes 1:3 on river side and 1:2 on country side. Since 1985 BWDB carries annual maintenance and repairs of the Surma embankment under FFW Programme.

The Surma embankment, as constructed, varies greatly in height and cross-section. It is about 1.0 to 2.5 m high, has about 2.4 to 3.0 m crest width and about 1:2 side slopes. The embankment does not have a sufficient set back and in many places it is located right on the river bank. Embankment erosion by river flow and public cuts frustrate the objective of flood prevention.

Kushiyara Embankment
Kushiyara embankment construction has been carried out locally over the last 30 years, and at present it extends from Amalshid to Chandrapur (about 65 km). The main purpose of the embankment is to protect homesteads along the river. The alignment of the embankment is along the high ridge, in some places close to the river bank, it is about 1.5 m high, has a 2.4 m crest width and 1:1 side slopes. Unlike the Surma embankment, there are no public cuts in the Kushiyara embankment, but because of its proximity to the river, erosion and breaching during peak floods is a problem.

Structures
Along the Surma there are two flushing/drainage regulators: a single-vent (1.5 x 1.8 m) Moulavir Khal Regulator in the Surma embankment to control the flow to Erali Beel, and a two-vent (1.5 x 1.8 m) Sunam Khal bridge cum regulator located about 1 km inland from the Surma River. These regulators, constructed in 1980 and 1985 respectively are in good operating condition. The Moulavir Khal was re-excavated in 1991.

One three-vent (1.8 x 2.4 m) bridge cum regulator was constructed in 1987 along the Kushiyara at Rahimpur. This regulator is used for flushing during monsoon, mainly for pisciculture. The structure is in good condition but the khal, which was closed prior to the construction of the regulator, fills with silt and needs to be re-excavated every year.

3.2.2 Irrigation

At present boro crops are grown in about 5,000 ha, using water conserved in local beels and khals at the end of monsoon. Traditional irrigation methods are used for irrigating the local boro grown in lower lands and low lift pumps are used for irrigating HYV boro rice (about 1,700 ha) grown in relatively higher lands. Only one deep tube well and several shallow tube wells are in operation in the project area.

Surface Water
There is no externally planned surface water development in the area. Local farmers manage the existing low lift pump irrigation which is based on the internal water stored in the basin at the end of monsoon. There is no irrigation from the Surma and Kushiyara Rivers within the project boundary.

Ground Water
Essentially the present ground water development in the project area is limited to hand tube wells for the supply of drinking water. The water potential of the deep aquifer is poor, which limits development of tube well irrigation (Section 2.4).

3.3 Other Infrastructure

A Roads and Highways Department regional highway runs through the project area from Golapganj to Zakiganj via Amalshid and from Charkhai to Sheola. Feeder roads connect the Highway with Mirganj Bazar, Sunampur, Chagli Bazar, Kanaighat, and Zakiganj with Atgram and Kaliganj Bazar. These roads are above the average annual flood level and suffer little flood damage.

Table 3.3 Present Crop Production

Crop	Damage Free Area			Damaged Area			Total Production
	(ha)	(t/ha)	(t)	(ha)	(t/ha)	(t)	
b aus	1830	1.25	2,287.5	6750	1.15	7,762.5	10,050.0
hyv aus	125	3.75	468.8	700	3	2,100.0	2,568.8
b aman	3530	1.75	6,177.5	1760	1.45	2,552.0	8,729.5
lt aman	2590	2.05	5,309.5	9500	1.85	17,575.0	22,884.5
hyv aman	275	3.95	1,086.3	1350	3.55	4,792.5	5,878.8
l boro	7910	2.25	17,797.5	1750	1.75	3,062.5	20,860.0
hyv boro	2310	4.55	10,510.5	1450	3.75	5,437.5	15,948.0
pulses	176	0.85	149.6				149.6
oilseeds	587	0.75	440.3				440.3
spices	59	2.25	132.8				132.8
vegetables	353	3.75	1,323.8				1,323.8

Construction was started on a new feeder road linking Zakiganj with Sheola along the right bank of the Kushiyara in the late 1980s. With 20 bridges and culverts completed, this work has been deferred.

There are about 90 km of village roads in the project area, out of which about 40 km are not accessible 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 average annual flood damage of Tk 1,140,000.

3.4 Agriculture

Agricultural crops are damaged almost every year in the project area by floods and drainage congestion. During April and May, flash floods often destroy maturing local and high yielding varieties of boro rice. The situation is further aggravated by the accumulation of rainfall due to poor drainage. Water levels build up during pre-monsoon and during the monsoon season, and damage occurs to all rice types. The present cropping patterns and the crop production are given in Tables 3.3 and 3.4.

Information with respect to average yields obtained under damage-free conditions, crops damaged, percent of the crop area damaged, yield reduction due to crop damage etc. were collected by interviewing farmers in the project. These data were analyzed to obtain the total production and are presented in Table 3.4.

Table 3.4 Present Crop Patterns

Crop Pattern	F0	F1	F2	F3	Total
b-aus - hyv aman	525 (15)	1100 (22)			1625
b-aus - lt aman	1925 (55)	3600 (72)	1080 (12)		6605
b aus - rabi	350 (10)				350
hyv aus - lt aman - rabi	525 (15)	300 (6)			825
lt aman - fallow	175 (5)		5310 (59)		5485
b aman - fallow			2070 (23)	3220 (20)	5290
hyv boro - fallow			540 (6)	3220 (20)	3760
l boro - fallow				9660 (60)	9660
Total	3500	5000	9000	16100	33600

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

Crop marketing patterns within the project area, like in other areas of Bangladesh, are largely traditional. Producers are compelled to dispose of part or, in some cases, all of their crops immediately upon harvest. The reason for farmers' inability to store their crops is variously: i) a need for cash; ii) lack of proper storage facilities (these typically consist of granaries located inside the household's main house); iii) crop loan obligations; or iv) tenure crop division arrangements. The producers are then frequently obliged to replace this food grain at a much higher price to meet daily consumption requirements. It is estimated that only 20 to 25% of the production actually enters commercial markets. Private traders handle about 90% of this amount.

Homestead agriculture production varies with the level and size of homesteads. On higher homesteads, which tend to be larger as well, trees (banana, mango, jackfruit, betel nut, bamboo, and so on) are common, providing fruit, fuel, and building material for use/consumption or sale. Lower, smaller homesteads have fewer trees. Most of the vegetables consumed by farming families are produced on the homestead plot, or on lower land adjoining it. Most farms keep poultry and many have cattle.

Homesteads are an integral part of the farming system. Courtyards are used for post-harvest activities (threshing, winnowing, parboiling, drying). Cow dung and compost made of domestic waste are used to fertilize agricultural land.

3.5 Fisheries

3.5.1 Floodplain fishery

About 15 important permanent beels exist within the project area of which the Erali beel complex, Dubail beel, Jugni beel, Khagra beel are the most renowned for fish production. Beels serve as overwintering refuges for the species present in the area. During the monsoon season, water from the Surma and Kushiyara Rivers flows in through open khals, breached dykes, and

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Table 3.5 Major Fish Species in the Surma-Kushiyara Flood Plain

BOROMACH	CHOTOMACH
Catla, rui, mrigel, kalibaus, ghonia, boal, air, rita, chital, gazar, shoal.	Singi, magur, koi, tatkini, pabda, kanipabda, bashpata, batashi, bacha, tengra, gulsha, bajori, taki, chela, darkina, mola, dhela, titputi, puti, balichata, rani, foli, chapila, tara baim, baim, boicha, napit, bheda, chanda, kaikka, icha.

by overtopping both the rivers banks. Most of the beels are isolated basins and in a few cases they are interlinked with each other by narrow channels.

Most of the large fisheries are leased by a few rich influential persons for a period, usually of three years. They generally reside outside the area and appropriate the profits from the catch. This system deprives local fishermen of access to the fisheries resources. Neither is there much opportunity to serve as labourers for the final catch since fishermen from outside areas are generally hired for this purpose.

Conflicts and tension are common over the issue of fishing the jalmohals in the area, particularly between farmers and fishermen. The jalmohal lessees construct and maintain water retention dams on the beels drainage canals which prevents timely boro cultivation in the peripheral zone of the beels. On the other hand, annual beel fishing in mid-winter is a common practice in the area which results in completely draining the beels to maximize the catch. Neither of these practices are in the interests of the farmers.

Verify Existing jalmohal regulation laws.

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

3.5.2 Species present in the area

Of the 133 species identified in the region, about 56 species inhabit the Surma-Kushiyara floodplain and beels. The most common of these species are listed in 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 larger 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 4 duars in the Surma River and 20 duars in the Kushiyara River adjacent to the project boundary.

3.5.4 Sources of fish and breeding

It is generally understood that early rain, thunder, flooding, temperature, grassy or rocky land influence spawning of freshwater fish. If conditions are favourable, during the flooding time, fish migrate from beels to adjacent grassy areas, to the rivers, and vice-versa.

It is considered that the Erali beel area is a breeding ground for many carp species as well as other commercially important fish varieties. Large numbers of carp fry and fingerlings were seen by local people during the month of May in 1991 and 1992. The Erali Beel complex includes three beels with islands surrounded by small hills. These special topographical features combined with coarse sand in the vicinity of the beels make this a very favourable environment for carp breeding. The Erali Beel is also renowned for live fish production.

Other than carps, most species of fish could breed in other locations within the project area. Makria Khal near Bahar village, Rahimpur Khal, Jigirdari Khal, Napit Khal and Kharati Khal are the major channels linking the floodplain and the Kushiyara River. The presence of deep duars in the surrounding rivers combined with the extensive floodplain makes the area an ideal place for fish production.

3.5.5 Production trends

Fish production in the Surma-Kushiyara area has apparently declined by 30-40% over the last 5 years. While no real estimates have been made of overall fish production for the project area, the estimated production is 1700 metric tons per year (see Table 3.6).

According to the NERP study, fish abundance is directly related to the level and duration of flooding, and access to the flood lands. The fish production in the project area has been declining. The identified causes of the fish decline are outlined below:

- Siltation of beels. The beel area has been reduced by about 30-35 percent; both, the depth of water and the water hectare-months are declining.

- Construction of sluice gates and closures of khals along the Surma left bank and the Kushiyara right bank. Regulators on Rahimpur, Sunam and Moulavir Bazar khals and closing or siltation of Pagli, Senapati, Dubail, and other khals have restricted fish migration to and from the floodplain, which reduces fish resources in the area.

- Reduction of the fish population due to over fishing and loss of fish habitat.

- Reduction of reproductive stock due to indiscriminate use of some fishing gear in the duars (kona jal, current jal, jam jal in the duars).

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

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

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

3.5.6 Fishing practice

Floodplain

Open water fisheries are the major source of fish in the area (floodplain 60%, beels 23% and ponds 17%). Subsistence fishing occurs mainly during the flooding period and large-scale beel fishing occurs from November to February. In most cases, beel fishing is done on an annual basis.

Table 3.6: Present Fish Production

Types of water body	Area (ha)	Rate of Production (kg/ha)	Total Production (mt)
Beel	713	550	392
Floodplain	23000	44	1012
Pond	355	800	284
Total	24068		1688

Source: BFRSS

Piles are not maintained as a part of the biological management of the fishery resource, but for annual fishing, the installation of katha is common. Since hizal and koroch trees are very scarce in the area, jarul, tetul, and mango tree branches are widely used. Kathas are installed in the months of August and September during the time when the water recedes from the floodplain.

Closed Water

Pond fish culture practices are different here than in other parts of the country. Most pond owners in the project area release an uncounted number of fingerling into their ponds without undertaking other basic management activities such as predatory fish eradication and regular application of feed and fertilizer. Monitoring the growth and health of the fish is also not done on a regular basis. The fish are usually harvested during the dry season. It should be noted that the many ponds that adjoin homestead land provide domestic water supply for a wide variety of activities (bathing, washing clothes and dishes, occasionally watering homestead vegetable plots, and so on).

Recently some absentee landowners started pond construction and fish culture in the Golapganj area.

3.6 Navigation

Of the two project boundary rivers, the Kushiyara is navigable year-round and the Surma is navigable only during the monsoon season. During the dry season there is no flow in the Surma River between Amalshid and the outfall of the Lubha River, and downstream from the Lubha to Sylhet there is too little water for navigation.

During the monsoon most of village roads located in the low lying areas of the project are submerged and country boats are the only means of transportation. At present, small and medium-sized motorized country boats operate for about seven months a year between Surma and Kushiyara through the Kakura and the Sada Khals, but the navigation in the Sada Khal downstream from the Sheola Bridge is hampered by siltation. When the Surma-Kushiyara basin is flooded, boats enter the project area from the Surma River through public cuts in the flood embankment. The Kakura-Sada Khal route is used mainly for transport of boulders and shingles from Lubhachara.

3.7 Wetland Resources Utilization and Management

The most important use of these natural wetlands product is fodder. Plants such as *Hygroryza aristata* (phutki), *Oryza rufipogon* (jhara dhan), and *Panicum paludosum* (local name not found) are common and the people who are living in and around the beels are dependant on these lands for cattle feed, particularly during the monsoon. In Balai Haor, the most productive area, people are collecting and selling fodder for about Tk 150 per boat and it was estimated that the whole haor area is producing about 100 boats full of fodder per week. This is equivalent to Tk 15,000. The harvesting period is about 12 weeks. As a result, the gross total value could reach Tk 180,000 per year. Taking the fodder-producing area of Balai Haor to be about 4000 ha, this is a yield of Tk 40/ha. The other seasonal wetlands of the area (F2+F3+F4) occupy about 25,000 ha and are probably only half as productive.

The next important use is food. These wetlands are producing starchy food as well as various types of vegetable. Both types have market value and vegetables like Nymphaea's floral stalk (shapla shaluk). The yield is probably of the same magnitude as for fodder or Tk 40/ha in Balai Haor and half this elsewhere.

Another important use of these resources is bio-fertilizer. People in these area generally do not use chemical fertilizer. Rather they produce green manure from the weeds of the wetlands. In this way, they are maintaining soil fertility.

Other uses of the wetlands are:

- Fuel material. Mostly from *Ipomoea fistulosa* (dhol kalmi) and *Lippia javanica* (bhuiokra).
- Medicinal plants. Mostly *Polygonum* (bishkatali, kukra) and *Limnophila* (karpur, bijatighash).
- Thatching material. Various grasses.
- Duck feed. Molluscs are used for this purpose.

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

The area was studied earlier as the *Upper Kushiyara Project*. This study included an area confined between the Surma and Kushiyara Rivers from Amalshid to the Charkhai-Sheola Road, which was the western limit of the project (gross area 35,368 ha).

The original feasibility study report on the *Upper Kushiyara Project* was prepared by The Upper Kushiyara Study Team, Directorate of Schemes, EPWAPDA, Dacca, in accordance with the Scope of Work issued by EPWAPDA in April 1964. The Feasibility Study Report was issued in 1965 (Interim), and in 1966 and 1967 (Final). The Report was reviewed in October 1969 by an IDA Mission of the International Bank for Reconstruction and Development (IBRD), and recommendations were made for collection of additional data, revision and updating of the study.

The Revision and Updating of The Upper Kushiyara Project was carried out by SARM Associates Ltd. Dacca. An Interim report submitted in November 1972 was accepted by the BWDB, and the Final Report was issued in November 1973.

4.1 The "*Upper Kushiyara Project Feasibility Study Report*" by The Upper Kushiyara Study Team, Directorate of Schemes, EPWAPDA

The 1967 Final Report of The Upper Kushiyara Project considered six possible development schemes which are summarized below.

4.1.1 Scheme I

- full protection of 31,580 ha against the 100-year return period flood by an embankment along the periphery of the project area;
- drainage system for 31,580 ha with drainage to a pumping station of 198 m^3/s capacity for 10-year return period, 10-day duration, internal rainfall runoff; and
- irrigation system for 16,194 ha.

4.1.2 Scheme II

- flood protection of 31,580 ha by embankment as under Scheme I;
- a simplified gravity drainage system for 31,580 ha with drainage to a regulator instead of the pumping station; and
- irrigation system for 16,194 ha.

4.1.3 Scheme III

- full protection by flood embankments of 18,623 ha divided into 3 polders;
- drainage systems for each polder, each with its own small pumping station; and
- irrigation systems for each polder, serving a total of 16,194 ha.

4.1.4 Scheme IV

Scheme IV was similar to Scheme III except that there was no provision for drainage water removal by pump, but only by gravity flow to a regulator.

4.1.5 Scheme V

Scheme V was similar to Scheme II except that there was no irrigation. Flood embankments were to be constructed along the Surma and Kushiyara rivers for protection of the project area from external flood waters and a simplified gravity drainage system provided with a regulator but no pump drainage.

4.1.6 Scheme VI

Under Scheme VI, low flood embankments along the Surma and Kushiyara rivers were to be constructed to delay the sudden rush of water into the project area. These low embankments, submersible by high floods, had to protect 31,580 ha of land (same as under Schemes I, II and V). An area of 18,623 ha of land was to be irrigated.

A preliminary side study was also made to check if diversion of a portion of the Kushiyara flood peak through Rahimpur-Sada Khal could reduce the height of a needed embankment along the Kushiyara River. This study indicated that, as the main floodway passed through the low-lying areas and embankments would be required along both sides of this floodway in addition to the embankments along the main rivers, this diversion offered no advantage.

4.1.7 The Selected Alternative

Scheme II was found to be the most promising scheme and it was selected for development of the Upper Kushiyara Project. The proposed development for the project area was then as follows:

i) Full flood protection of 31,580 ha against the 10-year frequency flood, by construction of an embankment along the periphery of the project area.

ii) Simplified drainage system with a regulator at the outfall of Sada khal but without pump drainage at the initial stage. About 20,240 ha of land would be provided with a gravity drainage system.

iii) An area of 16,194 ha of land would be provided with irrigation facilities at a later stage, after flood protection and drainage works were completed.

4.2 The "*Upper Kushiyara Project, Revision and Updating of Feasibility Report*" by Sarm Associates Ltd.

This 1973 Upper Kushiyara Project Report considered four alternative development plans:

4.2.1 Alternative I: Flood Protection Only

This project concept envisaged 10-year flood embankments along the Surma and Kushiyara rivers and maintenance of the existing drainage system. All internal runoff would drain through Sada Khal into the Kushiyara River without provision of any structure at its outfall. A navigation lock was proposed at the offtake of Dalumati Khal for transport of boulders from Lubha Chara.

4.2.2 Alternative II: Flood Protection and Irrigation

This plan is identical to Alternative I except that irrigation was introduced for a total area of 9,474 ha. The irrigation water would be supplied to gravity canals from a 17 m^3/s pumping station at Rahimpur.

4.2.3 Alternative III: Flood Protection, Irrigation and Drainage

This plan envisages 10-year flood embankments along the Surma and Kushiyara rivers, a 60-vent gravity drainage sluice on Sada Khal at the Charkhai-Sheola road crossing, and two irrigation pumping plants — one at Rahimpur and the other at Chiralbag. The Rahimpur plant would supply gravity irrigation to 10,668 ha as in the Alternative II. The Chiralbag plant would pump water into the Sada Khal for LLP irrigation of 5,465 ha with 2 f^3/s pumps.

4.2.4 Alternative IV: Flood Protection, Irrigation and Pumped Drainage

Technically this plan is similar to Alternative III, except that the gravity drainage sluice is replaced by a pumping plant with 170 m^3/s capacity. Also the irrigation area by the Rahimpur pumping station is increased to 18,826 ha.

4.2.5 The Selected Alternative

Alternative III was identified as the optimum plan and consequently proposed for development of the project area. In the final proposal the following changes were made:

- the size of the drainage sluice was changed to 24 vents 3.05 m x 2.29 m
- 2 gated inlet structures were proposed mainly for fish passage; one near Andua Beel on the Surma Embankment, and the other near Dhaikuri Beel on the Kushiyara Embankment
- the embankment from Charkhai to Zakiganj via Sheola was to be used as a road; the crest width was accordingly increased to 12.19 m as compared to 4.27 m for the other embankments.

4.3 Environmental Impact Assessment Case Study

A feasibility level environmental impact assessment (EIA) study of the Surma-Kushiyara Project was carried out from July 1991 through April 1992 as a case study under the FAP 16 environmental study component of the Bangladesh Flood Action Plan. The case study assessed impacts under two development scenarios: full flood protection with high embankments, and partial flood protection with submersible embankments. Two documents were issued: *Environmental Impact Assessment Case Study, Surma Kushiyara Project Report* dated June 1992, and *Nutritional Consequences of Fisheries Bio-Diversity* issued in March 1993.

4.4 Conclusion

The previous development plans called for limited flood protection that would allow a marginal increase in the monsoon season cropping, and development of winter irrigation with a major increase in area under the boro crops. The project area would be protected from the river peak floods, while in absence of gravity drainage a large part of the medium lowlands would be inundated by local rainfall runoff. According to the previous reports, without the irrigation component the project would not be economical.

5. WITHOUT-PROJECT TRENDS (NULL OPTION)

Independently of any water resources development, certain trends will be occurring in the area:

- Net population growth: about 3% per year. This is above the national average but below the growth rate of the past 10 years.

- Food grain production growth: 0% per year. Without intervention, seasonal floods caused by heavy rainfall would continue to damage broadcast and transplanted aman. April and May flash floods would continue to damage both local and high yielding varieties of aus and boro rice. The current land types would remain much the same though drainage condition could be aggravated because of sedimentation. Consequently, current cropping practices are expected to remain stable and no changes are expected in present agricultural production.

- Floodplain fisheries are expected to decline by 1.5% per year over the next 5 years before stabilizing at a level which is about 8% lower than the present. The decline is due to present management practices which include overfishing of brood stock.

- River course changes: The Kushiyara and Surma channels are quite stable, and no significant changes are expected in the future; the present erosion is considered to be normal.

- Loss of arable land to settlement: negligible.

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 the 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.

Flood embankments have already been constructed but the area continues to be flooded through open khals. This encourages boatmen to cut the embankments to shorten their navigation routes. Farmers also cut the Surma embankment to introduce silt onto the arable land and to infill the low beel areas. This siltation affects fisheries and causes drainage congestion, which magnifies the flood risk.

6.2 Water Resources Development Options

There are six basic options for water resources development in the project area:

i) *Full flood control with high embankments and pump drainage.* In addition to the flood embankments, a 300 m^3/s pumping capacity would be required to evacuate the internal runoff. Although this option is technically feasible, it is not economic due to the high cost of the pump drainage.

ii) *Partial flood control with submersible embankments.* Basically this option presently exists, but the local population keep cutting the embankments, mainly to take advantage of the existing navigation across the flooded basin. Under this option the internal road system is submerged for part of the year, and the potential for double cropping by adding monsoon season crops to the crop rotation can not be realized.

iii) *Full flood control with high embankments and sluice drainage.* This option is technically and financially feasible, but the closed outlet will restrict fish migration, gravity drainage and navigation in the lower basin which will remain flooded due to high river stage.

iv) *Drainage improvement.* Amelioration of the existing drainage system offers a partial improvement of the basin flooding conditions and it is necessary with every flood control option.

v) *Full/partial flood control with high embankments and open channel drainage.* Under this option the flood control benefits are basically equal to those under option No. 3 (with sluice drainage) but at lower capital and operation cost. The open channel drainage option is more fish and navigation friendly.

vi) *Pump irrigation.* The area lies within high rainfall zone where the kharif crops are grown successfully without supplementary irrigation. Therefore only winter irrigation need be developed in the project. This option can be studied as an additional development along with the flood control and drainage option.

Two project concepts are developed in Chapters 7 and 8. Chapter 7 describes a project that includes elements of full flood protection in the upper part of the project area and partial flood protection in the lower part, as well as improvement of internal drainage. Chapter 8 describes the same project but with the addition of an irrigation component.

- What about introduction of compartmentalization concept and controlled flooding concepts?

- What about utilization of the activities of RRH, LGED and Railway, BIWTA and other NGO and Govt agencies.

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7. PROPOSED FLOOD CONTROL AND DRAINAGE PROJECT

7.1 Project Rationale

This plan provides for flood control embankments and improved drainage. It will increase total flood-free cultivable area from 3500 ha to about 23,000 ha, an increase of about 19,500 ha. Roads and homesteads located in the area to the east from the Charkhai-Sheola road will be protected from river floods.

7.2 Project Objectives

The objectives of the Surma-Kushiyara Flood Control and Drainage Project are:

i) to reduce flood damage to monsoon and boro rice;

ii) to promote expansion of HYV rice onto lower lands by reducing flood depths on these lands, improving internal drainage, and reducing risk of early flooding; and

iii) to reduce flood damage to homesteads and infrastructure by river floods.

7.3 Project Description

The Surma-Kushiyara Project boundaries have been re-defined from those used in the earlier studies by shifting the western boundary from the Charkhai-Sheola road to the basin divide line across the hills from Golapganj in the north to Manikkona (on the Kushiyara bank upstream from Fenchuganj) in the south. This was done since it conforms more naturally with the topography of the area and takes advantage of the existing embankments along the Surma and Kushiyara Rivers. It has resulted in increasing the project area by 13,832 ha to a gross area of 49,200 ha.

For planning purposes, the project area has been subdivided into two areas (see Figure 4):

Area A — the upper basin extending from Amalshid to Charkhai-Sheola Road, and

Area B — the lower basin covering the remaining part of the project west from the Charkhai-Sheola Road.

At present, Area A is basically protected from the pre-monsoon floods by the existing infrastructure but only about 40% of its cultivable land is flood-free. All the cultivable land in Area B is subject to pre-monsoon flooding. In total, about 90% of the project's cultivable land is subject to annual monsoon flooding; and about 70% of homesteads are also flooded by peak floods every few years. The proposed development offers full flood protection to about 90% of Area A and to about 40% of Area B.

Project designs are based on flood protection of the area with high embankments and improved gravity drainage through an open channel discharging into the Kushiyara at the downstream end of the project area at Manikkona near Fenchuganj. High embankments will prevent entry of flood waters into the project along the entire Surma border and along the Kushiyara from the Amalshid to Manikkona.

With the project, Kushiyara flow will enter the area at Manikkona which is downstream of the present entry points Kanaighat and Sheola. Kushiyara flood levels are 3 m lower at Manikkona than at Kanaighat and Sheola, so shifting the flood entry point will reduce flooding in the basin. Kushiyara levels will however increase at Manikkona by about 0.5 m, due to the effects of confining the river to its channel, which will increase flood levels at Manikkona, partly cancelling the gains. With hills covering a large part of Area B, the high levels will affect a relatively small area of cultivable land in the narrow flood valley along the Kushiyara River. Since the drainage channel will remain open for local rainfall runoff, there will be no restriction on the migration of fish.

7.3.1 Flood Protection

Embankments
The flood protection of the area will be effected with continuous embankments along the Surma and Kushiyara Rivers designed for a 1:20-year return period flood.

To minimize land acquisition and earthwork volume, it is proposed to follow the present embankment alignment and to upgrade existing embankments by building up to the new section on the country side. New retired embankments should be constructed in places where river erosion is foreseen as a potential problem and where the present embankments are obviously too close to the river bank.

Existing embankments will need to be raised, on average, by about 1.5 m to an average height of 3 m. The required height of the new embankment along the Kushiyara is about 3.5 m. The proposed ring embankment along the western boundary of the project is about 6.0 m high in the low section through the Dambhadigha Beel. The proposed cross section of the embankment is 4.27 m crest width, with side slopes 1:2 and 1:3 on country and river side respectively. Longitudinal profiles of the proposed embankments are shown in Figure 6 and 7, and typical cross sections of the embankments are shown in Figure 9. The project embankment works include the following:

- upgrading of the existing Surma left bank embankment from Amalshid to the Moulavir Bazar Regulator near Golapganj (about 90 km),
- upgrading of the existing Kushiyara right bank embankment from Amalshid to Chandrapur (about 65 km),
- construction of new embankment along the right bank of Kushiyara from Chandrapur to Manikkona (about 20 km), and
- construction of new ring embankment along the right bank of the new link channel (outfall of Kura Gang 6 km).

Design embankment crest elevations are shown in Table 7.1. Details are provided in Annex B. All open khals will be closed, and 5 regulators will be constructed on major khals mainly for fish passage Flushing regulators at Atgram Dubail and Jagirdari Khals, and flushing cum drainage regulators will be constructed on Kakura and Kharati Khals.

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. A lower return period is used for the pre-monsoon flood because investments in the affected crop (boro) are higher and the required degree of protection should also be higher.

Table 7.1 Design Embankment Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Surma River		
Bifurcation at Amalshid	0.0	19.35
Outfall at Lubha River	40.0	17.05
Moulavir Bazar Regulator	90.0	14.25
Kushiyara River		
Bifurcation at Amalshid	0.0	19.35
Sheola	43.0	15.70
Manikkona (Kurigang outfall)	85.0	13.20

7.3.2 Drainage

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

The existing natural drainage system of khals and beels with minor improvements will be used for drainage of the project area. The project basin internal rainfall runoff will be evacuated through the main drainage collectors of the project, Sada Khal in the upper basin and Kura Gang (old Kushiyara channel) in the lower basin. The combined flow of the Kura Gang will be diverted into the Kushiyara channel through a 3 km long link channel near Manikkona (Figure 5).

Channels

The improvement works of the Kura Gang-Sada Khal channel include 3 km excavation of new channel (section 0.0 to 3.0 km), and about 35 km of re-excavation of existing channels (approximate section 15.0 to 45 km, Amami and Sada Khals, and section 75.0 to 80.0 km, Rahimpur Khal).

To eliminate water logging and to improve local drainage, it is proposed to re-excavate about 23 km of lateral khals: Kharati, Pagli, Dubail, Jagirdari, and Senapati Khals. These khals will also be used for flushing, and their sections should be designed accordingly to the discharge capacities of the regulators; 8.2 m and 10.0 m channel bed width for two- and three-vent 1.5 x 1.8 m regulator respectively.

The design parameters of the Kura Gang-Sada Khal channel are: 1(v):1.5(h) side slopes; a single slope bed with elevation 4.50 m PWD at the outfall and 9.50 m PWD at the offtake from Kushiyara at Rahimpur; bed width varying from 70.0 m for the new channel at the outfall to 11.0 m at the Rahimpur Khal. The channel is designed to convey the annual flood flow generated by 5-day basin rainfall with 1:10-year return period. Longitudinal profile of the Kura Gang-Sada Khal main drainage channel is shown in Figure 8.

The lower portion of the Sada Khal and the Kura Gang channels will be submerged by backflow from the Kushiyara during flood stages, therefore it is not necessary to provide a channel section for the full flood discharge. Instead, an existing channel improvement and re-excavation works will be sufficient. For the purpose of cost estimate it is assumed that the volume of the re-excavation works is equivalent to about 30% of the required channel section. A 100% excavation will be needed in the proposed 3 km long link channel at the outfall of the Kura Gang into the Kushiyara.

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

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
Area A, upstream from Sheola-Charkhai Road		
0.00-0.30	11,000	25,000
0.30-0.90	4500	1,000
0.90-1.80	6,000	—
>1.80	4,500	—
Total	26,000	26,000
Area B, downstream from Sheola-Charkhai Road		
0.00-0.30	—	3,700
0.30-0.90	3,200[b]	1,300
0.90-1.80	3,200[b]	1,600
>1.80	1,200	1,000
Total	7,600	7,600
Total (A+B)		
0.00-0.30	11,000	28,700
0.30-0.90	7,700	2,300
0.90-1.80	9,200	1,600
>1.80	5,700	1,000
Total	33,600	33,600

[a] These figures do not reflect cultivable land acquired for infrastructure. Production impacts of land acquisition are documented in the Evaluation section.
[b] Estimated from Sheola and Fenchuganj stations.

7.3.3 Structures

Regulators
Three regulators exist in the Surma-Kushiyara Project, all in good condition: a one-vent (1.5 x 1.8 m) flushing and drainage regulator on Moulavir Khal; a two-vent (1.5 x 1.8 m) flushing and drainage regulator on Sunam Khal; and a three-vent (1.9 x 2.4 m) flushing and drainage regulator on Rahimpur Khal, which is in fact used only for flushing.

Within the project, construction of five new regulators are proposed on major khals, mainly to allow fish passage: three two-vent (1.5 x 1.8 m) flushing regulators at Pagli, Dubail, and Jagirdari Khals; and two three-vent (1.5 x 1.8 m) flushing cum drainage regulators on each of Kakura and Kharati Khals.

Bridges
To improve surface communication two new bridges need to be constructed: a 90 m span RCC bridge on Sada Khal to replace a temporary baily bridge at Sheola and a 90 m span RCC bridge in the Kushiyara embankment over the excavated Kura Gang channel at Manikkona.

7.3.4 Expected Benefits

The benefits expected from the project mainly relate to agriculture. Changes in land type (Table 7.3) combined with the pre-monsoon land type changes (Table 7.2) are expected to be associated with changes in area under different cropping patterns as shown in Table 7.4. The increase in area under F0 and F1 land types is expected to lead to an increase in the area under local and high yielding varieties of aman rice with a corresponding reduction in the area under b aman. Assuring farmers of a safe harvest would also result in some local boro being converted into hyv boro.

Changes resulting from improved monsoon flood protection were analyzed and integrated with changes resulting from improved drainage to identify changes in the area under various land types within the project area (Table 7.4).

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

Flood Depth (m)	Cultivable Area (ha)	
	Pre-Project	Post-Project[a]
Area A, upstream from Sheola-Charkhai Road		
0.00-0.30	3,500	22,000
0.30-0.90	5,000	2,000
0.90-1.80	6,000	2,000
>1.80	11,500	—
Total	26,000	26,000
Area B, downstream from Sheola-Charkhai Road		
0.00-0.30	—	1,000
0.30-0.90	—	1,500
0.90-1.80	3,000[b]	2,500
>1.80	4,600[b]	2,600
Total	7,600	7,600
Total (A+B)		
0.00-0.30	3,500	23,000
0.30-0.90	5,000	3,500
0.90-1.80	9,000	4,500
>1.80	16,100	2,600
Total	33,600	33,600

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

[b] Estimated from Sheola and Fenchuganj stations.

Protection from floods (both flash floods and seasonal floods) would reduce the damage to different types of rice. Projected crop production has been estimated assuming that the yields presently being obtained in areas free of damage would be obtained within the project area (Table 7.5).

Cereal production is expected to increase annually by about 46,000 tonnes from 88,000 tonnes (future without) to 134,000 tonnes as a result of the project (exclusive of the land use impacts of land acquisition, see Section 7.8.1), an increase of 52%. Non-cereal production would increase by about 700 tonnes which is a 33% increase.

7.3.5 Mitigation Measures Incorporated

To minimize the negative impacts on fisheries, particularly in the Balai Haor complex and the Erali Beel, regulators are being incorporated to facilitate passage of fish. These regulators would be located at Moulavir Bazar, Kakura Khal, and Sunam Khal (existing). Improvements to current

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Table 7.4 Projected Cropping Patterns

Cropping Patterns	F0	F1	F2	F3	Total
b aus - hyv aman	2760 (12)				2760
b aus - lt aman	10350 (45)				10350
b aus - rabi	690 (03)				690
hyv aus - rabi	920 (04)				920
lt aman - fallow	2760 (12)				2760
lt aman - hyv boro	2300 (10)	2100 (60)			4400
hyv aman - fallow	1840 (08)				1840
hyv aman - hyv boro	1380 (06)	1400 (40)			2780
b aman - fallow			675 (15)		675
l boro - fallow			3825 (85)	2600 (100)	6425
Total	23000	3500	4500	2600	33600

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

Table 7.5 Projected Crop Production

Crop	Area (ha)	Yield (t/ha)	Production (t)
b aus	13800	1.25	17,250
hyv aus	920	3.75	3,450
b aman	675	1.75	1,181
lt aman	17510	2.05	35,896
hyv aman	7380	3.95	29,151
l boro	6425	2.25	14,456
hyv boro	7180	4.55	32,669
pulses	242	.85	206
oilseeds	805	.75	604
spices	81	2.25	182
vegetables	483	3.75	1,811

structure designs would need to be incorporated to ensure the functionality of these regulators for the intended purpose. Development of "fish friendly" regulator designs will be undertaken as a separate initiative.

Also, to ensure appropriate post-monsoon drainage while maintaining a water linkage between the Kushiyara River and the various wetlands in the lower half of the project area, no structures are planned where the project drains into the Kushiyara at Manikkona. In combination with the regulators mentioned in the previous paragraph, this is expected to ensure that the integrity of the wetlands are maintained.

7.4 Project Operation and Maintenance

Under this development plan, operation and maintenance requirements would be minimal. Mainly, requirements would be to open and close the flushing/drainage regulators which are 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.

7.5 Organization and Management

During the early part of the feasibility study process, at least two client groups would need to be organized to oversee project development (one would be responsible for the upper part A of the area, the other would be responsible for the lower Part B area). 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 which designs, in the end, would require their approval. 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 Sylhet. 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 has a high dependency on central government for key inputs. The extent to which project targets are realized will be determined by how effectively it serves people's needs and how actively the local community participates in all stages of project development.

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 Estimates

Total project costs are Tk 844 million.

The estimates of land requirement and physical works are based on preliminary designs and lay-out plans prepared using 4 inch to 1 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/ha; land that could be double cropped was Tk 300,000/ha; and, land suitable for homesteads and gardens (including high ridges along the rivers) was Tk 500,000/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, 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 Annex B.

Table 7.6 Capital Cost Summary

Item	('000 Tk)
Structures	28,250
Embankments	173,710
Channels	98,519
Bridges	79,740
Buildings	1,250
Land Acquisition	205,624
BASE COST	587,093
Physical Contingencies (25%)	146,773
SUBTOTAL	733,866
Study Costs[1] (15% of Subtotal)	110,080
TOTAL	**843,946**
Net Area (ha)	33,600
Unit Cost (Tk/ha)	25,117

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

7.7 Project Phasing and Disbursement Period

Five 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 four. An itemized implementation schedule is shown in Table 7.7.

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 Evaluation.

Table 7.7 Implementation Schedule

Activity	Year (% Completion)				
	0	1	2	3	4
Preconstruction Activities					
Feasibility Study	100				
Engineering Investigation	70	30			
Detail Designs		70	30		
Land Acquisition		30	45	25	
Construction Activities					
Construction of Embankments		20	30	30	20
Excavation of Channels		30	30	30	10
Construction of Structures		20	40	40	
Construction of Bridges				40	60
Project Buildings				100	

Agriculture
The project is expected to facilitate annual cereal production to increase from 88,000 tonnes (FWO) to 134,000 tonnes (FW), an increase of 46,000 tonnes (+52%) (exclusive of the land use impacts of land acquisition, see below). This increase is mainly due to: shifts from b aman to l aman and hyv aman; shifts from l boro to hyv boro; and an increase in the area cultivated to hyv boro. The production increase implies a per person increase in cereal availability 308 (FWO) to 469 (FW) gm per person per day, an increase of +52% (Table 7.8). Current Bangladesh average consumption is 440 gm per person per day.

Non-cereal production is expected to increase from 2100 tonnes (FWO) to 2800 tonnes (FW) (+33%). This results from a 400 ha increase in area cultivated to non-cereals from 1200 ha to 1600 ha and implies an increase in the availability of non-cereals from 7 grams per person per day to 10 grams per person per day (Table 7.8).

Fisheries
There are generally three types of impacts considered of importance. The first relates to reduced flood plain fisheries resulting from reduced grazing areas, the second relates to reduced beel fisheries resulting from drainage and destruction of water links between beels and rivers, and the third relates to impacts on spawning resulting from destruction of water links between spawning grounds and rivers.

The flood control infrastructure will reduce the seasonally flooded area of the project by about 65%. The reduction will occur mainly in the Area A, the project area upstream of the Charkhai-

Sheola Road. Only a small reduction in floodplain area will occur in Area B, the area downstream of Charkhai-Sheola Road. Most of the lowlands in the Area B, which include the Erali Beel complex will remain flooded during the monsoon months by backflow from the Kushiyara River through the open Kura Gang channel.

Table 7.8: Indicators of Food Availability (grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2020)	FWO (2020)
Cereals	634	796	469	308
Non-Cereals	15	17	10	7
Fish	10	5	3	5

Floodplain fisheries have been declining within the project area by an estimated 1.5% per year. This on-going process combined with project implementation is expected to reduce floodplain fisheries annually from its current level estimated at 1,000 tonnes to a post implementation level of 370 tonnes. Implementation of this project would directly account for 550 tonnes or about 90% of this decline. It is estimated that the level of effort required to capture 1 kg of fish on the flood plain is two person days, implying that project-related fishing employment losses would be about 1.1 million person days.

The project is not expected to have a negative impact on beel fisheries or spawning grounds. The water linkage between the Surma river and Balai Haor complex (including Erali Beel), which is considered to be a spawning ground for carp, will be maintained.

In summary, fisheries production is expected to decrease from 930 tonnes (FWO) to 370 tonnes (FW) (-60%). This implies a decrease in fish availability per person due to the project from 5 (FWO) to 3 (FW) gm per person per day (Table 7.8).

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 60,200 homesteads in the area, and the average plinth level is at about the 1:5 year flood level. About half of homesteads are affected by flooding of 10-20 cm in the 1:10 to 1:25 year floods. The estimated annualized economic value of reduced flood damage is Tk 8 million.

Wetlands
The seasonally flooded area will be reduced by about 65%. This has several implications:

- Incremental economic output: decrease of Tk 0.6 million/yr. Yields are estimated to be (economic prices) Tk 50/ha in Balai Haor and Tk 25/ha elsewhere.

- Incremental labour in gathering wetland products: decrease of nine thousand person-days per year.

- Ecological character of Balai Haor will be adversely affected. One of the terms of the Ramsar convention is that Contracting Parties are to maintain the ecological character of internationally-valuable wetlands.

- Because this is a key site for the region, regional biodiversity will be threatened, in particular some aquatic plants, small wetland-dependent mammals, and migratory birds.

Land Use
Land use changes are summarized in Table 7.9. A total of 517 ha of land (about 1% of the project gross area) will be required for embankments, drains, and regulators. Of this, 378 ha will be taken from cultivated area; assuming average yields and that this is all under rice, this corresponds to incremental production foregone of about 1000 tonnes per year or about 2% of total incremental cereal production; this impact has been incorporated in the economic analysis. Another 131 ha will be taken from fallow (mostly F4) areas; assuming Tk 80/ha of wetland products, this corresponds to wetland production foregone of Tk 10,000 per year. The remaining 8 ha will be taken from homestead area; this is 0.7% of total homestead area, which implies that 400 households or about 2500 persons will be displaced. Also, homestead agricultural production from these sites will be lost: Tk 1.6 million per year, very roughly estimating homestead agricultural production at Tk 1000 per decimal or Tk 200,000 per ha.

Transportation/navigation
Transportation in Area A will be transformed from navigation-based for seven to eight months of the year, to road-based. Transportation in Area B will remain largely unchanged. The total length of existing roads in the project is 29 km of which 12 km is inundated every year. The project would make these roads flood-free (up to the 1:25 year flood). Assuming a capital cost of Tk 190,000/km and 15% flood damage, the annual benefit of flood protection is Tk 342,000.

Higher Kushiyara flood levels
Kushiyara flood levels could increase by not more than 0.5 m at Manikkona. This could affect areas outside the project, most likely un-embanked haors to the south (Hakaluki, Bardal). Improved understanding of this impact requires regional flooding analysis, which is ongoing as a part of NERP.

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 1.31 million person-days per year. This is composed of:

- an increase in owner-labour employment of +1.73 million pd yr^{-1}, of which very roughly 20% is post-harvest processing activities traditionally done by women of the household. This increase is partly cancelled out by . . .

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What is their present employment status?

- an net decrease in employment opportunities for landless people of -0.42 million pd yr^{-1}, composed of changes in the following areas:
  - Agricultural hired labour: +0.69 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: -1.10 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): -0.009 million pd yr^{-1}. Fodder and building material is gathered mainly by men. Food, fuel, and medicine is gathered mainly by women.

Table 7.9: Changes in Land Use

Use	Change in area (ha)
Cultivated	-378
Homesteads	-8
Beels	-
Ponds	-
Channels	+139
Hills	-
Fallow[1]	-131
Infrastructure[2]	+378

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

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.

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 Balai Haor. 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.

In Area A, the flood protection will transform monsoon-season transport from navigation to roads. This would eliminate the present reason for some embankment cuts would no longer be cut to facilitate navigation, but This will increase the distance that boatmen must ply to move goods and materials within the area. Improvement in the internal road network may offset this consideration.

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

Equity

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

- Landowners, in proportion to landholdings, benefit directly from investment in agriculture production. This is the main benefit (96% in economic terms) of the project and its distribution is quite *regressive*.

Who loses?

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

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

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

Gender Equity

The net equity impact would appear to be somewhat *progressive*. Employment opportunities for women will increase in all categories except wetland gathering. Reduced homestead flood damage will 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 8 ha of homestead land (400 households or 1250 women) may fall mainly on the women in those households. Nevertheless, women's gains are proportionately less then mens since they do not generally have control of the incremental production.

7.8.3 Economic

The project has an economic rate of return of 18%, which compares well to the required rate of 12% as prescribed by government. It is a relatively high investment project, at Tk 844 million or Tk 25,117 per hectare, and it covers a large geographic area (49,200 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 16%). The other sensitive variable is the timing of the benefits, and a delay in benefits by two years would reduce the ERR to 14%.

The foreign costs associated with the project are low, at 6% (excluding FFW contributions), making it a relatively small project from a donor perspective. Donor funding considerations would clearly need to include funding local costs.

Almost all of the benefits of the project relate to increased rice production, mostly resulting from shifts to hyvs. Average crop yields would increase as a result of reduced flood damage, and cropping intensity would increase by 30%. Non-cereal production would increase by 33%, but floodplain fish production fall to about 40% of future-without-project production. The value of the lost fisheries output amounts to about 6% of the value of increased agricultural output. About 4% 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 7.10.

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 7.11), the project is not attractive:

- Benefits derive almost entirely from increased rice production, at the expense of fisheries and wetlands.
- The net employment impact is positive, but is composed of a large gain in employment for owners at the expense of a significant number of jobs for hired labourers.
- A number of households would lose their homestead land to project land acquisition.
- The project would adversely affect regional biodiversity by changing the ecological character of Balai Haor, a wetland of international importance.
- Kushiyara flood levels would increase somewhat.
- Conflicts between farmers and fishermen, and between families living within and outside the embankment, would increase.
- The project has a high dependency on central government for implementation.

The positive aspects of the project would be:

- Rate of return is acceptable.
- Substantial increase in rice production.
- Increased economic returns to land owners.
- Reduced flood damage to homesteads and roads.
- Small increment in non-cereal production.
- Gender equity of impacts is somewhat progressive.
- Project responds to some public concerns.

Table 7.10: Summary of Salient Data

Economic Rate of Return (ERR)	18%			
Capital Investment (Tk million)	844			
Maximum O+M (Tk million / yr)	31			
Capital Investment (Tk/ha)	25,117			
Foreign Cost Component	6%			
Net Project Area (ha)	33,600			
Land Acquisition Required (ha)	517			

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (Tk million / yr)	213			
Cropping Intensity		1.3	1.3	1.7
Average Yield (tonnes/ha)		2.1	2.1	2.5
Average Gross Margins (Tk/ha)		11222	11404	13373
Owner Labour (md/ha)		122	122	126
Hired Labour (md/ha)		25	25	32
Irrigation (ha)		13420	13420	13605
Incremental Cereal Prod'n (' 000 tonnes / yr)	46			
Incremental Non-Cereal (' 000 tonnes / yr)	0.7			
Incremental Owner Labour (' 000 pd / yr)	1731			
Incremental Hired Labour (' 000 pd / yr)	692			

FISHERIES IMPACTS		Flood plain	Beels	Spawning
Incremental Net Econ Output (Tk million / yr)	-12	-12	0	0
Impacted Area (ha)		14600	0	0
Average Gross Margins (Tk/ha)		1448	23290	-
Remaining Production on Impacted Area, %		0%	-	-
Incremental Fish Production (tonnes / year)		-550	0	-
Incremental Labour ('000 pd / yr)		-1,100	0	0

FLOOD DAMAGE BENEFITS				
Households Affected		30100		
Reduced Econ Damage Households (Tk M / yr)	8			
Roads/Embankments Affected -km		12		
Reduced Econ Damage Roads (Tk M / yr)	0.3			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	-0.6			
Wetland Incremental Labour ('000 pd / yr)	-9			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	-4			
Persons Displaced by Homestead Acquisition	2500			

Table 7.11: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	18
EIRR, Increase Capital Costs by 20%	per cent	16
EIRR, Delay Benefits by Two Years	per cent	14
Net Present Value	Tk	275,296

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	45,000	+51
Incremental Non-Cereal Production	tonnes	700	+33
Incremental Fish Production	tonnes	-550	-60
Change in Floodplain Wetland/Fisheries Habitat	ha	-14,600	-66
Homesteads Displaced Due to Project Land Acquisition	homesteads	400	-0.7
Homesteads Protected From Floods	homesteads	+30,100	+100
Roads Protected From Floods	km	+12	+100
Kushiyara Flood Levels	m PWD	+0.5	-
Owner Employment	million pd/yr	+1.73	+50
Hired Employment (Agri+Fishing+Wetland)	million pd/yr	-0.42	-13

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

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

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

8. PROPOSED FLOOD CONTROL, DRAINAGE AND IRRIGATION PROJECT

8.1 Project Rationale

The flood control and drainage components of this plan are identical to those described in the previous chapter. In addition, this project includes the provision of infrastructure to irrigate about 5600 ha in Area A, the upper part of the project area.

8.2 Project Objectives

The objectives are the same as for the FCD project (Section 7.2), plus:

iv) to provide irrigation to 5600 ha in the upper part of the project area.

8.3 Project Description

The general remarks of Section 7.3 apply here as well. The irrigation would be provided by a pumping station at Rahimpur with a capacity of 7.5 m^3/s.

8.3.1 Flood Protection, Drainage, and Structures

As in Sections 7.3.1, 7.3.2, and 7.3.3.

8.3.2 Irrigation

During the dry season, often there is no flow in the Surma River in the section between Amalshid and the outfall of Lubha River, and the dry season flows recorded at Kanaighat are too low to be considered for irrigation development (minimum daily 2.7 m^3/s). Therefore, the Kushiyara River, which has the lowest guaranteed flow of 17.78 m^3/s (at 90% dependability in first decade of April; see Annex B) is the only potential surface water source for irrigation during the winter season.

Irrigation development is proposed in Area A, the eastern, upper part of the project area. Irrigation water would be made available throughout the year to a net cultivable area of about 5,600 ha from a 7.5 m^3/s capacity pumping station located at Rahimpur. The water would be supplied through two main canals located along Zakiganj-Sylhet Road with distribution by conventional gravity canal systems as shown in Figure 5.

No irrigation development is planned in the lower part of the project along the middle and lower reaches of the Sada Khal. At present over 5,000 ha of boro crops are successfully grown in this area using low lift pumps and indigenous methods of irrigation.

The absence of effective flood protection results in about 3,000 ha of the boro crop being damaged annually by pre-monsoon flash floods. The improved protection provided by the project should facilitate further expansion of low-lift pump irrigation.

To minimize land acquisition, it is proposed that the country side borrow pit canal along the Zakiganj-Amalshid-Sylhet Road and the Senapati Khal be utilized as irrigation canals.

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The maximum intake of 7.5 m³/s at the Rahimpur plant represents about 30% of the minimum winter flow in the Kushiyara measured at Sheola, which represents the discharges after withdrawals by India along the left bank.

The main components of the irrigation system are listed in Table 8.1.

Table 8.1 Irrigation Components

Component	Quantity
Earthworks	
main canals (km)	30
lateral canals (km)	64
field canals (km)	95
Structures	
pumping station (7.52 m^3/s)	1
main canal aqueduct	19
main canal head regulator	2
main canal overflow	2
lateral canal head regulator (offtake)	9
lateral canal head regulator (with highway crossing)	8
main canal check regulator/bridge	2
lateral canal check/drop	26
field canal offtake	160
field turnout	530
pipe culvert (0.6 m dia)	28
box culvert (1.5 m)	16
box culvert (3.0 m)	10

8.3.3 Expected Benefits

The main benefits of the irrigation component will relate to increase rice production. The provision of irrigation is expected to increase hyv boro cultivation by 4600 ha, from 7180 ha (FW, FCD-only) to 11,780 ha. There would also be slight decreases in lt aman and a corresponding increase in hyv aman. There would be an overall increase in the cropping intensity since some of the hyv boro would be produced on land that is currently lying fallow in winter (Tables 8.2 and 8.3).

Cereal production would be expected to increase annually by about 69,000 tonnes (FWO 88,000 tonnes to FW 157,000 tonnes). This is a 78% increase. The provision of irrigation will not have any impact on non-cereal production.

8.3.3 Mitigation Measures Incorporated

As described in Section 7.3.5. No additional mitigation measures were incorporated specifically for the irrigation component.

8.4 Project Operation

The addition of an irrigation component to the project complicates the operation and management considerably. Qualified civil, mechanical and electrical technical staff would be required to operate the pumping station. In addition, a mechanism would be required to permit the farmers to interact effectively with project staff.

8.5 Organization and Management

This is as described in Section 7.5, though the addition of the public sector irrigation component suggests that public participation is even more critical for this concept throughout project development, project operation, and maintenance.

Table 8.2 Projected Cropping Patterns with Irrigation

Cropping Patterns	F0	F1	F2	F3	Total
b aus - hyv aman	2760 (12)				2760
b aus - lt aman	10350 (45)				10350
b aus - rabi	690 (03)				690
hyv aus - rabi	920 (04)				920
lt aman - hyv boro	4140 (18)	2100 (60)			6240
hyv aman - hyv boro	4140 (18)	1400 (40)			5540
b aman - fallow			675 (15)		675
l boro - fallow			3825 (85)	2600 (100)	6425
Total	23000	3500	4500	2600	33600

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

Table 8.3 Projected Crop Production with Irrigation

Crop	Area (ha)	Yield (t/ha)	Production (t)
b aus	13800	1.25	17,250
hyv aus	920	3.75	3,450
b aman	675	1.75	1,181
lt aman	16590	2.05	34,010
hyv aman	8300	3.95	32,785
l boro	6425	2.25	14,456
hyv boro	11780	4.55	53,599
pulses	242	.85	206
oilseeds	805	.75	604
spices	81	2.25	182
vegetables	483	3.75	1,811

At feasibility, explicit consideration needs to given to ways and means of cost recovery of any investment in irrigation. A suggested option would be to levy a nominal fee to be paid by beneficiaries of the irrigation system into a project account for system maintenance prior to any construction taking place. Failure to collect this advance payment would be interpreted as a lack of beneficiary interest in project implementation.

8.6 Cost Estimate

The total project costs are Tk 1,398 million: Tk 844 million for the flood control and drainage component, and Tk 554 million for the irrigation component.

The summary of total costs is presented in Table 8.4. Details of the development components and cost estimates are provided in Annex B.

Table 8.4 Capital Cost Summary
(Tk '000)

Item	FCD	Irrig	Total
Structures	28250	54176	82,426
Embankments	173710	—	173,710
Channels	98519	26268	124,787
Bridges	79740	—	79,740
Pumping Station	—	250000	250,000
Buildings	1250	3000	4,250
Land Acquisition	205624	52290	257,914
Subtotal	587,093	385,734	972,827
Base Cost			972,827
Physical Contingencies (25%)			243,207
Subtotal			1,216,034
Engineering and Investigation (15%)			182,405
Total Capital Cost			**1,398,439**

8.7 Project Phasing and Disbursement Period

Five years are required to implement the project (Table 8.5). Feasibility studies would be carried out in first year (year zero) and construction activities would be carried out from year one through year four as shown in the implementation schedule below. Field surveys would start during the feasibility in year zero and be completed in year one. 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 of embankments and re-excavation of canals will require about four years, and the works should start in year one and be completed in year four. Construction of the regulators in the flood embankments should start in year one and be completed in year three; so the project benefits will start in year two. Pumping station and construction of irrigation system can be completed in the last three years.

8.8 Evaluation

8.8.1 Environmental

Environmental impacts are as indicated in Section 7.8.1, except as noted below.

Agriculture

The project is expected to facilitate annual cereal production to increase from 88,000 tonnes (FWO) to 157,000 tonnes (FW), an increase of 69,000 tonnes (+78%). This increase is mainly due to: shifts from b aman to l aman and hyv aman; shifts from l boro to hyv boro; and an increase in the area cultivated to hyv boro (5000 ha of which is attributable to the provision of irrigation). The production increase implies a per person increase in cereal availability 308 (FWO) to 550 (FW) gm per person per day, an increase of +78% (see Table 8.6). Current Bangladesh average consumption is 440 gm per person per day.

The irrigation component will not affect non-cereal production.

Table 8.5 Project Implementation Schedule

Activity	Year (% complete)				
	0	1	2	3	4
Preconstruction Activities					
Feasibility Study	100				
Engineering Investigation	70	30			
Detail Designs		50	50		
Land Acquisition		30	45	25	
Construction Activities					
Construction of Embankments		20	30	30	20
Excavation of Drainage Channels		30	30	30	10
Construction of Irrigation Canals				40	60
Construction of Structures		20	30	30	20
Construction of Bridges				40	60
Pumping Station			30	40	30
Project Buildings				50	50

Fisheries

The irrigation component could affect fisheries negatively in two ways.

First, water abstraction for irrigation from the Kushiyara of 7.5 $m^{3}s^{-1}$m is 42% of the 90%-dependable lowest guaranteed flow. Survival of overwintering brood stock is key to overall fisheries diversity and productivity. River duars and beels are the only habitats available to overwintering brood stock. Reduction of lowest flow will likely reduce brood stock survival in duars. the implications extend well beyond the boundaries of the project area. In particular, the effects of industrial pollution from the Fenchganj fertilizer factory and other sources downstream of the project area on fish will be exacerbated by the reduction in flushing and dilution. Information to develop a quantitative model for this impact is not available, however.

Second, irrigation will support shifts to hyv boro and the associated high inputs of pesticides and fertilizers required. Irrigation runoff which is contaminated with agrochemicals will have adverse effects on fish production in beels surrounded by hyv cultivation. It will also cause increased contamination of fish flesh as pesticides bio-accumulate, which in turn will have adverse impacts on species higher in the food chain such as birds of prey and humans. This has been crudely modelled as a 40% decrease in beel fish production.

Land Use

Land use changes due to the project are summarized in Table 8.7. An additional 173 ha will be required for the irrigation component, bringing the total to 690 ha. Of this, 550 ha will be taken from the cultivated area, which corresponds to incremental production foregone of about 1500 tonnes per year. As for the FCD-only project, 131 ha will be taken from fallow areas, which corresponds to Tk 10,000 per year in wetland products. The remaining 9 ha will be taken from homestead area, which implies that 450 households will be displaced and Tk 1.8 million per year of homestead production will be foregone.

Table 8.6: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2020)	FWO (2020)
Cereals	634	809	550	308
Non-cereals	15	17	10	7
Fish	10	4	2	5

Table 8.7: Changes in Land Use

Use	Change in area (ha)
Cultivated	-550
Homesteads	-9
Beels	-
Ponds	-
Channels	+135
Hills	-
Fallow[1]	-131
Infrastructure[2]	+555

[1] Multi-use land, wetlands, grazing lands, village grounds.

[2] Government-owned land not appearing elsewhere.

8.8.2 Social

Social impacts are as indicated in Section 7.8.1, except as noted below.

Employment

There will be an overall increase in employment of +2.11 million pd yr^{-1}. This is composed of +2.364 million pd yr^{-1} of employment for owner labour, and -0.25 million pd yr^{-1} of employment for landless people in agriculture, fishing, and wetland gathering. There is a significant (1.1 million pd yr^{-1}) shift out of fishing and wetland employment into agriculture. Gender implications of employment are as given in Section 7.8.2.

Equity

The main benefit of the additional substantial investment in irrigation infrastructure will be to those farmers owning the 5600 ha to be irrigated. In addition to increasing the productivity of this land, the capital value of the land will be enhanced.

8.8.3 Economic

The project has an economic rate of return of 15%, which is reasonable compared to the required rate of 12% as prescribed by government. It is a high investment project, at Tk 1398 million or Tk 41,620 per hectare, but it covers a large geographic area (49,200 ha gross). The rate of return is most sensitive to a delay of benefits: a delay in benefits by two years would reduce the ERR to 12%. A summary of salient data is provided in Table 8.8.

The foreign costs associated with the project are low, at 7% (excluding FFW contributions), making it a relatively small project from a donor perspective. Donor funding considerations would clearly need to include funding local costs.

Almost all of the benefits of the project relate to increased rice production, mostly resulting from substantial shifts to hyv aman and hyv boro. Average crop yields per hectare would increase from 2.1 tonnes per hectare to 2.7 tonnes per hectare, and cropping intensity would increase from 1.3 to 1.8. Non-cereal production would increase by 33% and fisheries production on the floodplain would be reduced to about 30% of FWO production, and that in the beels to about 60% of FWO production. The reduced fisheries output would amount to about 5% of the increased agricultural output. About 3% of the project benefits would result from reduced flooding of homesteads. A small amount of disbenefits would result from loss of food, shelter and tree products which are currently harvested from the floodplain and which would be displaced by rice.

8.8.4 Summary Analysis

The FCDI project is not attractive from a multi-criteria perspective (Table 8.9), and for the nearly the same reasons as for the FCD project (Section 7.8.4).

The addition of the irrigation component increases rice production further, at the expense of fisheries; increases the number of homesteads taken by project land acquisition; and is even more regressive given that irrigation benefits accrue to the owners of land to which irrigation will be provided.

Table 8.8: Summary of Salient Data

Economic Rate of Return (ERR)	15%			
Capital Investment (Tk million)	1398			
Maximum O+M (Tk million / yr)	41			
Capital Investment (Tk/ha)	41,620			
Foreign Cost Component	7%			
Net Project Area (ha)	33,600			
Land Acquisition Required (ha)	690			
AGRICULTURAL IMPACTS		**Present**	**FWO**	**FW**
Incremental Net Econ Output (Tk million / yr)	301			
Cropping Intensity		1.3	1.3	1.8
Average Yield (tonnes/ha)		2.1	2.1	2.7
Average Gross Margins (Tk/ha)		11,222	11,404	14,043
Owner Labour (pd/ha)		122	122	127
Hired Labour (pd/ha)		25	25	37
Irrigation (ha)		13420	13420	18205
Incremental Cereal Prod'n (' 000 tonnes / yr)	69			
Incremental Non-Cereal (' 000 tonnes / yr)	0.7			
Incremental Owner Labour (' 000 pd / yr)	2364			
Incremental Hired Labour (' 000 pd / yr)	1134			
FISHERIES IMPACTS		**Flood plain**	**Beels**	**Spawning**
Incremental Net Econ Output (Tk million / yr)	-15	-12	-3	0
Impacted Area (ha)		14600	713	0
Average Gross Margins (Tk/ha)		1448	23290	-
Remaining Production on Impacted Area, %		0%	60%	-
Incremental Fish Production (tonnes / year)		-550	-150	-
Incremental Labour ('000 pd / yr)	-1375	-1,100	-275	0
FLOOD DAMAGE BENEFITS				
Households Affected		30100		
Reduced Econ Damage Households (Tk M / yr)	8			
Roads/Embankments Affected -km		12		
Reduced Econ Damage Roads (Tk M / yr)	0.3			
OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	-0.6			
Wetland Incremental Labour ('000 pd / yr)	-9			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	-4.5			
Persons Displaced by Homestead Acquisition	2800			

Table 8.9: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	15
EIRR If Capital Costs Increase 20%	per cent	14
EIRR If Benefits Delayed Two Years	per cent	12
Net Present Value	Tk	254,079

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	'000 tonnes	+68	+75
Incremental Non-Cereal Production	'000 tonnes	+700	+33
Incremental Fish Production	tonnes	-700	-50
Change in Floodplain Wetland/Fisheries Habitat	ha	-14,600	-66
Change in Beel Habitat	per cent yield change * ha	-285	-40
Homesteads Displaced Due to Project Land Acquisition	homesteads	450	-0.8
Homesteads Protected From Floods	homesteads	+30,100	+100
Roads Protected From Floods	km	+12	+100
Kushiyara Flood Levels	m PWD	+0.5	-
Kushiyara Low Flow	m^3/s	-10.3	-42
Owner Employment	million pd/yr	+2.36	+68
Hired Employment (Agri+Fishing+Wetland)	million pd/yr	+0.03	+0.01

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Qualitative Impacts (ranked from -5 ...0... +5)	
Impact	**Rank**
Ecological Character of Key Wetland Site (Balai Haor)	-4
Regional Biodiversity	-3
Road Transportation	+1
Navigation	-3
Flood Levels Outside Project Area	-2
River Habitat for Overwintering Fish Brood Stock	-4
Conflicts	-3
Socioeconomic Equity	-4
Gender Equity	+1
Decentralized Organization and Management	-4
Responds to Public Concerns	+2
Conformity to Regional Strategy	?

[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

ANALYSIS OF PRESENT CONDITIONS

Annex A: Analysis of Present Conditions

1. Climatic Data

The climate of the project area is monsoon tropical with hot wet summers and cool dry winters. The weather stations within and in the proximity of the Surma-Kushiyara Project area are listed in Table A-1. The monthly distribution of the climatic parameters of the project area is presented in Table A-2. The rainfall parameters represent weighted averages from the four satations, and the other parameters are based on data from the Sylhet Station No. R-128.

TABLE A-1: SURMA-KUSHIYARA PROJECT WEATHER STATIONS

Station No.	Name of Station	Type of Observations	Latitude	Longitude	Since
R-116	Lallakhal	R	25°06.0'N	92°11.0'E	1902
R-118	Latu	R	24°40.8'N	92°01.8'E	1962
R-128	Sylhet	R/E/T/H/W/S	24°53.0'N	91°53.0'E	1960
R-130	Zakiganj	R	24°55.5'N	92°17.0'E	1962

TABLE A-2: METEOROLOGICAL DATA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C) Max.	28.3	32.2	36.7	38.9	40.6	35.0	40.0	35.0	35.0	35.0	31.7	28.9
Min.	9.4	8.9	12.8	16.7	18.3	21.1	23.9	23.3	21.7	18.3	12.8	8.9
Mean	18.7	20.4	24.2	27.2	26.9	27.8	28.8	28.2	28.1	26.6	19.7	19.7
Humidity (%)	76.9	70.9	63.8	75.0	83.5	87.7	89.5	89.5	87.5	87.3	81.0	79.9
Sunshine (hr/day)	8.8	9.0	8.4	7.5	6.8	3.5	4.1	4.4	4.6	7.5	9.0	7.8
Wind speed (kph)	2.4	2.8	5.0	6.0	5.0	5.4	5.6	5.0	3.7	2.4	1.9	1.9
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
Mean Monthly Rainfall (mm)	9.2	36.5	101.4	397.1	514.0	916.5	747.2	555.0	282.2	198.7	53.7	30.2

2. Topographic Data

The Surma-Kushiyara Project area comprises of two topographically distinct sub-areas. The saucer shaped plain of Sada Khal basin in the eastern part, and the hills with Old Kushiyara (Kura Gang) floodway in the western part of the area.

The flooding conditions are different in the two areas at present and also the depths of flooding will be different under the post-project scenario. Therefore, the project basin elevation versus cumulative area relations were developed separately for Area A, the area upstream from the Sheola-Charkhai Road, and for Area B, the area downstream from the Sheola-Charkhai Road.

TABLE A-3 ELEVATION vs BASIN AREA RELATION

Elevation (m PWD)	Cumulative Area (ha)		
	Area A	Area B	Total Basin
4.00	-	0.0	0.0
6.55	-	625.0	625.0
8.08	0.0	2365.0	2365.0
9.60	1957.0	4500.0	6457.0
11.12	6450.0	8900.0	15350.0
12.65	18157.0	11000.0	29157.0
14.17	27964.0	12823.0	40787.0
15.70	34343.0	13740.0	48083.0
17.22	35368.0	13832.0	49200.0

3. Hydrological Data

The hydrological regime of the Surma-Kushiyara basin is governed by external flows in the project boundary rivers, the Surma and the Kushiyara Rivers which are distributaries of the Barak River, and by the local rainfall runoff.

Good hydrological records are available from six hydrometric stations located in and around the project boundary; two stations on the Surma: St. No. 266 at Kanaighat and St. No. 267 at Sylhet; three stations on the Kushiyara: St. No. 172 at Amalshid, St. No. 173 at Sheola and St. No. 174 at Fenchuganj; and one station Sada Khal, St. No. 173A. The Sada Khal water records represent a combined flow of the local runoff and the spills from the Kushiyara and Surma Rivers. Location of the stations with the type of observations are indicated in Table A-4.

The analysis of water levels and discharges shown below were measured at the stations are based on the last 25 years of records.

TABLE A-4: SURMA-KUSHIYARA PROJECT HYDROMETRIC STATIONS

Station No.	Name of Station	Type of Observations	Latitude	Longitude	Available Records
Kushiyara River					
172	Amalshid	S	25°52.13'N	92°28.54'E	Since 1947
173	Sheola	S,Q	25°39.50'N	92°11.44'E	Since 1949
Surma River					
266	Kanaighat	S,Q	25°00.00'N	92°15.55'E	Since 1952
267	Sylhet	S,Q	24°53.24'N	91°52.26'E	Since 1938
Sada Khal					
173A	Sheola	S,Q	24°53.80'N	92°10.72'E	1947-1977

Surma River

TABLE A-5: RANGE OF DAILY WATER LEVELS AND DISCHARGES IN SURMA RIVER (REPORTING PERIOD 1964-1989)

	Kanaighat St. 266		Sylhet St. 267	
	Water Level (m PWD)	Discharge (m^3/s)	Water Level (m PWD)	Discharge (m^3/s)
Minimum	3.93	2.20	1.99	2.60
Mean	8.25	524.30	6.30	548.30
Maximum	15.00	2730.00	11.94	2480.00

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TABLE A-6: MEAN MONTHLY WATER LEVELS and DISCHARGES IN SURMA RIVER AT KANAIGHAT, ST. NO. 266

Month	Water Level (m PWD)			Discharge (m^3/s)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	4.43	6.67	10.12	6.0	227.4	621.3
May	5.97	8.56	11.34	107.4	479.3	961.1
June	7.79	11.57	14.06	385.5	1064.6	2239.0
July	11.41	13.10	14.11	981.3	1428.2	1903.9
Aug	10.83	12.51	14.01	750.4	1273.5	1960.3
Sept	9.40	11.67	13.21	504.9	1031.2	1724.0
Oct	7.45	9.59	12.41	162.0	551.8	1300.8
Nov	4.96	6.28	9.46	13.9	119.2	508.7
Dec	4.49	5.02	6.26	8.2	25.0	105.8
Jan	4.26	4.55	4.92	5.0	8.6	17.9
Feb	4.07	4.44	5.03	2.8	6.4	17.0
Mar	3.97	4.72	6.74	2.7	37.5	231.9

TABLE A-7: MEAN MONTHLY WATER LEVELS and DISCHARGES IN SURMA RIVER AT SYLHET, ST. NO. 267

Month	Water Level (m PWD)			Discharge (m^3/s)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	2.64	4.94	8.13	31.6	238.1	677.6
May	4.85	6.98	8.96	107.8	489.9	933.3
June	6.18	9.18	10.79	318.9	1109.3	1829.3
July	9.28	10.30	10.95	1038.9	1471.3	1918.7
Aug	8.98	9.93	10.76	825.9	1322.8	1667.1
Sept	7.87	9.37	10.47	554.0	1074.7	1447.2
Oct	6.30	7.81	9.82	211.6	614.5	1302.4
Nov	4.09	5.15	7.18	19.6	130.2	406.6
Dec	2.95	3.62	5.01	6.6	32.9	123.5
Jan	2.36	2.73	3.14	4.5	11.9	33.0
Feb	2.07	2.47	3.34	4.2	7.8	22.8
Mar	2.03	2.84	4.65	3.9	36.2	193.4

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Kushiyara River

TABLE A-8: DRY SEASON WATER AVAILABILITY (IN M³/S) IN KUSHIYARA AT SHEOLA (ST. NO. 173)

Month	Decade	10-day Mean Discharge (m^3/s) at		
		50% Dependability	80% Dependability	90% Dependability
December	I	162.72	121.36	105.02
	II	129.54	99.72	92.05
	III	118.55	89.99	77.61
January	I	108.46	82.04	68.71
	II	98.08	74.46	62.93
	III	87.38	68.10	57.48
February	I	81.57	58.89	51.82
	II	77.35	53.63	45.57
	III	76.73	57.22	49.94
March	I	87.48	52.55	37.63
	II	75.47	44.78	36.65
	III	81.71	35.75	28.67
April	I	157.47	46.28	17.78
	II	253.65	87.58	41.34
	III	277.99	149.12	116.97

TABLE A-9: RANGE OF DAILY WATER LEVELS AND DISCHARGES IN KUSHIYARA RIVER (REPORTING PERIOD 1964-1989)

	Amalshid St. 172	Sheola St. 173		Fenchuganj St. 174
	Water Level (m PWD)	Water Level (m PWD)	Discharge (m^3/s)	Water Level (m PWD)
Min	5.94	3.91	27.70	2.05
Mean	10.60	8.68	655.60	6.53
Max	17.91	14.14	2990.00	11.09

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TABLE A-10: MEAN MONTHLY WATER LEVELS (in m PWD) IN KUSHIYARA RIVER AT AMALSHID AND FENCHUGANJ

Month	Amalshid St. No. 172			Fenchuganj St. No.174		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	6.62	8.95	12.94	3.07	5.06	8.34
May	7.92	10.49	14.03	4.66	7.04	9.75
June	9.60	13.79	16.72	5.45	8.96	10.54
July	13.61	15.38	17.10	8.62	9.96	10.71
Aug	12.80	14.78	16.45	9.00	9.93	10.83
Sept	11.82	14.00	15.84	8.59	9.57	10.46
Oct	9.61	11.82	14.13	6.75	8.43	10.03
Nov	7.74	9.08	12.13	3.92	5.81	7.78
Dec	7.05	7.75	9.10	2.89	4.00	5.83
Jan	6.60	7.06	7.78	2.50	3.22	3.87
Feb	6.36	6.84	7.86	2.28	2.95	3.67
Mar	6.20	7.09	9.57	2.27	3.17	5.12

TABLE A-11: MEAN MONTHLY WATER LEVELS and DISCHARGES IN KUSHIYARA RIVER AT SHEOLA, ST. NO. 173

Month	Water Level (m PWD)			Discharge (m^3/s)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	4.68	7.04	10.61	69.3	291.4	870.4
May	6.33	8.99	12.09	165.7	546.7	1204.5
June	7.79	11.58	13.70	419.3	1164.1	2134.7
July	11.66	12.91	13.83	1146.8	1609.6	2029.0
Aug	11.18	12.63	13.73	904.8	1476.4	2188.1
Sept	10.36	12.07	13.25	678.7	1258.2	1903.0
Oct	8.24	10.35	12.66	328.2	770.2	1705.6
Nov	5.78	7.41	10.28	112.1	279.7	721.3
Dec	4.83	5.85	7.40	70.6	141.8	249.1
Jan	4.45	5.11	5.98	45.5	95.9	136.7
Feb	4.20	4.86	5.90	45.0	80.0	145.9
March	4.17	5.08	7.49	37.0	111.0	445.1

Sada Khal

TABLE A-12: MEAN MONTHLY WATER LEVELS and DISCHARGES IN SADA KHAL AT SHEOLA, ST. NO. 173A

Month	Water Level (m PWD)			Discharge (m^3/s)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
June	10.60	11.77	13.23	99.3	245.9	636.0
July	11.73	12.39	13.23	126.5	312.7	577.7
Aug	11.52	12.07	12.81	126.5	284.8	553.6
Sept	10.25	11.46	12.49	61.7	122.1	300.4
Oct	9.00	10.39	11.44	6.1	50.8	178.9
Nov	8.10	8.71	9.05	0.1	4.6	13.1

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Groundwater

TABLE A-13: SURMA-KUSHIYARA BASIN EXPLORATORY WELLS

Hole No.	Location	Depth (m)	Ground Water Potential
E-1	Dolairmati	86.0	No ground water potential up to 96 m.
E-2	Sardarmati	93.6	No groundwater potential.
E-3	Sutra Nagar	92.0	No groundwater potential.
E-4	Atgram	96.0	Medium and coarse below 93.3 0 m depth. Limited water potential.
E-7	Biabail	92.6	No groundwater potential.
E-8	Bara Takri	96.6	Medium and coarse below 93.3 0 m depth. Good water potential.
E-9	Thanar Hat	93.6	No ground water potential.

Source: BWDB 1965

4. Flood Frequency Analysis

The flood frequency analysis were carried out separately for the pre-monsoon floods expected before 15 May and for the maximum annual floods expected during the monsoon months. The pre-monsoon flood levels are needed for planning and desing of flood protection for *bore rice*, and the annual flood levels are needed for design of high flood embankments and for planning monsoon season cropping patterns.

The flood frequency analysis are summarized in Tables A-14 and A-15.

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TABLE A-14: MAXIMUM DAILY WATER LEVELS IN SURMA RIVER
(m PWD)

Return Period (Years)	Kanaighat No. 266	Sylhet No. 267	Moulavir Bazar (Project boundary)
Before 15 May Flood			
2	11.36	8.75	9.53
5	12.73	9.64	10.57
10	13.25	9.94	10.93
25	13.65	10.14	11.19
50	13.84	10.22	11.30
100	13.96	10.27	11.28
Maximum Annual Flood			
2	14.63	11.22	12.24
5	14.85	11.53	12.53
10	14.92	11.68	12.65
25	14.97	11.82	12.76
50	14.99	11.89	12.82
100	15.99	11.95	13.16

TABLE A-15: MAXIMUM DAILY WATER LEVELS IN KUSHIYARA RIVER
(m PWD)

Return Period (Years)	Amalshid No. 172	Sheola No. 173	Fenchuganj No. 174	Manikkona (Project boundary)
Before 15 May Flood				
2	13.00	11.02	7.99	8.55
5	14.59	12.64	9.02	9.69
10	15.41	12.86	9.51	10.13
25	16.25	13.42	9.98	10.62
50	16.74	13.73	10.24	10.89
100	17.15	13.98	10.44	11.10
Maximum Annual Flood				
2	17.26	13.85	10.57	11.18
5	17.58	14.02	10.79	11.39
10	17.72	14.10	10.91	11.50
25	17.84	14.17	11.06	11.64
50	17.90	14.20	11.15	11.72
100	17.95	14.23	11.24	11.80

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Fisheries

TABLE A.16: WATER BODIES IN THE SURMA-KUSHIYARA PROJECT

Balai haor basin		Erali beel basin	
Beel Name	**Dry Season Area (ha)**	**Beel Name**	**Dry Season Area (ha)**
Dubail beel	110	Erali beel	320
Jugni beel	60	Bomail beel	
Khagra beel	50	Chatal beel	
Singikuri beel	40		
Uni beel	10		
Chatal beel	3		
Dhankuri beel	5		
Chapti beel	12		
Bhatarkur	4		
Dighai beel	10		
Chunia beel	22		
Dubagh	30		
Canals	37		
Total	393		320

TABLE A.17: CLOSED WATER BODIES IN THE PROJECT AREA

Thana	Number of ponds	Pond area (Ha)	Average pond size (ha)	Pond concentration (nos/km^2)
Zakiganj	2531	196	0.077	8
Kanaighat	666	51	0.076	9
Golapganj	702	54	0.076	9
Beanibazar	695	54	0.077	9
Total	4594	355	-	-

Source: BFRSS,1986 & Population census report, 1991.

TABLE A.18: DUARS AROUND THE PROJECT AREA

Name of duar	Approx. depth during dry season (m)	Boromaach occurred *	Chotomaach occurred *
River: SURMA			
Atgram	8-9	LC, C, MC	Ca,Ch,P,T
Sayadpur	8-9	As above	As above
Birdhalpara	8-9	As above	As above
Astagram	8-9	As above	As above
River: KUSHIYARA			
Amalshed	9-10	LC,C,MC	B,Ch,Ca,L,P,T
Gangajal	7-8	As above	As above
Zakiganj	7-8	As above	As above
Bhuiamura	7-8	As above	As above
Moiyakhali	9-10	As above	As above
Choria	16-17	LC,MC,C	As above
Mewa	10-11	LC,C	As above
Dheunaga	8-9	LC,C	As above
Digholbak	10-11	As above	As above
Alipur	9-10	As above	As above
Kakordi	14-15	MC,LC,C	As above
Balianga	8-9	LC,C	As above
Fenchuganj	10-11	As above	As above
Mahammadpur	9-10	MC,LC,C	As above
Govindsree	9-10	LC,C	As above
Amkona	8-9	As above	As above

* *B:Bacha; C:Chital; Ca: Chapila; Ch: Chela; L:Laso; LC: Large catfish; MC: Major carp; P: Puti; T: Tengra.*

Source: NERP

ANNEX B

ENGINEERING COST ANALYSIS

ANNEX B: ENGINEERING COST ANALYSIS

1. Flood Protection

At present the project area is embanked long the entire border with the Surma River (about 90 km) and along about 65 km out of the 85 km border with the Kushiyara River. The Surma embankment which had been designed for 1:10-year flood has been overtopped in 1991 in several places. The Kushiyara embankment, of which the design specifications are not available, has also been overtopped.

The water levels recorded during the 1991 flood season, in Surma at Kanaighat 15.04 m PWD, in Kushiyara at Amalshid 17.87 m PWD and at Sheola 14.22 m PWD correspond to higher than 1:50-year flood. See Flood Frequency Analysis, Annex A.

It is proposed to protect the project area from external foods with embankments designed for 1:20-year return period floods in the Surma and Kushiyara Rivers.

The flood embankment crest elevations are designed for the expected flood levels which include the embankment confinement and a sufficient freeboard. The confinement effect calculations are based on discharge and the future - embanked cross section of the river channel. As no topographical surveys of the rivers were conducted for the pre-feasibility study, it was not possible to determine the embankment confinement effect. Therefore, the proposed embankment crest elevations are based on the present flood levels, assuming about 0.6 m increase in the flood levels due to the embankment confinement.

For the purpose of costing, the design crest elevation of the embankment was set at about 1.5 m above the average height of the existing embankments. The added height includes the expected confinement and the freeboard. The proposed embankment crest levels are about 1.5 - 1.6 m above the 1:20-year annual flood.

The existing embankments will be raised in average by a about 1.5 m to an average height of about 3.0 m. The required height of the new embankment along the Kushiyara is about 3.5 m. The proposed ring embankment along the western boundary of the project is about 6.0 m high in the low section through the Dambhadigha Bil.

The proposed cross section of the embankment is 4.27 m crest width and side slopes 1:2 and 1:3 on country and river side respectively. Longitudinal profiles of the proposed embankments are shown in Figure 7 and 8, and typical cross sections of the embankments are shown in Figure 9.

The project embankment works include the following:

- upgrading of the existing Surma left bank embankment from Amalshid to the Moulavir Bazar Regulator near Golapganj (about 90 km),
- upgrading of the existing Kushiyara right bank embankment from Amalshid to Chandrapur (about 65 km),
- construction of new embankment along the right bank of Kushiyara from Chandrapur to Manikkona (about 20 km), and

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- construction of new ring embankment along the right bank of the new link channel (outfall of Kura Gang 6 km).

The preliminary design embankment crest elevations are as follows.

Location	Section (km)	Crest Level (m PWD)
Surma River:		
Bifurcation at Amalshid	0.0	19.35
Outfall of Lubha River	40.0	17.05
Moulavir Bazar Regulator (end of project boundary)	90.0	14.25
Kushiyara River:		
Bifurcation at Amalshid	0.0	19.35
Sheola	43.0	15.70
Outfall of Kura Gang at Manikkona (end of project boundary)	85.0	13.20

The embankment designs will be reviewed in the feasibility study using detail analysis of the post-project floods based on discharges and surveyed cross-sections of the rivers. The expected flood levels will be verified by regional flood analysis using mathematical model.

2. Drainage

At present the flooding in the project is intensified due to slow drainage during the pre-monsoon and the post-monsoon periods. The project has a dense network of internal khals, but because of siltation of the channels their drainage capacity is limited. A detail survey of the existing drainage system is required to determine the exact volume of channel improvement works.

The project drainage improvement works include re-excavation of the main basin drainage channel; the Sada Khal linked with Kura Gang, and re-excavation of five lateral drains.

The identified lateral drains are: Kharati, Pagli, Dubail, Jagirdari and Senapati Khal. These khals will also be used for flushing, and their sections should be designed accordingly to the discharge capacities of the regulators; 8.2 m and 10.0 m channel bed width for two- and three-vent 1.5 x 1.8 m regulator respectively.

The Sada Khal-Kura Gang channel has been designed to convey an annual flood flow generated by 5-day basin rainfall with 1:10-year return period. The design discharges at various locations along the khal are shown in Table 16, and the longitudinal profile is shown in Figure 10.

The design parameters of the Kura Gang-Sada Khal channel are: 1(v):1.5(h) side slopes; a single slope bed with elevation 4.50 m PWD at the outfall and 9.50 m PWD at the offtake from Kushiyara at

Rahimpur; bed width varying from 70.0 m for the new channel at the outfall to 11.0 m at the Rahimpur Khal.

The lower portion of the Sada Khal and the Kura Gang channels will be submerged by backflow from the Kushiyara during flood stages, therefore it is not necessary to provide a channel section for the full flood discharge. Instead, an existing channel improvement and re-excavation works will be sufficient. For the purpose of cost estimate it is assumed that the volume of the re-excavation works is equivalent to about 30% of the required channel section. A 100% excavation will be needed in the proposed 3 km long link channel at the outfall of the Kura Gang into Kushiyara.

TABLE B-1: SURMA-KUSHIYARA PROJECT
KURA GANG-SADA KHAL FLOOD DISCHARGE
(5-day 1:10-year rainfall)

Location (km)	Watershed Area (ha)	Discharge (m^3/s)	Channel Bed Width (m)
Rahimpur Regulator (80.0)	0	25.8*	11.0
Zakiganj Road Crossing (68.0)	12,092	76.9	25.0
Jagirdari Khal outfall (52.0)	27,562	175.4	45.0
Sheola Road Bridge (33.0)	34,793	220.0	60.0**
Kharati Khal offtake (25.0)	38,352	244.1	60.0**
Sunampur Road Bridge (13.0)	44,144	281.0	60.0**
Outfall into Kushiyara (0.0)	48,324	307.6	70.0

* Discharge of Rahimpur Khal Regulator
** Channel submerged by backflow. The required channel section may be reduced due to overbank spill at flood stage.

Structures

Regulators

Three regulators exist in the Surma-Kushiyara Project, all in good condition; one-vent (1.5 x 1.8 m) Fl/Dr regulator on Moulavir Khal, two-vent (1.5 x 1.8 m) Fl/Dr regulator on Sunam Khal and three-vent (1.9 x 2.4 m) Fl/Dr regulator on Rahimpur Khal. Only flushing takes place through the Rahimpur Regulator.

5 new regulators are proposed to be constructed on major khals mainly for pisciculture. Two-vent (1.5 x 1.8 m) flushing regulators at Pagli, Dubail and Jagirdari Khals, and three-vent (1.5 x 1.8 m) flushing/drainage regulators on Kakura and Kharati Khals.

Bridges
To improve surface communication two new bridges are to be constructed as part of the project development. One 90 m span RCC bridge on Sada Khal, to replace the temporary Baily bridge at Sheola and one 90 m span RCC bridge in Kushiyara embankment over the excavated Kura Gang channel at Manikkona.

3. VOLUME AND COST ESTIMATES

Alternative 1: Flood Protection and Drainage

Flood Embankments

TABLE B-2: SURMA RIVER LEFT EMBANKMENT

Item	Quantity	Unit	Rate (Tk)	Amount (Tk)
1. Upgrading of existing embankment 90.0 km				
Earthwork	2743200	m^3	25.66	70390512
Dressing & Turfing	1314900	m^2	2.27	2984823
Land Acquisition	146.34	ha	500000	73170000
			Total:	146,545,335

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TABLE B-3: KUSHIYARA RIVER RIGHT EMBANKMENT

Item	Quantity	Unit	Rate (Tk)	Amount (Tk)
1. Upgrading of existing embankment 65.0 km				
Earthwork	1981200	m^3	25.66	50837592
Dressing & Turfing	949650	m^2	2.27	2155706
Land Acquisition	106	ha	500000	53000000
2. Construction of new embankment 20.0 km				
Earthwork	1001800	m^3	25.66	25706188
Dressing & Turfing	468600	m^2	2.27	1063722
Land Acquisition	123.0	ha	500000	61500000
		Total:		196,494,208

TABLE B-4: KURA GANG RIGHT EMBANKMENT (RING DYKE)

Item	Quantity	Unit	Rate (Tk)	Amount (Tk)
1. Construction of new embankment 6.0 km				
Earthwork	653760	m^3	30.75	20103120
Dressing & Turfing	206400	m^2	2.27	468528
Land Acquisition	49.2*	ha	120000	5904000
		Total:		26,475,648

* Includes land for new link channel

Drainage Channels

TABLE B-5: KURA GANG-SADA KHAL MAIN DRAIN

Item	Quantity	Unit	Rate (Tk)	Amount (Tk)
1. Excavation of link channel 3.0 km				
Earthwork	965400	m^3	25.35	24472890
2. Re-excavation of existing channel 30 km				
Earthwork	2156250	m^3	23.50	50771875
Land Acquisition	90.0	ha	120000	10800000
		Total:		86,044,765

TABLE B-6: LATERAL FL/DR KHALS

Item	Quantity	Unit	Rate (Tk)	Amount (Tk)
2. Re-excavation of existing channels 23 km				
Earthwork	1075000	m^3	21.65	23273750
Land Acquisition	-	ha	120000	
		Total:		23,273,750

Structures

Regulators

5 new regulators are proposed on larger lateral khals mainly for pisciculture. Two regulators will be used for flushing and three for flushing and drainage. The proposed regulators with the cost estimate based on parametric costs are listed below.

	Unit Cost (Tk)
1) 2-vent 1.5x1.8 m Pagli Fl. Regulator	5,000,000
2) 2-vent 1.5x1.8 m Dubail Fl. Regulator	5,000,000
3) 2-vent 1.5x1.8 m Jagirdari Fl/Dr Regulator	5,000,000
4) 3-vent 1.5x1.8 m Kakura Fl/Dr Regulator	6,000,000
5) 3-vent 1.5x1.8 m Kharati Fl/Dr Regulator	6,000,000
Total Regulators Civil Works:	Tk 27,000,000

Land requirement 0.5 ha x 5 = 2.5 ha

Cost of Land 500,000 Tk/ha

Total Regulators Land Acquisition:	Tk 1,250,000
Total Regulators	**Tk 28,250,000**

Bridges
To improve surface communication two new bridges are to be constructed as part of the project development. One 90 m span RCC bridge on Sada Khal, to replace the temporary Bailay bridge at Sheola and one 90 m span RCC bridge in Kushiyara embankment over the excavated Kura Gang channel at Manikkona.

Adjusted to June 1991 price of big bridge, Tk 443,000 per meter. Source T.R. No.13, MPO, 1987.

	Unit Cost (Tk)
1) 90 m span Sada Khal Bridge	39,870,000
2) 90 m span Kura Gang Bridge	39,870,000
Total Bridges	**Tk 79,740,000**

Project Buildings
The project Operation includes only closing and opening of the regulator gates, and the Maintenance includes the repairs and guarding of the flood embankments. The internal management of the project area will be the responsibility of the Agricultural Extension. Therefore, there is no need for a separate project office space. The operation of the regulators and inspection of the embankments will be carried out by Khalashis.

A provision has been made for five Regulator/Embankment Khalasi Sheds, which will be constructed at the regulator sites. The unit cost of a standard design BWDB two-room khalashi shed is about Tk 250,000.

Total 5 Khalashi Sheds Tk 1,250,000

CAPITAL COST SUMMARY

		(1000 Tk)
Structures		28,250
Earthworks		272,229
Bridges		79,740
Buildings		1,250
Land Acquisition		205,624
Base Cost,	Sub-total A	Tk 587,093
Physical Contingencies (25% of A)		146,773
	Sub-total B	Tk 733,866
Engineering Costs (15% of B)		110,080

TOTAL CAPITAL COST Tk 843.946 Million

Project Net Area 33,600 ha

Unit Cost 25,117 Tk/ha (661.0 US $/ha)

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Alternative 2: **Flood Protection, Drainage and Irrigation**

Alternative 2 is identical to Altenative 1 except that a gravity irrigation from a pumping station at Rahimpur introduced to a net area of about 5,600 ha located in the upper, eastern part of the project. At present there is no winter irrigation in this part of the area, and the proposed development will not affect the existing irrigation in the remaining part of the project.

The main irrigation components of the project are listed below.

Earthworks:

1. Main Irrigation Canals (MC)

MC1		19.0 km
MC2		11.0 km
	Total	30.0 km

2. Lateral Irrigation Canals (LC)

MC1 Laterals	41.0 km	
MC2 Laterals	23.0 km	
	Total	64.0 km

3. Field Irrigation Canals (FC) 79.0 km

Pumping Station:

1.	7.52 m^3/s total capacity pumping station (four units 1.88 m^3/s)	1 no.

Structures:

1.	Main Canal Head Regulator	2
2.	Main Canal Aqueduct (drainage channel crossing)	19 Nos.
3.	Main Canal Waste-way	2
4.	Lateral Canal Head Regulator (at LC offtake from MC)	9
5.	Lateral Canal Head Regulator (with highway crossing)	8
6.	Main Canal Check Regulator	2
7.	Lateral Canal Check/Drop	26
8.	Field Canal Intake	160
9.	Field Turnout	933
10.	0.60 m dia. Pipe Culvert	38
11.	1.5 m span Culvert	16
12.	6.0 m span Bridge	10

TABLE B-7: IRRIGATION CANALS

Canal Number		Net Command Area (ha)	Canal Length (km)	Reqd. Canal Capacity (m^3/s)
1. Main Canal 1 (MC1)		600.0	19.0	4.91
1a. Lateral Canals	L1-1	300.0	3.5	0.39
	L1-2	600.0	8.0	0.79
	L1-3	450.0	5.5	0.59
	L1-4	150.0	2.0	0.20
	L1-5	200.0	3.0	0.26
	L1-6	100.0	2.0	0.13
	L1-7	100.0	2.5	0.13
	L1-8	200.0	3.0	0.26
	L1-9	150.0	2.5	0.20
	L1-10	750.0	7.0	1.00
	L1-11	150.0	2.0	0.20
		3150.0	41.0	
	Total MC1	3750.0		4.91
2. Main Canal 2 (MC2)		200.0	11.0	2.42
2a. Lateral Canals	L2-1	100.0	1.5	0.13
	L2-2	100.0	2.0	0.13
	L2-3	150.0	2.0	0.20
	L2-4	150.0	2.0	0.20
	L2-5	150.0	2.0	0.20
	L2-6	100.0	1.0	0.13
	L2-7	150.0	2.0	0.20
	SKC	200.0	4.0	1.00
	LS-1	150.0	2.0	0.20
	LS-2	150.0	1.5	0.20
	LS-3	50.0	1.0	0.07
	LS-4	200.0	2.0	0.26
		1650.0	23.0	
	Total MC2	1850.0		2.42
3.0 Field Canals		4750.0[(1)]	79.0[(2)]	

Notes:

i) About 850 ha of land assumed to be irrigated directly from mains and laterals.

ii) The length of field canals estimate based on an average canal spacing of 600 m.

COST ESTIMATES (IRRIGATION)

TABLE B-8: IRRIGATION CANALS

Item	Quantity	Unit	Rate (Tk)	Amount (Tk)
1. Main Canals 30.0 km				
Earthwork	269400	m^3	24.27	6538338
Dressing & Turfing	275500	m^2	2.27	625385
Land Acquisition	34.3	ha	300000	10290000
2. Lateral Canals 64.0 km				
Earthwork	464640	m^3	24.27	11276813
Dressing & Turfing	706560	m^2	2.27	1603891
Land Acquisition	83.8	ha	300000	25140000
3. Field Canals 79.0 km				
Earthwork	208560	m^3	24.27	5061751
Dressing & Turfing	511920	m^2	2.27	1162058
Land Acquisition	53.7	ha	300000	16110000
Total Earthworks				26,268,236
Total Land Acquisition 171.8 ha				51,540,000
		Total		77,808,236

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TABLE B-9 : STRUCTURES

Structure	Number	Unit Cost (1000 Tk)	Amount (1000 Tk)
1. Main Canal Head Regulator	2	3,500	7,000
2. Main Canal Aqueduct (drainage channel crossing)	19	800	15,200
3. Main Canal Overflow	2	300	600
4. Lateral Canal Head Reg.	9	280	2,520
5. Lateral Canal Head Reg. (with road crossing)	8	370	2,960
6. Main Canal Check Reg/Br.	2	2,400	4,800
7. Lateral Canal Check/Drop	26	36	936
8. Field Canal Offtake	160	28	4,480
9. Field Turnout	530	6	3,180
10. Pipe Culvert (0.6 m dia)	28	160	4,480
11. Box Culvert (1.5 m)	16	280	4,480
12. Box Culvert (3.0 m)	10	354	3,540
TOTAL			Tk 54,176,000

PUMPING STATION

Rahimpur Pumping Station	Total Capacity Q = 7.52 m^3/s (4 units 1.88 m^3/s each)
Design Supply Level	18.0 m PWD
Kushiyara R. Design LW level	6.0 m PWD
Design Static Head	H = 12.0 m

Pumping Station Costs:

Pumping Station	250,000,000[1]
Office Building (200 m^2)	1,000,000
Godown & Workshop (240 m^2)	1,200,000
Residence (160 m^2)	800,000
Land Acquisition (1.5 ha)	750,000
Total	**Tk 253,750,000**

[1] This cost figure was taken from an identical pumping station (Baniada) completed in Feb 93.

CAPITAL COST SUMMARY

	FC&D	IRRIGATION	TOTAL ALT II
	(1000 Tk)	(1000 Tk)	(1000 Tk)
Structures	28,250	54,176	82,426
Embankments	173,710	-	173,710
Channels	98,519	26,268	124,787
Bridges	79,740	-	79,740
Pumping Station	-	250,000	250,000
Buildings	1,250	3,000	4,250
Land Acquisition	205,624	52,290	257,914
	587,093	385,734	972,827

Alternative II Base Cost, Sub-total A Tk 972,827

Physical Contingencies
(25% of A) 243,207

Sub-total B Tk 1,216,034

Engineering Costs
(15% of B) 182,405

TOTAL CAPITAL COST Tk 1,398.439 Million

Total Project Cultivable Area 33,600 ha

Project Net Irrigated Area 5,600 ha

Unit Cost
(based on total project cultivable area) 41,620 Tk/ha (1095.3 US $/ha)

Unit Cost of Irrigation
(based on net irrigated area) 99,016.5 Tk/ha (2605.7 US $/ha)

ANNEX C

INITIAL ENVIRONMENTAL EXAMINATION

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: 49,200 ha.

Impacted (net) area: 33,600 ha.

Impacted area outside project: possible downstream effects. Peak water levels at downstream end could increase by up to 0.5 m due to confinement effects. During feasibility studies, the impact of this on external areas should be assessed.

Temporal:

Preconstruction: years zero through year 3 (see Table 7.7).

Construction: year one through year four (see Table 7.7).

Operation: year five through year 29.

Abandonment: after year 29.

Cumulative impacts:

With other floodplain infrastructure: This will be looked at in the context of the Regional Plan.

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. The same matrix was used for both Alternatives 1 and 2, but the impacts of 'surface water irrigation' (operation phase) do not apply to Alternative 1 which is under consideration here. 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 7.10 and 7.11 (multi-criteria analysis).

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. Flushing sluices for water exchange to maintain water quality and some fish passage. Resettlement of homesteads left outside the embankment, in an attempt to prevent embankment cutting when channel water levels are high, should be considered during the feasibility study.

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. This is an institutional question that needs to be looked at on a national or regional scale. DOE is responsible for reviewing EIAs, but has no authority to enforce compliance to the terms of an EMP. In any case, project implementation should be contingent upon the preparation at the feasibility stage of satisfactory reporting/accountability arrangements.

Budget estimates. These should be generated as part of the feasibility study.

C.3 Alternative 2: Proposed FCD Project with Surface Water Irrigation Component

Note that Alternatives 1 and 2 are identical except for the addition of a surface water irrigation component to Alternative 2.

C.3.1 Project Design and Description (Step 1)

As in Section 8.3, Project Description.

C.3.2 Environmental Baseline Description (Step 2)

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

C.3.3 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.3.4 Bounding (Step 4)

Physical:

Gross area: 49,200 ha.
Impacted (net) area: 33,600 ha.

Impacted area outside project: possible downstream effects:

(1) Peak water levels at downstream end could increase by up to 0.5 m due to confinement effects. During feasibility studies, the impact of this on external areas should be assessed.

(2) Fish brood stock overwintering in the Kushiyara River downstream of the pumping station could be adversely affected due to lower water levels, lower flow rates, and poorer water quality. The lowest 90%-dependable flow rate is 17.8 $m^3 s^{-1}$, and the pumping station capacity is 7.5 $m^3 s^{-1}$ or 42% of the lowest 90%-dependable flow. Of particular concern would be the reduced flushing and dilution of industrial pollutants from the Fenchuganj fertilizer factory and other sources.

Temporal:

Preconstruction: year zero through year three (Table 8.5).
Construction: year one through year four (Table 8.5).
Operation: year five through year 29.
Abandonment: after year 29.

Cumulative impacts:

With other floodplain infrastructure: This will be looked at in the context of the Regional Plan impact assessment.
With pre-existing no-project trends. These are noted in Chapter 5.

C.3.5 Field Investigations (Step 5)

Field investigations were limited to seven to ten days informal reconnaissance by a multidisciplinary team.

C.3.6 Impact Assessment (Step 6)

At this level of detail, a screening matrix is used (Table C.1). The same matrix is used here as for Alternative 1, and the impacts of 'surface water irrigation' (operation phase) do apply to this Alternative. Impacts are discussed in Section 8.8.

C.3.7 Quantify and Value Impacts (Step 7)

Quantification and evaluation of impacts is documented in Section 8.8 and Tables 8.8 and 8.9 (multi-criteria analysis).

C.3.8 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).

The EMP is the same as for Alternative 1 except for the following.

Mitigation and enhancement. Options to mitigate the fisheries impact of the irrigation water withdrawal need to be investigated.

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 (ALT 2 ONLY)		+	-		+					
		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											

Matrix does not follow the EIA guideline FPCO, October, 1992

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 (ALT 2 ONLY)		+	-		+					
		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

Figure 1

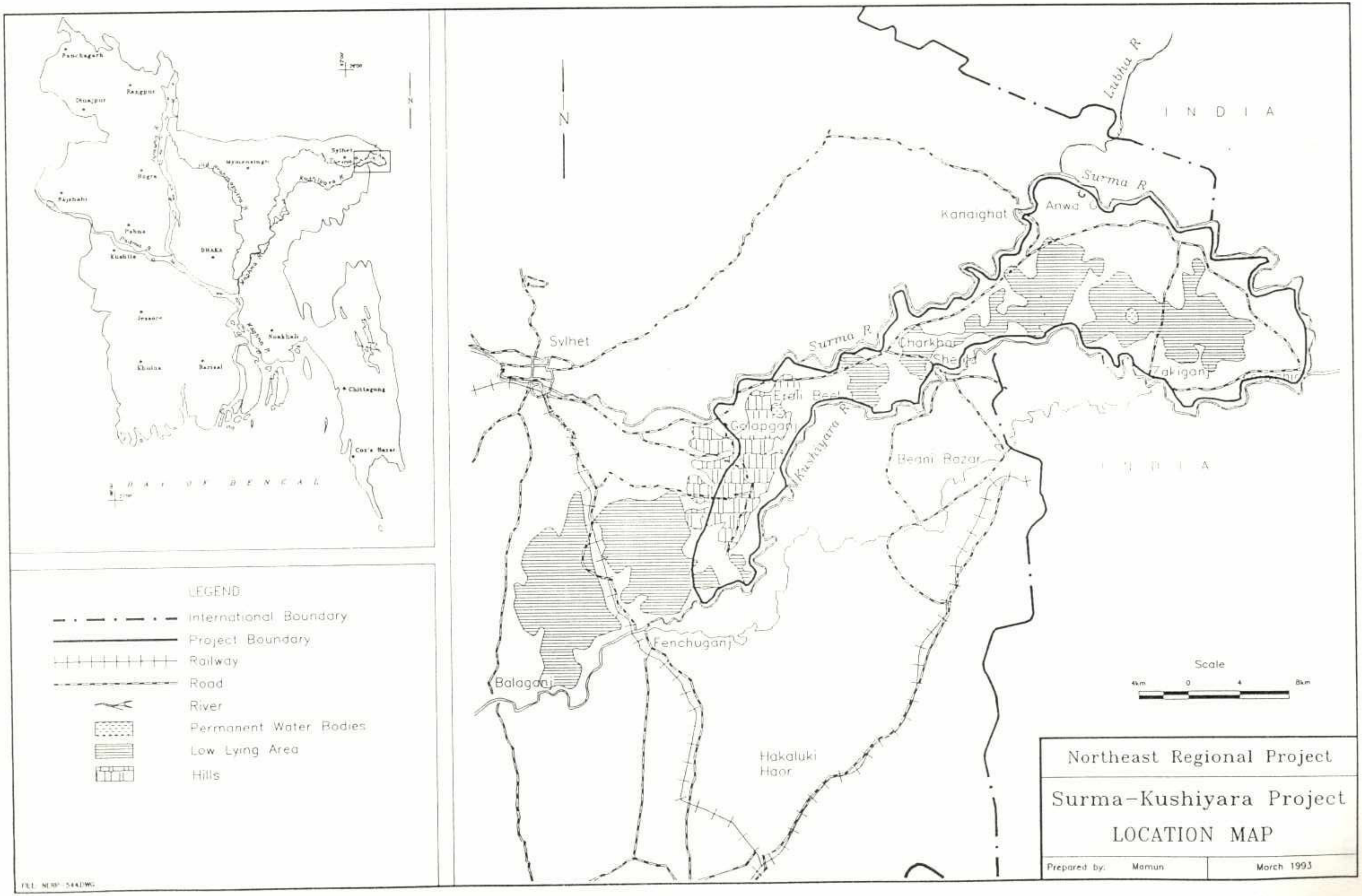
Northeast Regional Project
Surma-Kushiyara Project
LOCATION MAP
Prepared by: Mamun
March 1993
Scale
4km 0 4 8km
INDIA
INDIA
N
Lubha R
Surma R
Surma R
Kushiyara R
Kanaighat
Anwa
Charkbar
Sheola
Zakiganj
Eroli Beel
Golapganj
Beani Bazar
Sylhet
Fenchuganj
Balaganj
Hakaluki Haor
LEGEND
International Boundary
Project Boundary
Railway
Road
River
Permanent Water Bodies
Low Lying Area
Hills
BAY OF BENGAL
DHAKA
Chittagong
Cox's Bazar
Sylhet
Mymensingh
Rangpur
Dinajpur
Panchagarh
Rajshahi
Bogra
Pabna
Kushtia
Jessore
Khulna
Barisal
Noakhali
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Figure 2

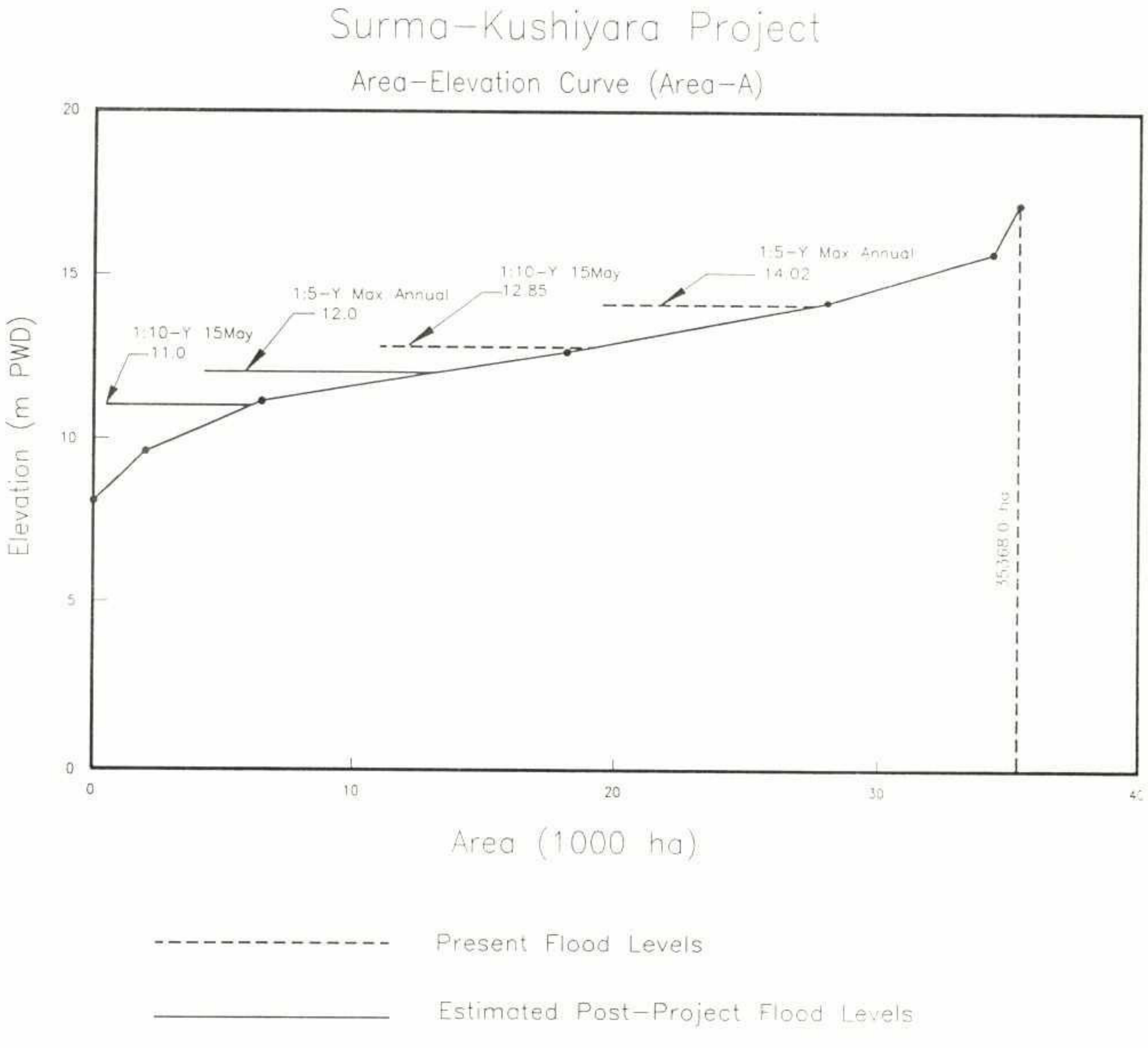

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Figure 3

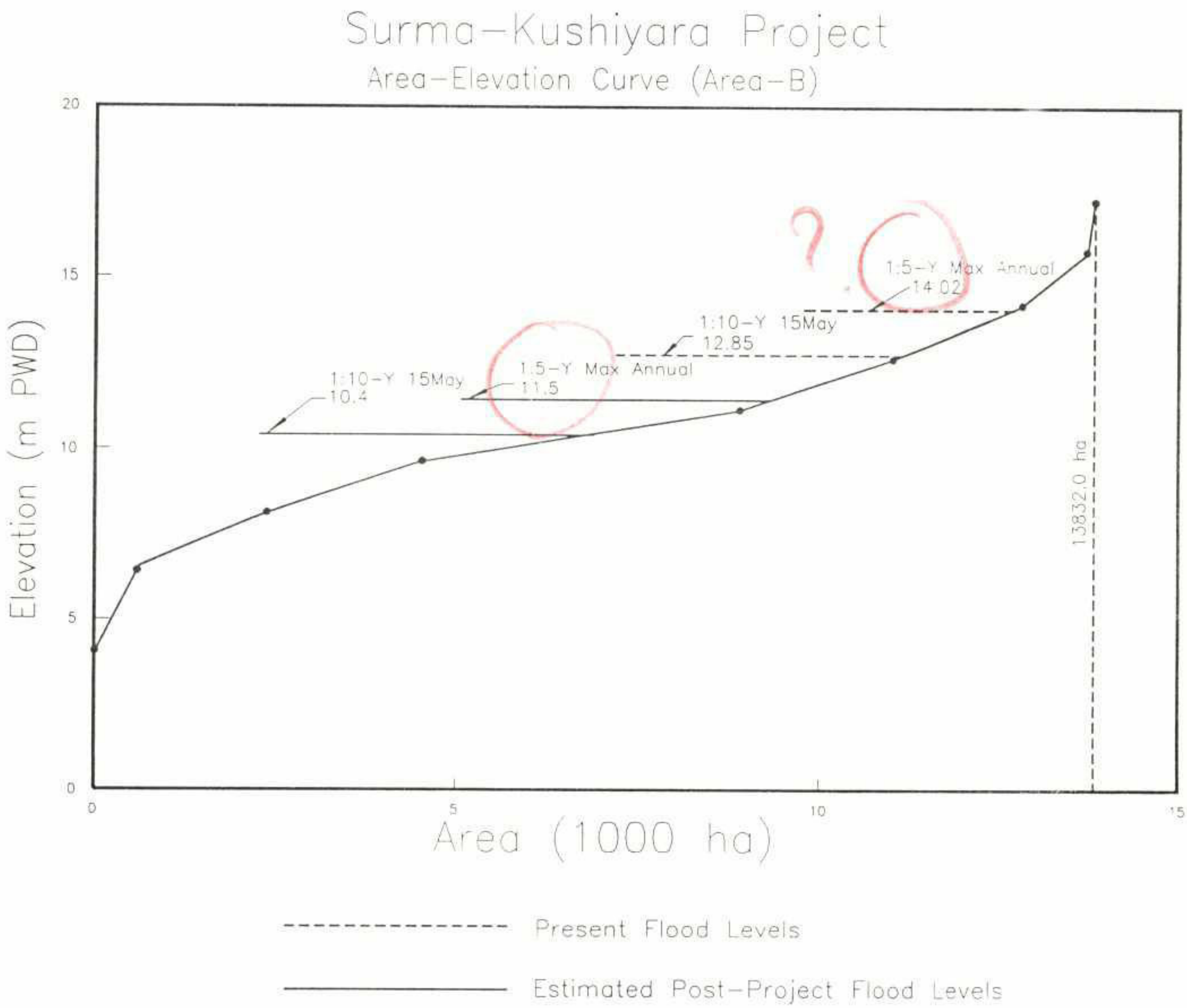

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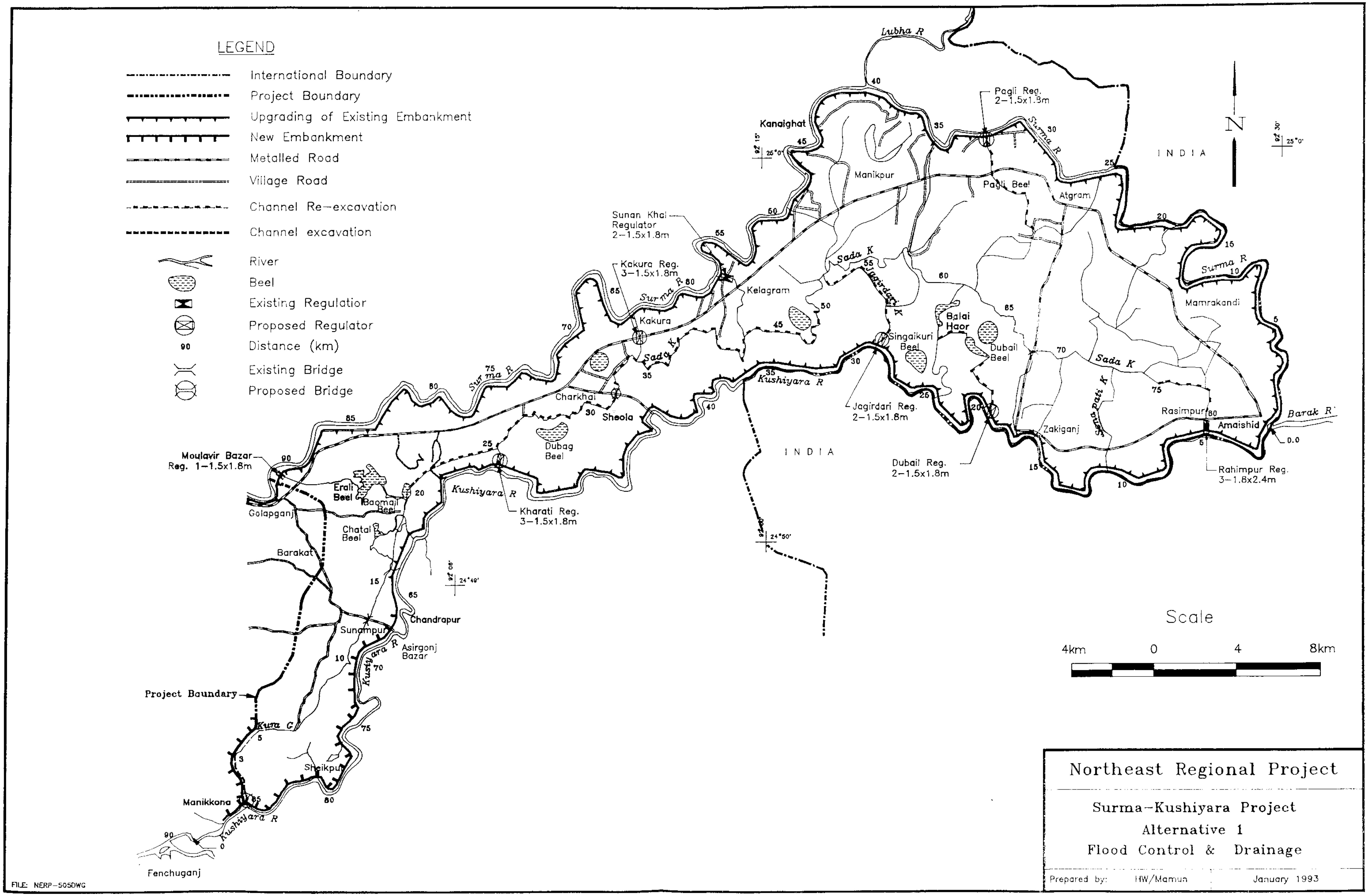
Figure 4



Northeast Regional Project

Surma-Kushiyara Project

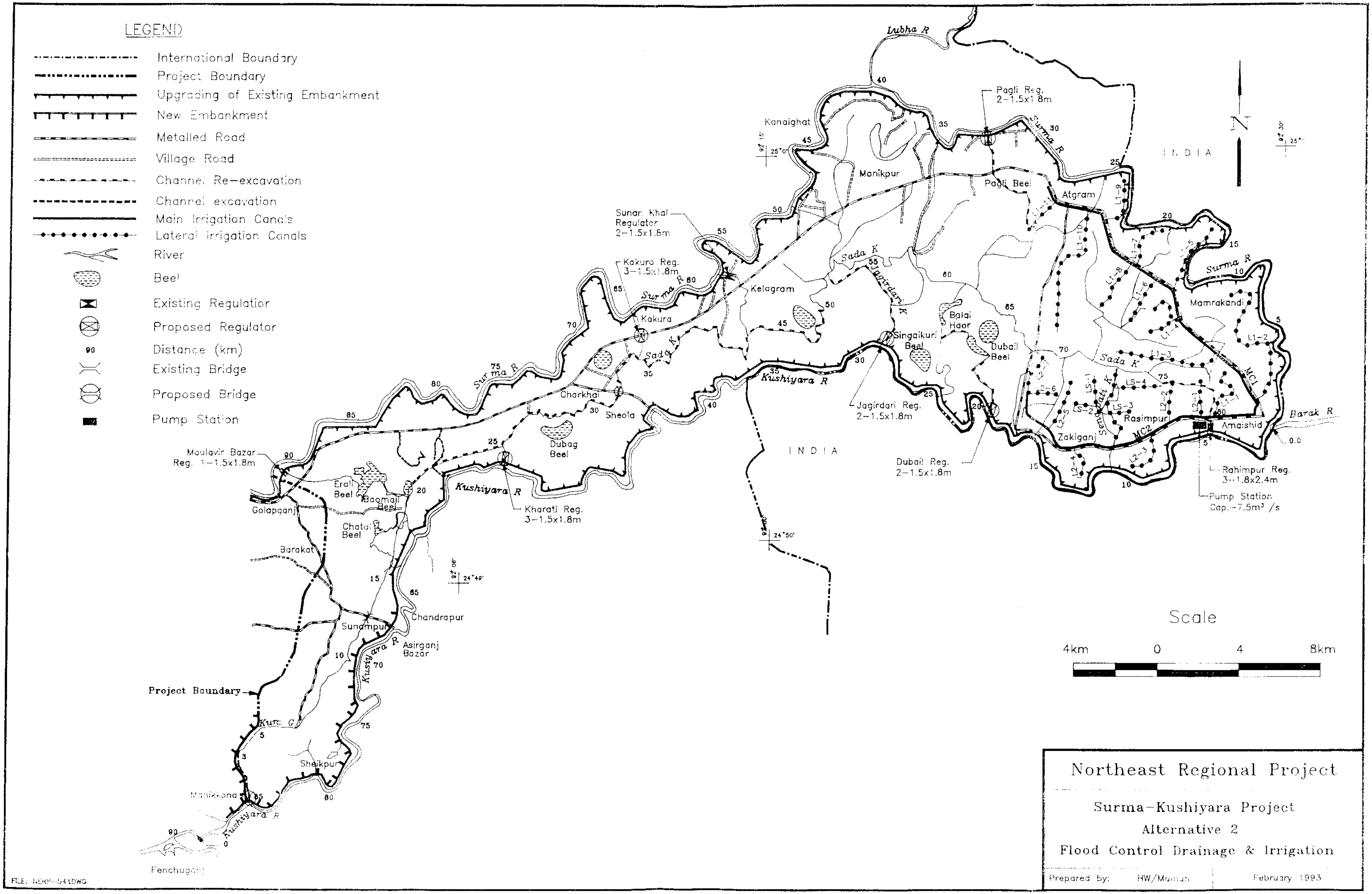
Alternative 1

Flood Control & Drainage

Prepared by: HW/Mamun January 1993

FILE: NERP-505DWG

209 Figure 5



Northeast Regional Project

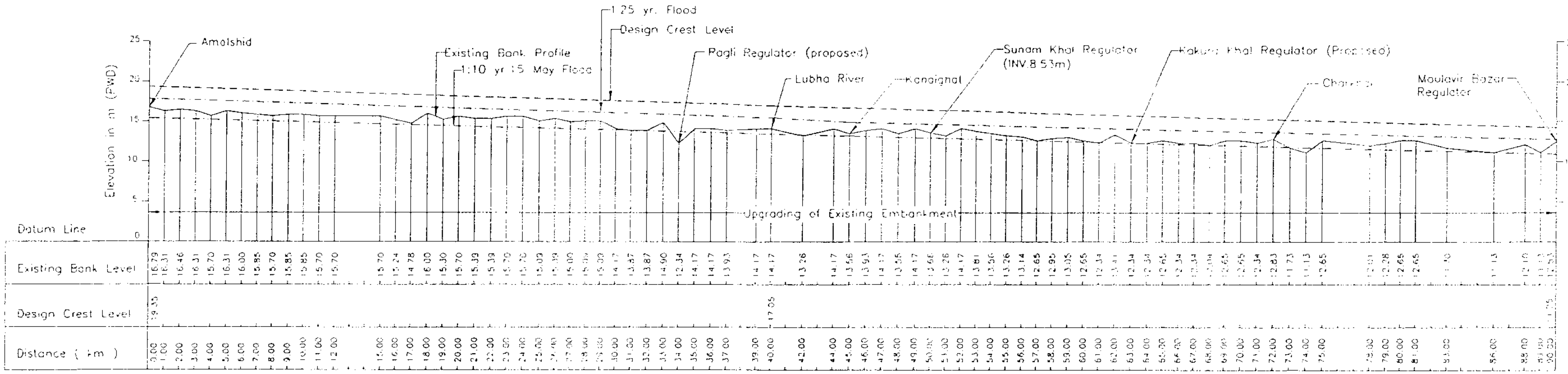
Surma-Kushiyara Project

Alternative 2

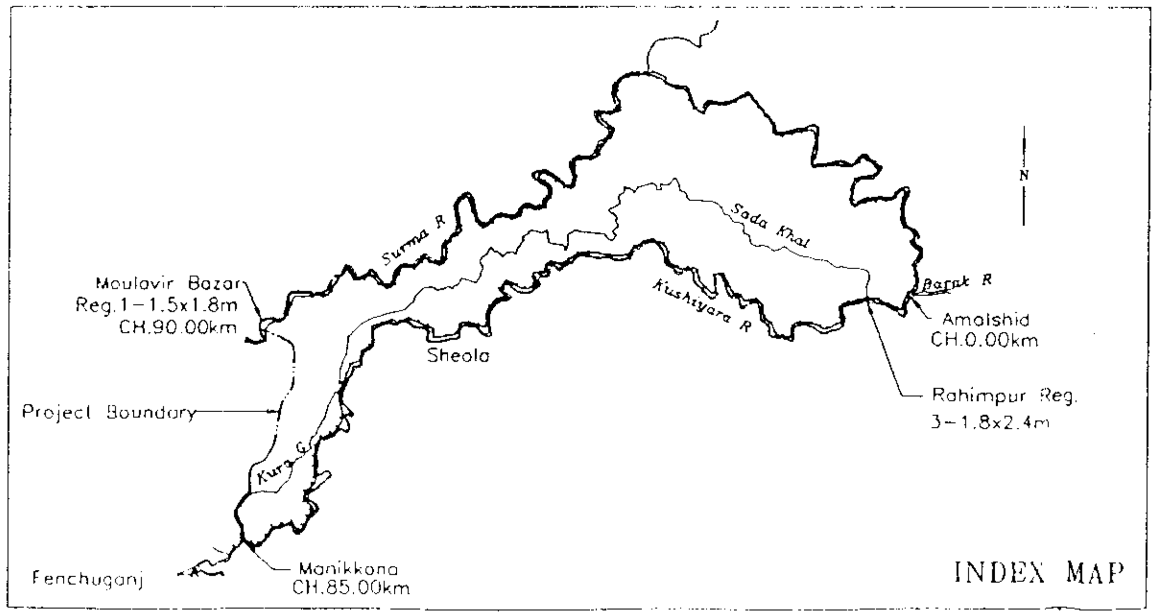
Flood Control Drainage & Irrigation

Prepared by: HW/Mamun February 1993

Figure 6



SURMA RIVER LEFT EMBANKMENT PROFILE



INDEX MAP

Northeast Regional Project

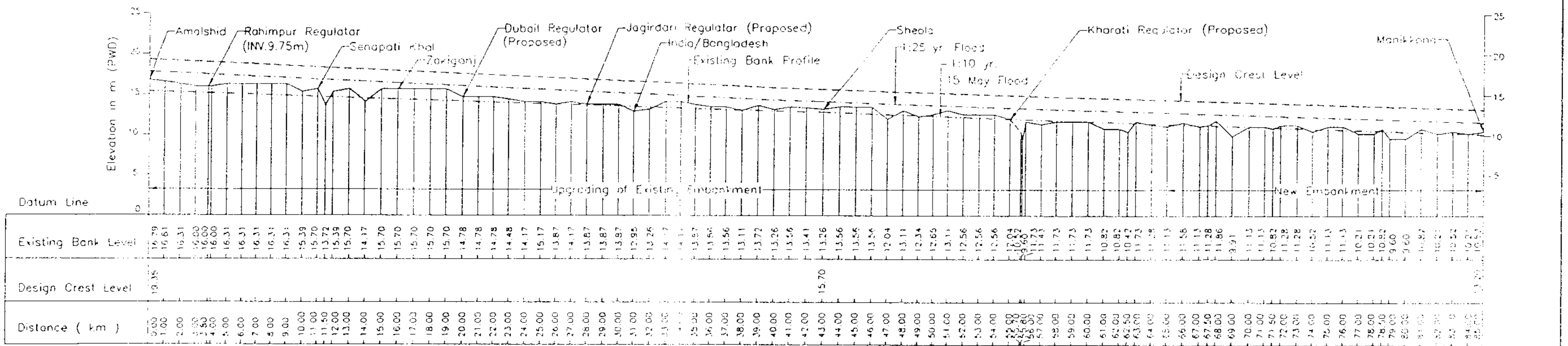
Surma-Kushiyara Project

Surma River
Left Embankment

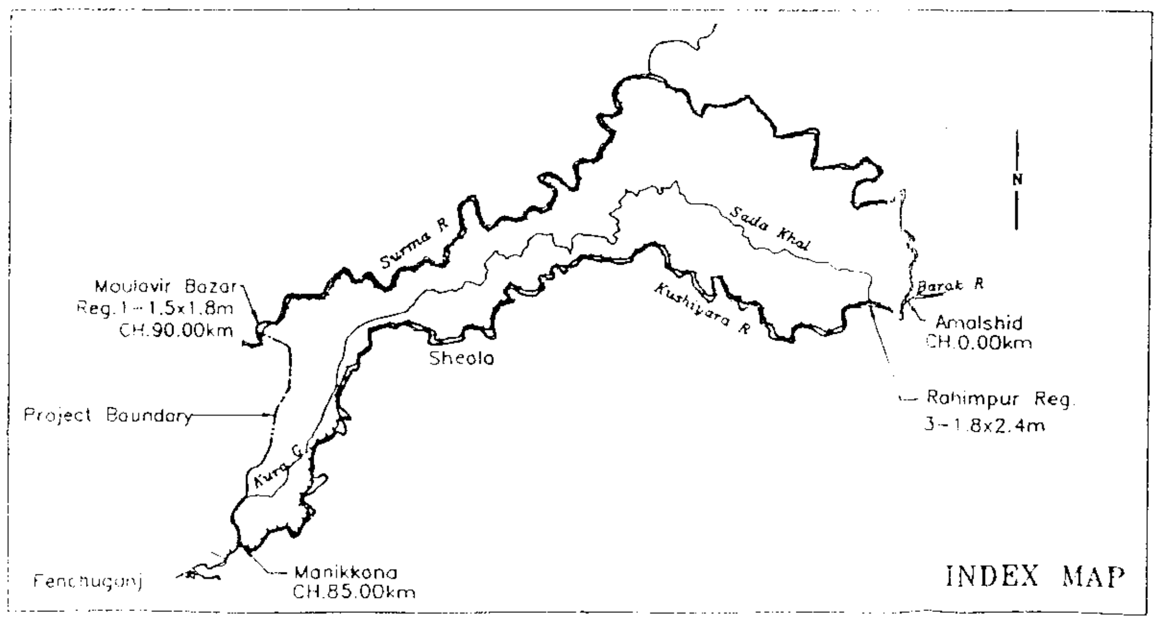
Prepared by: HW/Jalal | March 1993

FILE: NERP-096.DWG

Figure 7



KUSHIYARA RIVER RIGHT EMBANKMENT PROFILE



INDEX MAP

FILE: NERP-097.DWG

Northeast Regional Project

Surma-Kushiyara Project

Kushiyara River
Right Embankment

Prepared by: HW/Jalal | March 1993

Figure 8

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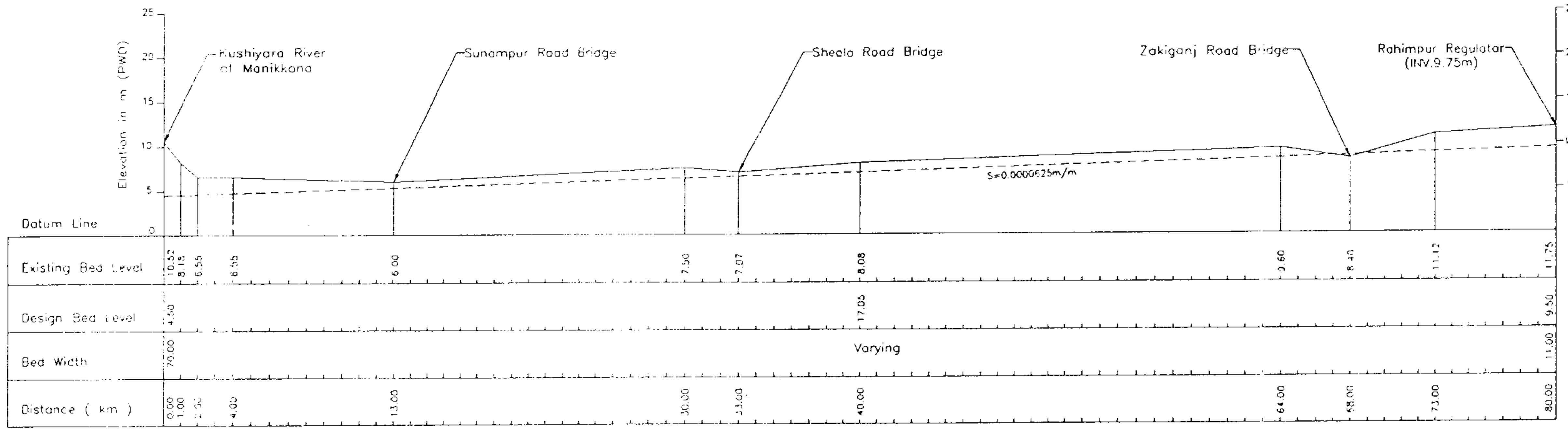
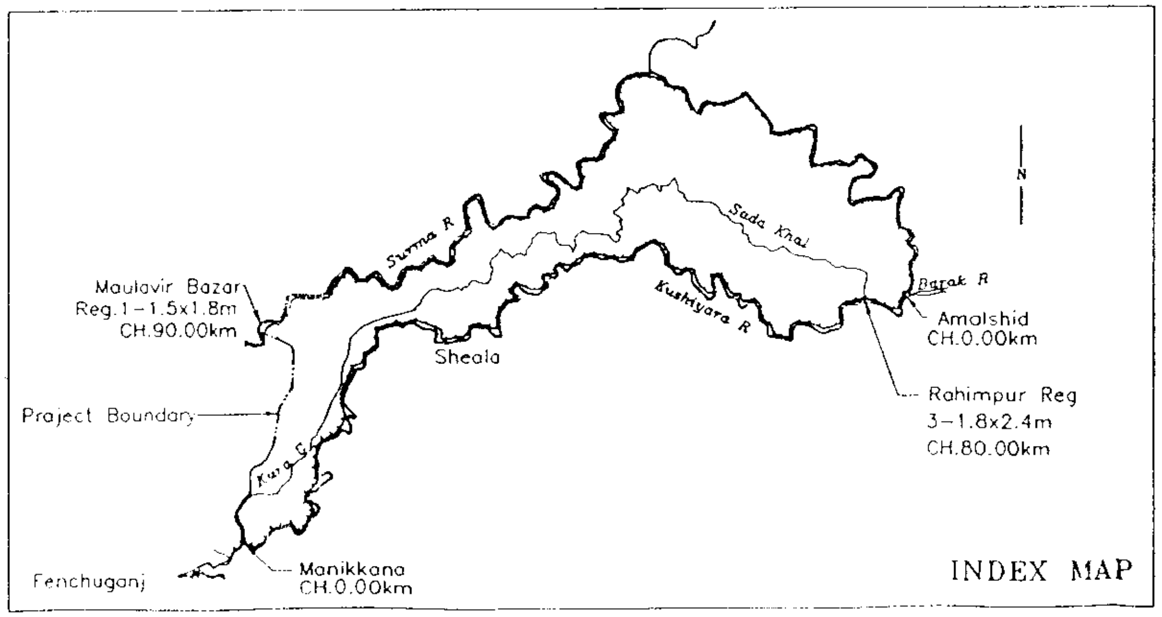


KURA GANG–SADA KHAL MAIN DRAINAGE CHANNEL PROFILE



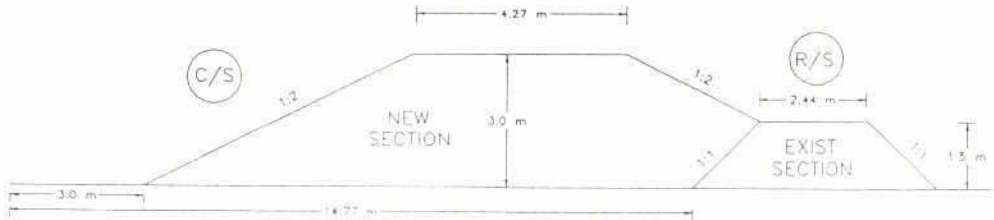
INDEX MAP

FILE: NERP-098.DWG

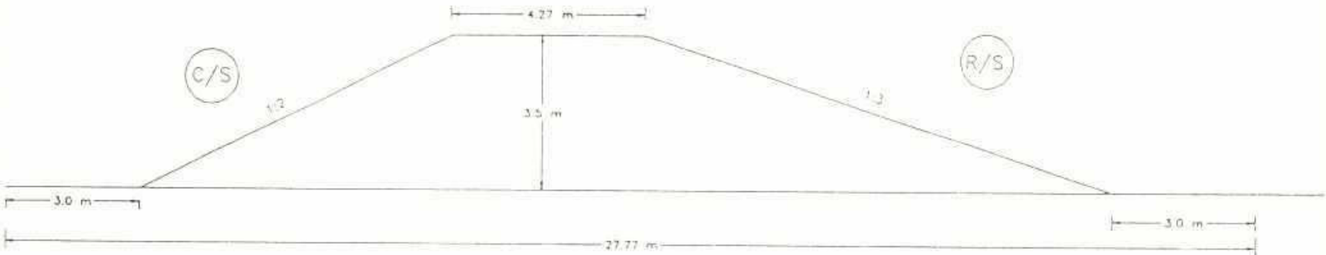
Northeast Regional Project	
Surma–Kushiyara Project	
Kura Gang–Sada Khal Main Drainage Channel Profile	
Prepared by: HW/Jalal	March 1993

2 0 2

UPGRADED EXISTING EMBANKMENT

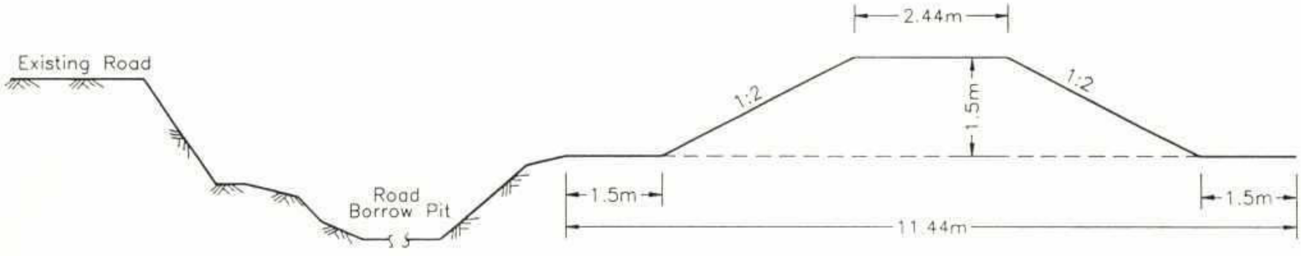


NEW EMBANKMENT

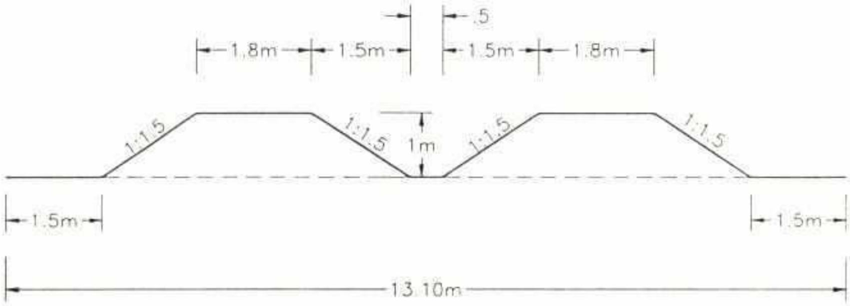


FILE: HENRY.DWG

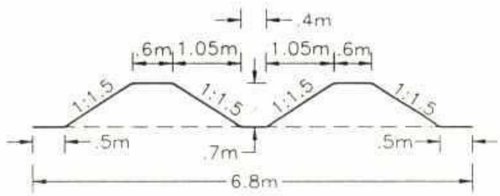
Northeast Regional Project	
Surma Kushiyara Project	
Typical Cross Section of Flood Embankments	
Prepared by: HW/Nasim	March 1993



MAIN CANAL (Along Road)



LATERAL CANAL



FIELD CANAL

NOTE:-
ALL DIMENSIONS ARE IN METRES

Northeast Regional Project

Surma-Kushiyara Project

Typical Cross Sections
of Irrigation Canals

Prepared by:	HW/Jalal	March 1993

FILE: NERP-105.DWG