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)

DHARMAPASHA - RUI BEEL PROJECT

PRE-FEASIBILITY STUDY

Draft Final
February 1994

Shawinigan Lavalin (1991) Inc.
Northwest Hydraulic Consultants

in association with

Engineering and Planning Consultants Ltd.
Bangladesh Engineering and Technological Services
Institute For Development Education and Action
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Acronyms and Abbreviations

ADB	Asian Development Bank
AEZ	agroecological zone
AST	Agriculture Sector Team
BANBEIS	Bangladesh Bureau of Educational Information and Statistics
BBS	Bangladesh Bureau of Statistics
BIWTA	Bangladesh Inland Water Transport Authority
BFRSS	Bangladesh Fisheries Resource System Survey
BRDB	Bangladesh Rural Development Board
BWDB	Bangladesh Water Development Board
CIDA	Canadian International Development Agency
DAE	Department of Agricultural Extension
DPHE	Department of Public Health Engineering
DSSTW	deep-set shallow tube well
DTW	deep tube well
EIA	environmental impact assessment
EIRR	economic internal rate of return
EMP	Environmental Management Plan
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
IEE	Initial Environmental Evaluation
ISPAN	Irrigation Support Project for Asia and the Near East
LLP	low-lift pump
LT	local transplanted
MPO	Master Planning Organization
NERP	Northeast Regional Water Management Planning Organization
NGO	non-governmental organization
NHC	Northwest Hydraulic Consultants
NPV	net present value
PD	person-day
PWD	Public Works Department
RCC	reinforced concrete
RRA	rapid rural appraisal
SLI	SNC-Lavalin International
STW	shallow tube well
SWMC	Surface Water Modelling Centre
WARPO	Water Resources Planning Organization

US $1 = Tk 38

MPO Land Classification Terminology

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

Executive Summary

The purpose of this project is to increase *boro* rice and *rabi* crop production, while incurring the best possible outcomes for navigation and the openwater fishery.

Many *haor* areas are suitable for only one crop annually, and the window within which that crop (*boro*) is produced relatively short. Changes in the hydraulic regime (the result of human interventions and natural processes such as sedimentation) are further reducing the time available for this crop, with the result that the crop is damaged or destroyed in more than half the years it is planted. While efforts are needed to diversify farming systems in this flood regime, the system will be based on *boro* rice production into the foreseeable future.

The proposed project involves the construction of 2 m high submersible embankments (50 km) for protection against flash floods. The embankments would connect existing high lands and homesteads on the perimeter of *beel*. Five drainage/flushing regulators, three pipe sluices, and 20 irrigation inlets would be provided in the embankment; an additional two pipe sluices would be provided in an internal village road. Internal channels (50 km) would be re-excavated.

The negative impacts on navigation and the openwater fishery of the pre-monsoon flood protection and increased surface water irrigation withdrawals would be partially mitigated by the channel re-excavation; by retaining water in the dry season behind the regulators in the improved channels and in the *beels*; by providing boat passes in two of the regulators; and by providing fish passes (once these have been field tested in the region).

The river system within which the project is located is actively changing in a number of places. Future hydrologic conditions in the project area will depend on natural processes, and on the outcomes of several of the NERP initiatives affecting this system, including *Baulai River Improvement*, *Upper Kangsha River Basin Development*, and *Updakhali Project*.

NERP DOCUMENTS

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

Northeast Regional Water Management Plan

Main Report
Appendix: Initial Environmental Evaluation

Specialist Studies

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

Public Participation Documentation

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

Pre-feasibility Studies

Jadukata/Rakti River Improvement Project
Baulai River Improvement
Mrigi River Drainage Improvement Project
Kalni-Kushiyara River Improvement
Fisheries Management Programme
Fisheries Engineering Measures
Habiganj-Khowai Area Development
Flood- and Erosion-Affected Villages Development Project
Pond Aquaculture
Applied Research for Improved Farming Systems
Manu River Improvement Project
Narayanganj-Narsingdi Project
Narsingdi District Development Project
Northeast Region Environment Management, Research, and Education Project (NEMREP)
Upper Kangsha River Basin Development
Upper Surma-Kushiyara Project
Surma Right Bank Project
Surma-Kushiyara-Baulai Basin Project
Kushiyara-Bijna Inter-Basin Development Project
Dharmapasha-Rui Beel Project
Updakhali River Project
Sarigoyain-Piyain Basin Development

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TABLES

1. INTRODUCTION

1.1 General Information

BWDB Division:	Sunamganj
Districts:	Sunamganj and Netrokona
Thanas:	Dharmapasha, Madhyanagar, Barhatta, Mohanganj
MPO Planning Area:	23
Gross Area:	20,500 ha
Net Area:	17,024 ha

1.2 Scope and Methodology

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

1.3 Data Base

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

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

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

Agricultural analysis: Data used from secondary sources include Land Resources Appraisal for Agricultural Development in Bangladesh (AEZ Reports) for soils and Water Resources Planning Organization (WARPO) for agricultural inputs. This being a pre-feasibility level study, Rapid Rural Appraisal (RRA) technique was followed for collecting primary data on cropping pattern by land type, crop damage, and trends. An experienced professional agronomist, accompanied by a multidisciplinary team, followed several traverses cutting across different land types in the project area and interviewed groups of farmers on each land type for collecting information on cropping patterns and crop damage on an *anna* (proportion of Taka) basis. These numbers were used in estimating cropping patterns by land type on a percentage basis. These were then applied for computing area under different cropping patterns on each land type developed by superimposing water level data on the area-elevation curve. Likewise data collected on percentages of crops damaged were applied for computing area under different crops suffering flood damage. Data on yield level of different crops both for damaged and damage-free conditions were also collected and used in computing present production. Views of farmers were considered in making future projections for both future without (null option) and with project conditions.

Fisheries analysis: Topographic maps, BFRSS data, CIDA Inception Report, NERP Fisheries Specialist Study, field observations and local interviews, information provided by local representatives during field seminars held at Sylhet in June, 1992 and at Habiganj in April, 1993.

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

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

1.4 Report Layout

A description of the biophysical features of the project area is provided in Chapter 2. Chapter 3 describes the current status of development and resource management including a summary of the types of problems faced by people living in the area. Chapter 4 briefly reviews previous studies directed towards development of the water resources and Chapter 5 lists trends which are occurring and which will continue if no interventions are made. Chapter 6 reviews water resource development options which were considered and Chapter 7 provides an analysis of the best option. The annexes consist of detailed information to support the main body of the report.

2. BIOPHYSICAL DESCRIPTION

2.1 Location

The Dharmapasha-Rui Beel Project covers a gross area of 20,500 ha between latitude 24°52′ and 25°04′ N, and longitude 90°56′ and 91°06′ E. The project area is bounded by the Someswari River in the north and east, the Kangsha River in the south, the Gunai and Updakhali Rivers in the northwest, and high land in the southwest (Figure 1).

To the northwest across the Gunai lies the proposed Updakhali River Project, and to the southwest the ongoing Singar Beel project.

2.2 Climate

Climate is monsoon tropical with hot wet summers and cool dry winters. Meteorological conditions, based on data from the nearest station in Sylhet, are summarized in Table A.1. The highest recorded temperature is 40.6 C in May; the lowest is 8.9 C in December. The highest mean monthly temperature is 26.9 C in May; the lowest is 19.7 C in December.

Average annual rainfall increases gradually from south to north, ranging from about 4000 mm near Mohanganj to about 5000 mm near Machhimpur (Figure 2). Mean monthly rainfall varies from 10 mm in January to 820 mm in June. Potential evapotranspiration varies from 102.64 mm/month in December to 162.4 mm/month in June.

2.3 Land (Physiography)

2.3.1 General Description

The major physiographic unit in the project area consists of low-lying flood basin and floodplain lands of the Sylhet Depression. *Haors* are one characteristic land form in this unit. These features are saucer-shaped, seasonally-flooded interfluvial depressions bounded by natural levees around their perimeter. The *haors* here are believed to have been created by the Brahmaputra River channel; earliest evidence of the Brahmaputra channel consists of a series of large scars extending from near Mymensingh into the Sylhet Basin (Morgan and McIntyre, 1959). The main river apparently extended east of the project area at one time and then swung southward into the Bay of Bengal.

Elevations and cumulative areas are presented in Figure 3. The central and southeastern part of the project have the lowest land elevations (as low as 2.0 m PWD). The highest land is found in the southwest along the Kangha and Gunai, where elevations range from 6.5 to 7.9 m PWD. The north and northeast are of intermediate elevation.

2.3.2 Soils

The area is covered mostly by Old Surma-Kushiyara floodplain basin soils and to a lesser extent by Young Surma-Kushiyara floodplain basin soils (somewhat surprisingly, these soils of eastern origin are found rather than soils of western origin from the Kangsha catchment; see Section 2.4.1 below).

The Old Surma-Kushiyara floodplain landscape consists of extensive basins, nearly level or very gently undulating, crossed by narrow high ridges adjoining rivers and creeks. Main ridge soils consist of grey, massive, puddled topsoil overlying grey, mottled, silty clay loam to clay subsoil with blocky or prismatic structure and medium to strongly acid reaction. The poorly-drained basin soils are grey to dark grey, clay with prismatic or blocky structure and medium to strongly acid reaction. The very poorly drained basin clays which remain saturated throughout the year have a strongly reduced colour and near neutral reaction and massive structure. Sometimes this landscape overlies a mucky or peaty layer within one metre of the surface. Depth to the organic layer gradually decreases from the periphery to the centre of the basins.

The Young Surma-Kushiyara floodplain landscape is criss-crossed by numerous cut-off channels, eroded levee remnants and broader basins, giving an impression of an undulating topography. The major soils on the ridges are grey to olive grey, loams to light clays, sometimes stratified from the surface or from below the plough layer. The ridge soils consist of a grey, massive, puddled loamy topsoil with strongly to medium acid reaction, overlying a grey, mottled clay subsoil with prismatic or blocky structure. The poorly drained basin soils consist of grey clays having prismatic or blocky structure and medium to strong acid reaction. The very poorly drained basin clays which remain saturated throughout the year have a reduced colour, near neutral reaction, and massive structure. The landscape may overlay a buried topsoil (peaty or mucky layer), which itself generally overlies a more silty deposit. Depth to the silty deposit gradually decreases towards the southwest.

2.4 Water (Hydrology)

2.4.1 River System

Geologically speaking the project area is located in the floodplain of the Brahmaputra as indicated by the land forms and meander scars which were mentioned in Section 2.3.1. However, over the past 200 years the Brahmaputra has largely abandoned its earlier course (the Old Brahmaputra River), leaving the existing rivers of the northeast region to define the present hydrologic and morphologic regimes regime of the project area.

The present hydrologic and morphologic regimes are defined by inflows from the Kangsha River from the west, by backwater from the central basin lying to the east, and to a lesser extent by water/sediment inflows from the Jadukata River on the north.

Kangsha River

The Kangsha River basin has an area of approximately 7,800 km^2 upstream of its confluence with the Baulai River, of which approximately half is located in India. It includes the upper Kangsha, the lower Kangsha (generally the reach downstream of Jaria Janjail), the Someswari River, and several other tributaries. A NERP report on the upper Kangsha basin[1] discusses fluvial processes therein; relevant aspects of this information are presented below.

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[1] *Upper Kangsha Basin Development Pre-Feasibility Study* (NERP, January 1994).

The fluvial processes that are the most significant to the project are related to sediment transport, erosion, and deposition in the Someswari River. The Someswari River is located on an active alluvial fan and undergoes periodic avulsions or large-scale shifts in river location. Prior to 1960 the major flow of the river was directed eastward into the Old Someswari channel and into the Kangsha floodplain, generally to the north of the project area. A major avulsion which occurred since 1963 formed the Shibganjdhala channel; it carries the major portion of the river flow into the Kangsha River upstream of Jaria Janjail. This shift has substantially increased the flow of water and sediment in the lower Kangsha River from Jaria Janjail to the confluence with the rivers of the central basin.

More recently the 1988 flood has formed a new avulsion of the Someswari eastward into the Atrakhali. This channel is rapidly growing and will likely become the major channel of the Someswari, depending on the occurrence of floods and other events in the upper watershed. If this process were to continue it would arrest the recent trends in the Kangsha River by directing more of the Someswari flow to the north. However, the regional development plan calls for closure of the Atrakhali channel in order to protect the area located on the east side of the Someswari fan from further flooding.

Near Thakurakona, upstream of the project, the Kangsha splits into three channel; the original Kangsha River, the Dhonaikhali River, and the Gholamkhali River (which joins the Gunai and the lower Someswari River near the project area). The old Kangsha and the Gholamkhali River form the project boundaries on the south and north respectively, while the Dhonaikhali flows away toward the south. The Kangsha has been largely abandoned as a result of sedimentation near its offtake and the Gholamkhali has grown to become the major channel of the Kangsha. This change is believed to be the result of the Someswari avulsion which forced more sediment to be carried into the Kangsha River, and is likely responsible for the channel siltation which has been reported in the project area.

The Gholamkhali/Gunai River has recently formed an avulsion to the north a short distance upstream of the project. Consequently the major portion of the pre-monsoon flow presently passes through the Updakhali project before rejoining the Someswari River at the northeast of the project area. This change may be contributing to siltation near in the project area. The NERP initiative *Updakhali Project* proposes to re-direct the flow down the Gunai, by partially re-excavating the Gunai and closing Gholamkhali Khal at the project boundary.

Central Basin

Water levels in the vicinity of the project are for the most part governed by backwater from the central basin. This low, wide area fills throughout the summer months as a result of the runoff from the rivers of the east (Barak, Surma, Kushiyara, and tributaries), as well as from the Kangsha. Generally the water levels reach their maximum in July or August.

Jadukata River

Discharges and sedimentation are affected to some extent by inflows from the Jadukata River from the north. The Jadukata River splits into a network of distributary channels, of which the Patnaigang is the largest. Recent changes have caused more river flow and sediment to be directed into the Patnaigang and from there into the project area.

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Table 2.1: Peak Water Levels

(a) Pre-monsoon floods

Station	Return periods			
	1:2	1:5	1:10	1:20
Kalmakanda (#263.1) [(a)]	5.09	5.65	5.89	6.07
Mohanganj (#36.1)	5.19	5.74	5.96	6.11
Sukdebpur (#72B)	4.92	5.04	5.09	5.12

(b) Monsoon floods

Station	Return periods			
	1:2	1:5	1:10	1:20
Kalmakanda (#263.1) [(a)]	7.94	8.44	8.85	9.31
Mohanganj (#36.1)	7.65	7.96	8.16	8.34
Sukdebpur (#72B)	7.40	7.76	7.91	8.01

[(a)] Kalmakanda water levels have been adjusted for +0.15 m datum correction indicated by NERP/Survey of Bangladesh second-order levelling programme.

Source: NERP.

2.4.2 Flooding

Virtually all of the project area comes under water annually during monsoon flood conditions, between June and October, which can damage aus and aman crops. Pre-monsoon flood levels are usually lower but they can damage boro rice crops between March and May. In some years flooding also occurs in the post-monsoon season between October and the end of December due to late-season rainfall such as occurred in 1991.

The major cause of flooding is the backwater from the central basin but this is aggravated by high runoff in the Kangsha basin which can cause water levels to be as much as 0.5 to 1 m higher near the project.

Peak pre-monsoon and monsoon flood levels for various return periods have been derived from historic water level data at Sukdebpur, Kalmakanda, and Mohanganj and are summarized in Table 2.1. In general the highest flood levels occur at Mohanganj during the pre-monsoon period and at Kalmakanda during the monsoon peaks, reflecting the general direction of flow. Kalmakanda levels have been corrected by adding a (provisional) 0.15 m datum correction which has been found in NERP's second-order survey program.

The pattern and depth of flooding within the project are shown in Figure 4 for both the pre-monsoon and the monsoon 1:2 year floods. About 11,500 ha (56% of the project area) are

Table 2.2: Flooded Areas

Flood Condition	Return Period	Non-Flooded	Flooded Area (ha)			
		< 0.3 m	0.3 to 0.9 m	0.9 to 1.8 m	> 1.8 m	TOTAL
Pre-monsoon	1:2	9000	5230	4270	2000	11500
Monsoon	1:2	700	2800	4000	13000	19800

Source: NERP.

inundated in the pre-monsoon flood, mostly on the northeast side of the project area. During the 1:2 year monsoon flood about 20,000 ha are inundated, or 96% of the project area. Of this, 13,000 ha are flooded to a depth exceeding 1.8 m.

Flooded areas are summarized in Table 2.2 according to the depth of flooding.

2.4.3 Drainage

The main drainage collector of the northern and eastern portions of the area is the Manai Nadi/Dahar Gang system which drains to the Someswari (Figure 5). The main drainage collector of the southern portion is the Khurma/Malai Nadi/Mara Gang/Saitan Khal system, which drains partly into the Someswari and partly into the Kangsha. Important local drainage channels include Gobrakhali Khal (drains to Updakhali), Ahmakkhali Khal (drains to Someswari), Chotojan Khal (drains to Gunai), and Dharam Khal (drains to Kangsha).

The Someswari and Kangsha Rivers have reportedly infilled with sediment and become almost dry during the winter months. Substantial sedimentation has also taken place in the collector drains of the project. As a result, post-monsoon drainage is delayed over a major part of the area; currently, water drains from the area until the first week of March. Local people report that late planting of crops renders them more vulnerable to pre-monsoon flash flooding and accumulated rainfall inundation; this limits the cropped area to the higher lands. Overall, the net cultivable area has been declining due to these causes.

Reportedly, the newly constructed road from Dharmapasha to Nawapara village impedes drainage from the western area.

2.4.4 Water Bodies

Open water bodies

About 75% (12,800 ha) of the area is seasonally inundated to a depth of greater than 0.3 m, of which about 20% (2500 ha) consists of perennial *beels*. The larger permanent *beels* are: Rui Beel, Labra Beel, Kamrati Beel, Kumiria Beel, Saidulla Beel, Hijla Beel, Hashua Beel, Digha Beel, Charta Beel, Dharam Beel, Karia Beel, Saidpurar Beel, Tukair Beel, Mardhola Beel, Shaldigha Beel, Chengian Beel, and Satkura Beel.

Closed water bodies

About 130 ha is occupied by approximately 1600 ponds.

2.4.5 Surface Water Availability

Each of the peripheral rivers is perennial but without significant flow; the flow has not been measured in any of them. Local people indicated that surface water (river plus *beels*) are quite sufficient for irrigation in the project area.

Ground Water

MPO (WARPO) data indicates that the estimated usable ground water recharge within the project area is 12 Mm^3, of which about 9 Mm^3 is thought to be accessible by DTW force-mode technology, and about 1 Mm^3 could be withdrawn by deep-set STW (Table 2.3). Suction mode STW technologies are not suitable due to aquifer constraints.

2.5 Land/Water Interactions

2.5.1 Siltation

Siltation occurs at the outfall of the Kangsha and Someswari Rivers and due to this, these rivers become almost dry during the winter months.

During the last decade at least 5 million m^3 of sand and silt (originating from the Jadukata, Surma, Thalukhali, and Someswari Rivers) has been deposited in the main channel of the Baulai River, mostly in the 50 km reach upstream of Itna. This deposition has been accompanied by siltation of *beels* and blockage of important distributary channels (Someswari, Kangsha, etc.) that drain into the Baulai River from the west. The deposition has impacted several existing submersible embankment projects and has also disrupted water transport.

Intensive siltation takes place in various *khals* and *beels* in Dharmapasha, Madhyanagar and Barhatta *thanas*.

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

2.5.2 River Erosion

The banks of the peripheral rivers seem to be quite stable.

2.5.3 Crop Damage

Crops are damaged by floods, drainage congestion, hailstorm, cyclones, pests, and so on. Data on floods and drainage congestion damage were collected from the field, and then cross-checked with the hydrologic analysis results.

Pre-monsoon flood damage affects local and high yielding varieties of *boro* rice in the reproductive phase and local varieties of broadcast *aman* in early vegetative growth phase. These crops are submerged when water levels rise suddenly after rains in the catchment. The extent of damage depends on the crop growth stage and submergence duration. Farmers sometimes manage to collect the partially matured *boro* panicles from underwater, but of course yields are much reduced.

Monsoon flood and drainage congestion damage affect local and high yielding varieties of transplanted *aman* rice. Damage takes place mostly at the vegetative stage, hampering tillering and ultimately bringing down yield levels. Damage also occurs when local varieties of broadcast *aman* seedlings are submerged before elongation ability is acquired.

2.6 Wetlands and Swamp Forest

2.6.1 Natural Wetlands

The project is located in the deeply flooded zone on the western side of the Sylhet depression, south of the key wetland sites Tangua Haor and Pashua Beel. In the monsoon more than 70% of the area is inundated, of which about 2500 ha are perennial *beels*. The larger *beels* are listed in Section 2.4.4. The eastern and especially the northeastern part, close to Gurmar Haor and Sonamoral Haor, are the most deeply flooded.

Table 2.3: Ground Water Recharge

Mode	Usable Recharge (Mm^3)	Available Recharge (Mm^3)
STW	0.0	0.0
DSSTW	1.14	1.00
DTW	12.16	8.72

Source: MPO (WARPO)

Wetlands throughout the area have fairly uniform characteristics, with minor variations. Deep flooding throughout the area restricts the growth of natural vegetation. As the water recedes, natural vegetation start growing and spreads very rapidly over almost the entire area.

The most important wetland plant community is sedges/meadow, which produces a lot of valuable grasses. These grasses grow on very low land, and on *beel* borders where residual moisture remains high through the dry season. Submerged and rooted floating plant communities are dominant in other areas. Although human interference is lower in this area than for the region on average, encroachment is still a big problem; most of the land where water is available for irrigation is already under rice cultivation.

Due to habitat degradation, wildlife are rare in almost the entire area. All of the bigger mammals have already disappeared; smaller mammals (otters, rats, and the smaller cats) persist. Waterfowl concentrations are restricted to the larger *haor* complexes and mostly in the northern side. [??]

2.6.2 Swamp Forest Trees

There are at least five small patches of swamp forest existing within this project, each having an area of from 2 to 5 ha. The dominant species of these forests is Barringtonia acutangula *hijal*. Smaller patches consisting of a few trees are quite common. Moreover, individuals of these species can be found in homestead groves.

3. SETTLEMENT, DEVELOPMENT, AND RESOURCE MANAGEMENT

3.1 Human Resources

3.1.1 Land Use and Settlement Pattern

Land Use
Current land use, derived from secondary data sources, is summarized in Table 3.1.

Table 3.1: Current Land Use

Use	Area (ha)
Cultivated (F0+F1+F2+F3)	17024
Homesteads	275
Beels	2491
Ponds	128
Channels	362
Hills	-
Fallow[1]	150
Infrastructure[2]	70

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

Some of the values used here are rather unsatisfactory and will require further investigation during feasibility studies. *Beel* area, which refers to perennially inundated area (Section 2.4.4), could be on the high side as siltation has been occurring in recent years. Homestead area is calculated from population (Section 3.1.2), using a nominal average homestead size, and should be confirmed in the field.

The fallow area reported here may be too low. Local people indicated that a substantial area (1000 ha was reported) remains fallow year-round (in addition to this, other which are fallow in summer only are used for grazing; Sections 3.1.5 and 3.7).

Relatedly, the cultivated area as stated here may be too high — if the estimate of fallow area is revised upward, the cultivated area estimate must decrease to balance it. Also, the cultivated area stated here implies an average size for large farms of 9 ha (calculated from the total cultivated area, minus small and medium farm areas, divided by the number of large farms). A more likely value would be around 5 ha, given local conditions (Section 3.1.5).

General Description of Settlements
Settlements generally consist of villages along river levees and *kanda*. Settlements on the western side of the project in Barhatta *thana*, where land elevation is higher, are sparsely scattered; homesteads are surrounded by bushy jungles. Settlements in low-lying areas in Madhyanagar and Dharmapasha *thanas* are extremely sparse and located mainly on *kanda* and river sides.

Flood Damage to Housing
Damage to homesteads from monsoon wave action is a problem throughout the area, except for villages along the Kangsha and a few villages in Mahanganj and Barhatta *thanas*. Homesteads located on higher lands are not affected by seasonal monsoon floods. Severe floods affect villages throughout the project.

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Table 3.2: Population Distribution by Age Group (%)

Sex	Population Age Group (Years)						Total
	0-4	5-9	10-14	15-54	55-59	>60	
Male	16.3	15.4	13.4	46.5	1.9	6.5	100.0
Female	17.2	16.3	12.6	47.4	1.5	5.0	100.0
Total	16.8	15.8	13.0	47.0	1.7	5.7	100.0

Source: BBS, 1981 Population Census

Coping Strategies

Most homestead platforms are raised to one metre or more to avoid monsoon flooding; three to five metre high platforms are found in the low-lying *haor* areas in Madhyanagar and Dharmapasha *thanas*.

If there is severe flooding, villagers generally make platforms inside their houses and shift their belongings to safer places, if available. The poor suffer the most.

Homesteads are protected from wave erosion by building a seasonal protection wall from soil, bamboo, and locally-available wild grasses.

3.1.2 Demographic Characteristics

The total population of the area is an estimated 78,000, of which 38,000 are female. The gender ratio is 104 (males to 100 females). The total number of households is an estimated 11,400, in 130 villages. Between 1981 and 1991, population increased 21.1%.

The age cohort distribution for males and females is shown in Table 3.2.

Average population density is 383 persons per km^2. Compared to regional (723 per km^2) and national (763 per km^2), this is very low: Dharmapasha *thana*, which accounts for almost 50% of the area, has the seventh lowest population density of the 90 *thanas* in the Northeast Region; Madhyanagar (18% of the area) has the fourth lowest.

Average household size is an estimated 6.9 persons.

3.1.3 Quality of Life Indicators

Quality of life is usually characterized in terms of selected key indicators. Those described here are literacy, access to health, sanitation, and pure drinking water facilities.

Literacy

Literacy rates are very low. The 1981 census indicates that for individuals aged five years and above, male and female literacy were lowest, at 13.5% and 8.5% respectively, in Dharmapasha *thana*, and highest, at 19.7% and 13.2%, in Mohanganj *thana*. Literacy appears to have increased slightly over the last ten years. The 1991 census gives a combined (male+female) literacy rate of 17.2% for Sunamganj district and of 18.1% for Netrokona district.

The 1981 census indicates that school attendance for children (male+female) five to nine years of age varies from a low of 15.7% (females only, 14.3%) in Dharmapasha *thana* to a high of 19.0% (females, 16.7%) in Madhyanagar *thana*. Attendance for youths (male+female) between the ages of five and 24 was reported as 12.5% (females, 7.7%) and 14.4% (females, 11.4%) for these *thanas*.

The situation is worst for the rural poor. They can not afford to send their children to school. Moreover, many villages, especially in Barhatta and Dharmapasha *thanas*, have no primary schools. The average number of primary schools per 10,000 population is estimated to be 5.6 for Sunamganj district and 4.3 for Netrokona district (BANBEIS, 1990).

Access to Health Services

The district headquarters of Sunamganj and Netrokona have hospital facilities. Similarly, hospital facilities are available at the *thana* headquarters of Dharmapasha, Barhatta and Mohanganj. 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 176,910 persons and one doctor for every 24,234 persons in Sunamganj district. One hospital bed is meant for 6,626 people. For Netrokona district, the figures are 159,208 persons and 21,621 persons respectively, while one bed is meant for 5,877 people. As of 1990, immunization coverage of children below two years of age is 18% in Barhatta *thana* and 63% in Dharmapasha *thana*.

Rural Water Supply

DPHE (1991-92) reports the availability of one working tube well per 181 persons in rural Sunamganj district, and one well per 108 persons in Netrokona district. In 1990, 82% of Sunamganj households and 89% of Netrokona households had access to potable water. Most tube wells are located in the houses of richer families, however, which limits the access of the poor.

Sanitation

Specific information on sanitation facilities is not available at the project level. In general, 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 protected by bamboo mats or banana leaves. During monsoon months, floodplain people generally defecate in running water. Sanitary latrines are uncommon in the village environment, except for very well-off and educated families.

3.1.4 Employment and Wage Rates

Most rural employment opportunities are in agriculture. The major crop is *boro*. Employment for men during *boro* cultivation has two peak periods: transplantation in January-February and harvesting in mid-April to mid-May. Similarly, employment during *aman* cultivation is available during the plantation and harvesting periods.

Peak period wages for male agricultural labourers vary from Tk 30 to 45 per day plus two meals. During the remaining slack periods, wages vary from Tk 25 to 30 per day. Employment opportunities for the poor are significantly reduced during the monsoon months. During this period, it is reported, some labourers (five or ten from a village) migrate to Companiganj and Tahirpur (Fazilpur) *thanas* to work carrying sand and stone from the quarries to various storing and construction centres. Some poor men also get employment plying boats during this time. Self-employment of the poor catching fish is also important in the *haor* floodplains. Wages from these activities varies from Tk 50 to Tk 70 per day.

During months when agricultural employment opportunities are limited, some poor people also migrate to the Netrokona district headquarters to work as rickshaw pullers, as construction workers, or sometimes in household activities.

Wage-paying employment opportunities for women are limited. A few women are reported to work as seasonal labourers with large farmers of the *haor* areas. A few poor women are employed by the CARE Rural Road Maintenance Program.

The project receives some in-migration, mainly from Mymensingh, Kishorganj, Faridpur, and Manikganj districts, by labourers who come and stay seasonally for rice harvesting and earth work.

3.1.5 Landlessness and Farm Size

About 5606 (49%) of all households (farm + non-farm) are landless, owning less than 0.2 ha of cultivable land. Of the 7700 farm households (includes owner-operators and landless share croppers, and excludes landowners not engaged in farming), 4300 (55%) are classified as small farmers (working 0.21 to 1.00 ha); 2300 as medium (1.01 to 3.00 ha); and 1100 as large (more than 3.00 ha). This implies an average large farm size of 9 ha, which seems too high.

About 6% of all households do not own any homestead land.

The area has a substantial amount of land that is not cultivated: deeper wetlands, reed lands, and community pastures.

The price of agricultural land varies from Tk 5,000 to Tk 25,000 per ker (0.12 ha) depending on the quality of the land and potential cropping intensity.

3.1.6 Land Tenure

Owner-operation is common in the area. Large land owners share-crop out their lands to tenants for operation. Under the system used here, the land owner provides half the input costs (for HYV *boro*) or no inputs (all other crops) and receives one-half the produce. *Rangjama* (leasing land out against payment of cash in advance is widely practised in the area; the usual rate‘ varies from Tk 500 to Tk 1,000 per ker (0.12 ha) for one season. This arrangement provides landless people with very little access to land, as they are seldom able to raise the cash needed for the lease fee plus inputs.

3.1.7 Fishermen

Fishing is an important activity. An estimated 300 to 500 traditional fisherman households live in the area. Traditional fishermen are those who have been engaged in the profession for generations. The *jalmohals* are sometimes leased out to their cooperatives, usually with the rich among them acting as financiers and appropriating most of the profit; poorer traditional fishermen provide skilled fishing labour in return for wages or a share of the catch. Additional information on fishing practices is given in Section 3.5.1.

In addition, the number of non-traditional fishermen is growing rapidly as landless and poor agriculturists turn to fishing to survive. These fishermen fish in open water, especially during monsoon months, and sell the catch. About 30% of households, especially from the deeply flooded *haor* area, are reportedly engaged in catching fish to generate income.

Finally, almost all residents of the area catch fish for their own family consumption (subsistence fishing).

3.1.8 Situation of Women

Women's role is agricultural production is important, especially in post-harvesting activities, but women's contributions tend to be under-valued and under-reported. Rural women are responsible for much of the post-harvesting processing of rice crops, in particularly drying, winnowing, par-boiling and storing. Most women work in homestead gardens and raise ducks or chickens, in addition to their responsibilities for domestic work and child care. Very few women work in the fields; some poor women reportedly work outside their homes for the CARE Rural Road Maintenance Program and in activities such as gathering wild fruits, vegetables, and fuel.

3.1.9 People's Perception

General

Local people were asked for their perceptions of their situation and problems. The responses were related mainly to water control problems, their impact on livelihoods, and suggestions as to how these problems might be solved. Information was collected through personal interviews, group discussions, and meetings during the relatively short field work in the area; and during one-day seminars held at the Sunamganj and Netrokona district headquarters attended by the Honourable Members of Parliament, district and *thana* officials, union parishad chairpersons, and representatives from village level organizations and NGOs. The results are described below.

Problems

The major problems are flooding and drainage congestion. Pre-monsoon flash flooding during April and May damages the *boro* crop to varying degrees almost every year in the *haors* and *beels*. These flash floods generally enter into the area through peripheral rivers and their spill channels. The Baulai River also causes pre-monsoon flash floods in the project area. The situation is further aggravated by intensive rainfall during the period leading to waterlogging. Such damage has been a regular feature in recent years in the area.

Boro transplantation is delayed in many pockets, especially in the low-lying *haor* areas, due to drainage congestion. Rivers and drainage channels, especially the Baulai, Kanagdha, and Someswari Rivers are silted up.

Monsoon wave erosion of homestead platforms is also a serious problem, especially in Madhyanagar and Dharmapasha *thanas*. Many villages in these areas are eroding away rather quickly, and their existence is reportedly threatened.

Poor fishermen stated that prohibition of open water fishing by powerful *jalmohal* lessees was a major problem. Fishermen considered fishing by de-watering *jalmohals* was a major cause of decreasing fish production. They stated that roads and embankments in the floodplains obstructed easy movement of fish and reduced fish production. They were also concerned about the loss of fish habitats and large scale deforestation in the flood plains.

Navigation is hampered by the silting up of the rivers and channels. Closure of channels and construction of embankments have created problems for boat traffic, especially during the early monsoon period.

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

- Dredge the Baulai River for quick drainage of the upstream flood waters, especially during pre-monsoon period.

- Provide sluice gates at Selimkhali Khal, Kandarpar Dhala, Mora Nadi near Horipur, Pathara Khal, Sataria Khal, Monai Nadi at Tunair Ghat, Gobrakhali Khal and Chotojan Khal.

- Re-excavate Manai Nadi, Malai Nadi, Saitan Khal, Dahar Gang, and Dharam Khal to improve post-monsoon drainage.

- Close Kamaurar Khal, Pipra Kandar Khal, and Palni Nadi of Shahpur village.

- Stop intrusion of flood waters from the Someswari River through Kandapara Khal, Ahmakkhali Khal, and Tungibari Khal.

- Take measures to protect the most vulnerable villages from monsoon wave erosion.

- Lease *jalmohals* to local fishermen only.

- Allow poor and subsistence fishermen to catch fish in the floodplain.

- Conserve enough fish habitat for normal production of fish and plant enough water-resistant trees, like *hijal* and *koroch* in the higher floodplains and along river banks.

- Designate a few suitable *jalmohals* as fish sanctuaries and protect them to increase fish production.

- Stop overfishing of *jalmohals*; stop fishing by complete de-watering.

- Keep adequate provision for navigation when building embankments, to reduce conflicts leading to public cuts. Provision for boat passage is also necessary for submersible embankments.

- Re-excavate the Kangsha and Someswari to facilitate navigation between the area and the Baulai.

3.1.10 Local Initiatives

People stated that it is their traditional practice to organize themselves to counteract crises arising from flash floods and drainage congestion. 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 voluntary basis by the villagers around a particular canal which is threatening their property. More recently the union *parishad* also allotted grain to pay for some of the earthwork.

3.2 Water Resources Development

3.2.1 Flood Control and Drainage

There is no water development project in the area.

3.2.2 Irrigation

Surface Water

About 11,611 ha is irrigated with surface water from LLPs and traditional modes (AST, 1991); most this is in Dharmapasha *thana*. Of this, 2,527 ha is reportedly irrigated by 185 LLPs; 153 of these have capacities of 57 l/s (Table A.3).

Ground Water

Very little ground water is used for irrigation. Reportedly 63 STWs irrigate 414 ha and two DTWs irrigate 86 ha; most of this is in Dharmapasha and Barhatta *thanas* (Table A.3; AST, 1991). Ground water abstraction is about 3 Mm3, based on MPO estimated ground water irrigation duty. MPO estimates of ground water availability indicate that STWs are not suitable in the area due to aquifer constraints, but the AST data clearly contradicts this assertion. This issue should be sorted out during feasibility studies and the results provided to the ADB-financed Northeast Minor Irrigation Project which is currently re-evaluating regional ground water resource estimates.

3.3 Other Infrastructure

A road links Netrokona, Mahanganj, and Dharmapasha. During the winter months this road is motorable; during the monsoon season, it is mostly submerged.

There are in addition about 50 km of main village roads running between the *thana* centres. Most (about 45 km) of these roads are not passable during the monsoon season due to flooding.

3.4 Agriculture

Present cropping patterns (Table 3.3) are the result of farmers' efforts to adjust crop production practices to the hydrologic regime, in particular flooding, in the pre- and monsoon seasons.

F3 land (flooding > 1.8 m) accounts for 30% of the cultivated area; F2 land (flooded from 0.9 to 1.8 m) accounts for another 26%. Most of these areas are flooded early in the pre-monsoon season and remain wet through part of the *rabi* season. The predominance of this semi-aquatic environment during most of the year has led to the emergence of rice as dominant crop in these areas. Local *boro* is grown in 95% of F3 land, initially in static water after the flood recession; irrigation water is provided at the later stage where available, elsewhere pre-monsoon rains must be relied upon. High-yielding varieties of *boro* are grown on 5% and 15% of F3 and F2 land respectively. HYV *boro* is grown mostly as a single crop, depending on irrigation facilities and flood onset date; the remainder is grown in sequence with transplanted deep water *aman*.

Local-variety broadcast *aman* is the dominant crop on F2 land. Most of this is single-cropped except in a small area where timely post-monsoon flood recession permit *rabi* crops to be grown in winter.

F0 land (flooded less than 0.3 m) accounts for another 25% of cultivated area. F1 land (flooded between 0.3 to 0.9 m) accounts for the remaining 19%. Rice-based multiple cropping is practised on both these land types. One or two monsoon rice crops are grown, either or both local *aus* during the *kharif* 1 (early monsoon) season, and/or local or high-yielding varieties of transplanted *aman* rice in the *kharif* 2 (late monsoon) season. In the *rabi* season, non-rice crops (potato, wheat and different types of pulses, oilseeds, spices and vegetables) are grown with residual soil moisture.

The agricultural production system is closely linked with farm family needs, and storage and marketing facilities. The inaccessibility of the area makes it difficult for farmers to get reasonable prices for their produce. Most farmers sell their products in village markets immediately after harvest when prices are typically low. Lack of storage facilities and the need for cash compel them to do this; later they must then buy back the same items for family consumption at higher prices. It is estimated that only 20 to 25% of the production actually enter commercial markets. Private traders handle most of this amount.

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

Table 3.3: Present Cropping Patterns

Cropping Pattern	F0		F1		F2		F3		Total Area
	Area	%	Area	%	Area	%	Area	%	
b *aman*-fallow					3101	70	0	0	3101
fallow-l *boro*					0	0	4858	95	4858
fallow-HYV *boro*	0	0	0	0	443	10	255	5	698
b *aus*-fallow-*rabi*	0	0	323	10	0	0	0	0	323
b *aus*-lt *aman*	1275	30	1292	40	0	0	0	0	2567
b *aus*-lt *aman*-potato	212	5	161	5	0	0	0	0	374
b *aus*-lt *aman-rabi*	425	10	323	10	0	0	0	0	748
b *aus*-HYV *aman-rabi*	212	5	0	0	0	0	0	0	212
lt *aman*-fallow	1063	25	646	20	0	0	0	0	1708
lt *aman-rabi*	425	10	484	15	0	0	0	0	909
HYV *aman*-wheat	637	15	0	0	0	0	0	0	637
b *aman-rabi*	0	0	0	0	664	15	0	0	664
b *aman*-HYV *boro*	0	0	0	0	221	5	0	0	221
Total	**4250**		**3230**		**4430**		**5114**		**17024**

Note: Areas in hectares.

Table 3.4: Present Crop Production

Crop	Damage free area			Damaged Area			Total Prod
	Area	Yield	Prod.	Area	Yield	Prod	
b *aus*	1724	1.25	2155	2500	1.05	2625	4780
b *aman*	1487	1.75	2602	2500	1.45	3625	6227
lt *aman*	5307	2.15	11410	1000	1.75	1750	13160
HYV *aman*	350	3.95	1382	500	3.55	1775	3157
l *boro*	1858	2.25	4181	3000	1.45	4350	8531
HYV *boro*	420	4.55	1912	500	2.75	1375	3287
Paddy			23644			15500	39144
wheat	637	2.05	1307				
potato	374	12	4488				
pulses	428	0.85	364				
oilseeds	1428	0.75	1071				
spices	143	2.25	321				
vegetables	857	8.75	7498				

Note: Areas in hectares; yield and production in metric tonnes.

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Table 3.5: Fish Species

Boromach	Chotomach
Catla, rui, mrigel, kalibaus, ghonia, boal, air, bagair, ghagot, rita, chital, gazar, shoal, pangas, mohashoal, ilish	*Singi, magur, gang magur, koi, kholisha, lati, cheng, garua, tengra, gulsha, bajori, bheda, fali, napit, darkina, mola, chata, dhela, chela, tit puti, puti, sarputi, kani pabda, pabda, chanda, boicha, tatkini, kanipona, baashpata, batashi, bacha, rani, chapila, keski, laso, tara baim, baim, gutum, cirka, kaikka, shilon, poa, ek tuitta, chanda, golda chingri, icha*

Present input levels are low for local varieties and moderate for high-yielding varieties. Yields vary depending on input levels and flood damage. Yield data under damaged and damage-free conditions were collected and used to generate crop production (Table 3.4).

3.5 Fisheries

3.5.1 Floodplain fishery

Beels serve as overwintering refuges for the species present in the area. During the monsoon season, water from the Kangsha, Updakhali, Someswari, and Gunai Rivers flows in through open *khals*, breached dykes, and by overtopping riverbanks. Most of the *beels* are interlinked with each other by narrow channels and fish can move freely between rivers, channels, *beels*, and floodplain.

The large fisheries are leased, usually for a three-year period, and generally to rich influential persons who live outside the area. They appropriate most of the proceeds, thereby depriving the locality in general and poor local fishermen in particular of much of the fisheries benefits.

Conflicts over *jalmohal* fishing, particularly between farmers and fishermen, are common. The *jalmohal* lessees construct and maintain water retention dams on the *beel* drainage canals, preventing timely *boro* cultivation near the *beels*. Later in the season, some *beels* are completely drained to facilitate fish capture, eliminating potential surface water irrigation supplies. Both practices harm the interests of farmers.

It was reported that lessees do not permit fishing by either traditional or non-traditional fishermen near *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). *Jalmohal* lessees' control of water management needs to be investigated in more detail during feasibility studies. intervention.

3.5.2 Species present in the area

Of the 155 species identified in the region, about 70 species inhabit the project area; the most common 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 nine *duars* in the adjacent Kangsha, Someswari and Gunai Rivers (Table A.4).

3.5.4 Sources of fish and breeding

Most of the species (except for major carp, *pangus*, and Hilsa ilisha *ilish*) breed more or less everywhere on the shallow floodplains surrounding the permanent water bodies. Localized breeding migration can be seen for *boal, ghonia, sarputi, pabda, fali, koi, singi, magur, puti, chanda, tengra, gulsha, kholisha, along, bheda, laso, lati, shoal, gazar* and some other smaller varieties of fish. Specific areas reportedly used by these species include Rui Beel, Digha Beel, Hijla Beel, Khurma Nadi area, Kurshibari area (Marai Nadi), and Hashua Beel. Reed habitat is favoured.

The species composition of the openwater fishery, excepting the *duars* and some deeper *beels*, is dominated by miscellaneous species (70%) followed by carps (15%) and catfish (10%).

The Tangua Haor mother fishery (including well-known carp breeding grounds) is located adjacent to the project area (Figure 1). It exerts a controlling influence on fish abundance over the entire floodplain of the area.

The giant freshwater prawn M. rosenbergii, a highly valuable export species, is also available in the rivers and floodplain of the area. The adults migrate downstream to spawn in estuaries and the sea; the juveniles move back into the rivers to grow and mature.

Ilish is also available in small amounts in the Kangsha and Gunai Rivers. The adults migrate from the sea far up the rivers to spawn.

3.5.5 Production trends

Openwater and aquaculture fishery production can be estimated from habitat areas and standard unit area production (Table 3.6) Of the total 2106 tonnes per year, *beels* account for 65%, floodplain for 27%, *khals* for 3%, and ponds for 5% (Table 3.6). No actual production data are available.

Fish production in the project area has declined about 25% over the last five years (i.e. 5% per year). Possible causes include:

- Siltation of *beels*. *Beel* area has declined by about 60% around the Someswari and Gunai River floodplain (Kalayani Haor); both water depth and hectare-months are decreasing. Sedimentation can be observed in the northern and southern parts of the area.

- Over-fishing.

- Loss of fish habitat, in particular as a result of encroachment of agriculture into *beels*.

- Fishing of reproductive stock from *duars* using *kona jal* and *current jal*, and similar gear.

- Increased fish mortality from fish ulcerative disease, which correlates well with *beel* water pollution due to agrochemical runoff from HYV *boro* cultivation; most noticeable during December and January.

- Lack of proper aquaculture extension services for pond owners.

3.5.6 Fishing practices

Openwater capture fishery
Floodplain subsistence fishing occurs mainly during the flooding period. Large-scale *beel* fishing occurs from November to February; in most cases, this is done on an annual basis.

Piles are not maintained as a part of the biological management of the fishery resource, but *katha* installation for annual fishing is common. *Hijal*, *koroch*, mango, *tetul* and *jarul* tree branches are widely used for *katha*. *Kathas* are installed in the months of August and September as water recedes from the floodplain.

Table 3.6: Present Fish Production

Habitat type	Area (ha)	Unit Prod'n (kg/ha)	Total Prod'n (MT)
Beel	2491	410	1021
Floodplain	12774	44	562
River/ Channel	362	175	63
Pond	128	800	102
Total	**15755**		**1748**

Source: BFRSS.

Closed Water
Pond fish culture practices are difficult here than in other parts of the country. Owners of flood-prone ponds (about 80% of the total) do not release fingerlings. Owners of flood-free ponds (the remaining 20%) usually release an uncounted number of fingerling into their ponds, but do not undertake any other management activities such as predatory fish eradication, regular feed/fertilizer application, or fish growth and health monitoring. The fish are usually harvested during the dry season.

It should be noted that ponds adjoining homestead land also provide domestic water supply for a wide variety of activities (bathing, washing clothes and dishes, occasionally watering homestead vegetable plots, and so on).

3.6 Navigation

The Kangsha and Someswari Rivers are the primary communication routes between the area and the Baulai River; BIWTA classifies them as class III routes. These rivers' outfalls into the Baulai become almost dry during the winter months as a result of siltation, and only very small boats can ply during the dry season. Local people requested for immediate re-excavation of these channels.

Country boats ply across the area during the monsoon season.

3.7 Wetland Resources Utilization and Management

The most important use of natural wetland products in this area is grass for building/thatching material and erosion protection works; the extent of utilization is very much confined to the deeply flooded areas. Various types of grasses are used: Hematheria protensa *chailla* is used for protecting homesteads, and Vetiveria zizanioides *binna*, Sclerostachya fusca *ikor*, Phragmites karka *khagra* and Clinogyne dichotoma *murta* are used for building materials. These species generally grow at the border of the perennial *beels* , and it is very difficult to estimate their growing area, but the total area is not less than 1000 ha. The estimated economic yield would be at least Tk 150 $ha^{-1} yr^{-1}$, giving a total value of Tk 0.15 million $year^{-1}$. Assuming a Tk 50 day^{-1} standard wage (i.e. 3 pd ha^{-1}), the associated employment would be 0.003 million pd yr^{-1}.

The second most important use is fodder. The people of the deeply flooded area are fully dependent on these materials, particularly during the monsoon when flood water covers almost all the grazing land. People from shallowly flooded areas also depend on these material for green fodder. Plants such as Nymphaea sp. *shapla*, Nymphoides sp. *chandmela*, and the grasses are commonly used. Quantification of the economic value is very difficult as most people collect for their own needs only. The area which produces fodder is perhaps 5000 ha, mostly composed of F3 land remaining fallow in the summer. Assuming an economic yield of Tk 40 ha^{-1}, the total annual value could be Tk 0.2 million, and the associated employment, again at Tk 50 day^{-1}, 0.004 million pd yr^{-1}.

The third most important use of these resources is for cooking fuel. Due to the high scarcity of fuel wood around the homesteads, people are becoming increasingly dependant on wetland plants for fuel. Swamp forest trees other than *hijal* are preferred, but woody shrubs as well as grasses are also used. The saplings of swamp forest trees are suffering badly due to this pressure.

Other wetlands products include:

- Food material — Poor people are heavily dependent on this food source, particularly in periods of scarcity. The Aponogeton rhizome is the most important item; the floral stalk of the water lily Nymphaea sp. and the seeds of the water chestnut Trapa maximowiczii are also used.
- Bio-fertilizer — From various weeds of the wetland.
- Medicinal plants — Polygonum sp. *kukra* is the most important; many other species are also used.

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, while fuel, food, and medicinal materials tend to be collected by women.

4. PREVIOUS STUDIES

In 1990, a project called *Dharmapasha-Rui Beel Project* was conceived by Sunamganj Water Development Division-II, BWDB in 1990. However, no further action was initiated by the Division.

5. WITHOUT-PROJECT TRENDS (NULL OPTION)

The purpose of this chapter is to characterize the "future without project" (FWO) scenario, that is, the future of the area if no new water resource development interventions are carried out. The time frame considered in this analysis extends to the year 2015.

In a later chapter (Chapter 7), the "future with project" (FW) scenario and the project impacts (the difference between FW and FWO conditions) are characterized.

The main FWO trends that can be identified are as follows.

Net population growth
The population of the area is estimated to be 98,190 by 2000 and 124,800 by 2015. This assumes the population growth rate will decrease from an annual rate of 2.1% as experienced over the last ten years to 1.6% by 2015.

River sedimentation
Active on-going changes in the rivers near the project area are expected to continue and will contribute to sedimentation problems. It is considered likely that the Gholamkhali River will continue to grow as the other channels of the Kangsha River fill in with sediments. This change will likely cause the Gholamkhali and Gunai Rivers to become deeper but will tend to increase the deposits of silt and clay overbank within the project area and general vicinity. In the longer term more sediment will be carried by the Shibganjdhala River into the Kangsha River and thence into the project area.

The implications of these changes in channel development and sedimentation are:

- The Kangsha River south of the Dharma-Pasha Rui Beel can be expected to gradually fill in with sediment.

- Gholamkhali Khal is actively developing; at its bottom end, the increased flow has cut a new channel into the proposed Updakhali Project area, accompanied by deposition of sediment from the development of Gholamkhali Khal.

- The Someswari channel to the north of Dharmapasha-Rui Beel project, which was largely abandoned until the recent shift of flow into Gholamkhali Khal and Atrakhali, can be expected to re-develop.

- There will be continued problems with shifting of the Gunai River on the north side of the project area and with deposition of sediments within the river and overbank within the project area.

This is subject, however, to ongoing changes within the Someswari River. If the present formation of the Atrakhali were to continue it would substantially alter the present trends. The locus of sedimentation would then shift to the northwest into the floodplain between the Kangsha and Someswari Rivers nearer to Kalmakanda. This change could possibly reduce the rates of sedimentation within the project area to some extent.

Openwater fisheries production
Some assumption must be made about FWO trends, to which FW fisheries production can be compared.

Past openwater fish production trends suggest a decline of at least 2% per year. On the other hand, suggestions for how biological management of the fishery could be improved suggest that great increases in production are possible. If the FWO trend is assumed to be negative, any negative impacts of the project on fish production will appear smaller than if the FWO trend is assumed to be positive.

Lacking any way to decide between these two scenarios, it is assumed that FWO production will be equal to present production.

Food grain production growth
Current trends in cropping patterns and agricultural production would continue in the absence of any water resources intervention in the area.

Future-without-project cropping patterns are presented in Table 5.1. The area under different land types would not change, except that some F3 land would be silted up. On some F0 land, some lt *aman* would be replaced by HYV *aman*. F1 land would continue to be dominated by lt *aman*. L *boro* would continue to dominate on F3 land, though continued siltation leading to drier winter conditions could lead to b *aman* replacing some l *boro*; farmers indicated that already they are growing b *aman* in some areas due to insufficient moisture. Only marginal irrigation expansion, accompanied by HYV *boro* replacing l *boro* and b *aman*, would occur because of the limited water available in the dry season. But this HYV *boro* would be at risk from pre-monsoon flooding. Farmers are expected to use their judgement to select relatively low-risk sites before making these investments.

Crop production under future-without-project conditions is presented in Table 5.2. As in the past (judging from historical data), changes in production will come from varietal shifts; yields of each of the varieties are not expected to change, given that input levels and flood damage would not change in the absence of interventions to protect from flooding. Damage to local and high yielding varieties of *boro* and b *aman* in the pre-monsoon season, and to local and high yielding varieties of transplanted *aman* from drainage congestion, especially on F1 land, would continue.

Table 5.1: Future-Without-Project Cropping Patterns

Cropping Pattern	F0		F1		F2		F3		Total Area
	Area	%	Area	%	Area	%	Area	%	
b *aman*-fallow					2880	65	255	5	3135
fallow-l *boro*					0	0	4602	90	4602
fallow-HYV *boro*	0	0	0	0	664	15	255	5	920
b *aus*-fallow- *rabi*	0	0	323	10	0	0	0	0	323
b *aus*-lt *aman*	1275	30	1131	35	0	0	0	0	2405
b *aus*-lt *aman*-potato	212	5	161	5	0	0	0	0	374
b *aus*-lt *aman*- *rabi*	425	10	484	15	0	0	0	0	909
b *aus*-HYV *aman*- *rabi*	212	5	0	0	0	0	0	0	212
lt *aman*-fallow	637	15	484	15	0	0	0	0	1122
lt *aman*- *rabi*	425	10	646	20	0	0	0	0	1071
HYV *aman*-fallow	425	10	0	0	0	0	0	0	425
HYV *aman*-wheat	637	15	0	0	0	0	0	0	637
b *aman*- *rabi*	0	0	0	0	664	15	0	0	664
b *aman*-HYV *boro*	0	0	0	0	221	5	0	0	221
Total	4250		3230		4430		5114		17024

Note: Areas in hectares.

Table 5.2: Future-Without-Project Crop Production

Crop	Damage free area			Damaged Area			Total Prod'n
	Area	Yield	Prod'n	Area	Yield	Prod'n	
b *aus*	1724	1.25	2155	2500	1.05	2625	4780
b *aman*	1521	1.75	2662	2500	1.45	3625	6287
lt *aman*	4882	2.15	10496	1000	1.75	1750	12246
HYV *aman*	775	3.95	3061	500	3.55	1775	4836
l *boro*	1602	2.25	3605	3000	1.45	4350	7955
HYV *boro*	641	4.55	2919	500	2.75	1375	4294
Paddy			24901			15500	40401
wheat	637	2.05	1307				
potato	374	12	4488				
pulses	477	0.85	405				
oilseeds	1590	0.75	1192				
spices	159	2.25	357				
vegetable	954	8.75	8347				

Note: Areas in hectares; yield and production in metric tonnes.

6. WATER RESOURCES INFRASTRUCTURE DEVELOPMENT OPTIONS

6.1 Summary of Problems

The main problems of the area are:

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

- Post-monsoon drainage has been delayed over a major part of the project area due to the sedimentation in the channel bed and at the outfall of the Kangsha and Someswari Rivers. Late plantation of crops makes it more vulnerable to damage by the pre-monsoon flash floods and accumulated rainfall inundation which also limits the cropped area to the higher lands. This has resulted in gradual decrease in the net cultivable lands.

- Sediment aggradation in the lower reaches and at the outfall of the Kangsha and Someswari Rivers is obstructing navigation between Baulai and Dharmapasha, Mohanganj and Madhyanagar *thanas* which are the main routes for communication in these areas.

- The condition of dry season fisheries habitat and of migration access appears to be deteriorating as a result of siltation. Some of the nominal *beel* area and many of the internal channels may no longer be perennial.

6.2 Development Option

The *boro* crop can be protected from pre-monsoon (before 15 May) flash floods if flow through the spill channels is prevented by regulating structures, and over bank spill by submersible embankments. Submersible embankments are preferred over the full flood embankments for this project because:

- Full flood embankments are not feasible because the project is located in a high rainfall zone. Pondage from rainfall within the protected area builds up very quickly to an elevation almost equal to river water levels. This indicates that free drainage is not possible until the monsoon season is over. Pump drainage in the high rainfall, deeply flooded area is not economically viable. Even b *aman* can not be grown because of deep flooding and quick rise of water levels.

- The area has rich fishery and wetland resources. Full flood embankments have a much greater potential for negative fisheries and wetland impacts.

- High waves during the monsoon period would make maintenance of high embankments difficult and costly.

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- Full flood embankments would reduce the peripheral rivers' floodway, and could adverse affect drainage of upland areas.

- Full flood embankments have greater negative effects on navigation.

Submersible embankments in association with drainage developments were the solution adopted. This option is described in Chapter 7.

7. PROPOSED FLOOD CONTROL AND DRAINAGE PROJECT

7.1 Rationale

This plan would protect *boro* crops from pre-monsoon flash floods, while having minimal negative and possibly even positive open water fishery impacts, and minimal negative navigation impacts.

7.2 Objectives

The objectives of the project are:

- To reduce damage of *boro* crops from pre-monsoon flooding up to 15 May
- To promote earlier planting, and therefore earlier harvest, of *boro* crops, by accelerating post-monsoon drainage
- To promote shifts from local *boro* to HYV *boro*
- In achieving the above, to incur the best possible outcomes for navigation and the openwater fishery

7.3 Description

Project works consist of:

- Partial flood control embankments at strategic locations along the Kangsha, Someswari, Gunai, and Updakhali Rivers.
- Along the project periphery, five drainage/flushing regulators and three pipe sluices for post-monsoon drainage, post-*boro*-harvest flushing, and dry season water retention to store irrigation water and enhance dry season openwater fisheries habitat. Two of the regulators would be provided with boat passage facilities.
- Inside the project area, two pipe sluices in the village road running north-south from Golaikhali to Dharmapasha to improve drainage of the western side.
- Twenty irrigation inlets along the right banks of the Someswari and Kangsha Rivers.
- Re-excavation of 50 km of internal channels to improve post-monsoon drainage, facilitate fish migration, improve dry season openwater fisheries habitat, and ensure that regulated channels can handle flushing discharges.

The proposed infrastructure is based on preliminary field information only. Additional investigation will be required during feasibility studies.

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7.3.1 Flood Protection Works

Embankments

The embankment along the southeast of the area from Dharmapasha in the south to Bade Haripur in the east mainly follows existing roads (Figure 5). The rest of the embankment would connect high land and villages along the Someswari-Updakhali-Gunai right bank. In the west, land elevations are high enough to exclude flooding before 15 May. Though it is not clear whether the several Kangsha spill channels here spill before 15 May, four (all but Dharam Khal) would be closed as requested by local people. Two of the closures would be on the Palni Nadi, which originates from and flows back to the Gunai.

Table 7.1: Design Embankment Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Kangsha River		
Dharmapasha	0.0	6.5
Bade Haripur		6.5
Someswari River		
Bade Haripur	0.0	6.5
Kandapara		6.5
Updakhali-Gunai River		
Kandapara-Machwa Kanda		6.5

Embankments are designed for a 1:10 year return period flood including a freeboard of 0.6 m. The average height of embankment is about 2 m. The proposed embankment cross section has a 4.27 m crest width and side slopes of 1(v):2(h) and 1(v):3(h) on the country and river sides respectively. Design embankment crest elevations are shown in Table 7.1.

Kalmakanda elevations have been adopted for preliminary design and cost estimates; it is considered that this is a conservative approach. Elevations will be reviewed during feasibility studies and detailed design, to include recent siltation and other river system changes, plus changes expected from proposed development in the vicinity.

Post-project pre-monsoon flooding will be limited to areas affected by accumulated local rainfall, thus increasing the flood-free area (Table 7.2). This calculation is preliminary (based on the area-elevation data and a water balance calculation, see Table A.5 and Figure 3); a standard routing programme should be used during feasibility studies.

7.3.2 Drainage Improvements

The area's drainage requirements will be greatly reduced by the project, which will decrease spill volumes from the Gunai, Updakhali, Kangsha, and Someswari Rivers.

Drainage will be effected via the existing natural drainage system of *khals* and *beels*. Re-excavation would be undertaken in:

- 13 km of channels in the northern main collector system (Manai Nadi and Dahar Gang) draining to the two northernmost regulators on the Someswari;

- 17 km in the southern main collector system (Mora Gang, Saitan Khal, Kurma River, and Mara Khal) leading to the regulator at Kandapara and thence to the Someswari; and

- 20 km of local drainage channels (Gobrakhali Khal, Ahmakkhali Khal, Chotojan Khal, and Dharam Khal).

The channels leading to regulators will be used for flushing, thus their design sections will need to match the regulators' discharge capacities.

For the purpose of cost estimates, it has been assumed that main channels would be excavated by 1.5 m on average, with a bed width of about 10 m, and 1(v):1.5(h) side slopes.

Table 7.2: Pre-Monsoon Flood Depth (1:2 Year Before 15 May)

Flood Depth (m)	Gross Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	9,000	14,500
0.30-0.90	5,230	3,000
0.90-1.80	4,270	2,700
>1.80	2,000	300
Total	**20,500**	**20,500**

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

7.3.3 Structures for Water Control

Regulators

Five drainage/flushing regulators would be constructed:

- Two six-vent (1.5 x 1.8 m) regulators at Bade Haripur village and Baral village on the Malai Nadi/Dahar Gang system. The Baral village regulator would be provided with boat passage facilities.

- One four-vent (1.5 x 1.8 m) regulator on the Saitan Khal.

- One three-vent (1.5 x 1.8 m) regulator on Chotojan Khal at Machwa Kanda village, with boat passage facilities.

- One two-vent (1.5 x 1.8 m) regulator at Gobrakhali Khal.

Ongoing siltation of the Gunai could compromise drainage at Machwa Kanda regulator. Re-excavation of the Gunai River has been included in the proposed initiative *Updakhali Project*. Drainage conditions at this location should be investigated thoroughly at feasibility.

Fish passes have not been included in this proposal, but should be added once designs and costs based on testing in the region become available.

The regulators would be closed after *boro* plantation is complete at the end of January to retain water up to the lowest plantation level. This would conserve for irrigation and fisheries any water that would otherwise drain out between 1 February and about 1 March, and convert some seasonal *beel* (i.e. fallow deeply flooded) land into perennial *beel*. It should be noted, however, that project drainage improvements may significantly reduce the volume of late-draining water, compared to current conditions. Also, the evaluation (Section 7.7) reflects positive impacts of water retention on the openwater fishery in the form of a 30 ha increase in perennial *beel* area and improved water quality, but impacts on land use and on agriculture are not reflected. That water retention could be particularly problematic in terms of increasing the potential for fisheries/agriculture conflicts is noted.

Pipe Sluices

Five 90-cm diameter pipe sluices are provided, three along the project boundary and two in the newly constructed village road from Dharmapasha to Nawapara village (Figure 5).

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Irrigation Inlets
Twenty irrigation inlets would be provided along the Kangsha and Someswari Rivers to facilitate irrigation along the river banks during the winter months. Their locations would be finalized with beneficiaries during feasibility studies. These inlets would command an incremental irrigated area of about 300 ha.

7.3.4 Expected Benefits

The benefits expected from the project relate to agriculture. Future-with-project (FW) cropping patterns and crop production are presented in Tables 7.3 and 7.4.

Pre-monsoon flood protection up to 15 May would greatly reduce flood damage to the *boro* crop. Reduced risk of *boro* damage would induce shifts from local *boro* to HYV *boro*. The delayed flooding would also reduce damage to b *aman*, which would be provided additional time for elongation ability to develop.

Monsoon water levels would not change, thus monsoon land type areas and monsoon cropping would not change.

Annual cereal production is expected to increase 7600 tonnes (19%), from 40,400 tonnes (FWO) to 48,019 tonnes (FW) as a result of the project, inclusive of the impacts of land use changes (see Section 7.8). This increase is mainly due to shifts from local *boro* to HYV *boro* and reduced flood damage to these crops. Non-cereal production would increase 1300 tonnes (8%), from 16096 tonnes (FWO) to 17415 tonnes (FW). This is mainly due to an increase in the area under *rabi* crops, resulting from drainage improvements in the post-monsoon season.

Note that agricultural benefits may be somewhat overestimated here, given that the fallow area may be underestimated and the cultivated area, in particular the F3 area where much of the increase in rice production would occur, may be overestimated (Section 3.1). Conversely, but probably to a smaller extent, agricultural benefits may be underestimated, if some of the perennial *beel* area has in fact silted up and is now under cultivation.

7.3.5 Mitigation Measures Incorporated

The negative fisheries impacts of pre-monsoon flood control (see Section 7.8 below) would be counter- (and possibly over-) balanced by mitigation impacts arising from the flood control infrastructure itself, channel re-excavation, water retention, and provision of fish passes:

- Reduction of the rate of sedimentation in fisheries habitats (flood control).
- Improved migration access (channel re-excavation);
- Increased dry season water volumes (channel re-excavation, water retention);
- Improved water quality (channel excavation, water retention); and
- Partial restoration of pre-15 May migration access (fish passes, if these can be incorporated at the feasibility stage)

The negative impacts of the submersible embankments, closures, and water control structures on navigation (routes cut in the pre-monsoon period, and draughts reduced in the monsoon period)

Table 7.3: Future-With-Project Crop Production

Crop	Damage free area			Damaged Area			Total Prod'n
	Area	Yield	Prod'n	Area	Yield	Prod'n	
b *aus*	4224	1.25	5280	0	1.05	0	5280
b *aman*	3765	1.75	6589	0	1.45	0	6589
lt *aman*	4882	2.15	10496	1000	1.75	1750	12246
HYV *aman*	775	3.95	3061	500	3.55	1775	4836
l *boro*	3579	2.25	8054	0	1.45	0	8054
HYV *boro*	2420	4.55	11012	0	2.75	0	11012
Paddy			44494			3525	48019
wheat	637	2.05	1307				
potato	374	12	4488				
pulses	538	0.85	457				
oilseeds	1794	0.75	1345				
spices	179	2.25	403				
vegetable	1076	8.75	9415				

Note: Areas in hectares; yields and production in metric tonnes.

Table 7.4: Future-With-Project Cropping Patterns

Cropping Pattern	F0		F1		F2		F3		Total Area
	Area	%	Area	%	Area	%	Area	%	
b *aman*-fallow					2880	65	0	0	2879
fallow-l *boro*					0	0	3579	70	3579
fallow-HYV *boro*	0	0	0	0	664	15	1534	30	2198
b *aus*-fallow- *rabi*	0	0	323	10	0	0	0	0	323
b *aus*-lt *aman*	1190	28	969	30	0	0	0	0	2159
b *aus*-lt *aman*-potato	212	5	161	5	0	0	0	0	374
b *aus*-lt *aman*- *rabi*	510	12	646	20	0	0	0	0	1156
b *aus*-HYV *aman*- *rabi*	212	5	0	0	0	0	0	0	212
lt *aman*-fallow	637	15	323	10	0	0	0	0	960
lt *aman*- *rabi*	425	10	807	25	0	0	0	0	1232
HYV *aman*-fallow	425	10	0	0	0	0	0	0	425
HYV *aman*-wheat	637	15	0	0	0	0	0	0	637
b *aman*- *rabi*	0	0	0	0	664	15	0	0	664
b *aman*-HYV *boro*	0	0	0	0	221	5	0	0	221
Total	4250		3230		4430		5114		17024

Note: Areas in hectares.

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would be partially mitigated by provision of boat passage facilities in two of the regulators. Channel excavation in the main channels within the area would increase their dry season navigability.

7.4 Operation and Maintenance

The drainage/flushing regulators, and the associated navigation and fish pass facilities, must be operated properly in order to achieve design performance of the drainage, flushing, water retention, fish passage, and boat passage functions. Embankment and channel maintenance will be required to achieve reliable as-designed flood control and drainage. During feasibility studies, an environmental management plan specifying necessary actions to achieve acceptable environmental impacts needs to prepared, showing plan costs and how planned actions will be institutionalized. During project design, operator training/reference materials need to be prepared.

7.5 Organization and Management

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

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

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

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

Bangladesh Rural Development Board (BRDB) is responsible for assisting with command area development through farmers' training and by organizing farmers into cooperatives which will then have access to short term crop production loans. Medium term credits are available to these cooperatives from all nationalized banks.

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

7.6 Cost Estimate

Total project costs are estimated at Tk 129.0 million.

Table 7.5: Capital Costs

Item	('000 Tk)
Structures	39,9000
Embankments	29,800
Channels	17,700
Bridges	-
Buildings	-
Land Acquisition	2,400
Base Cost	**89,800**
Physical Contingencies (25%)	22,400
Subtotal	**112,200**
Study Costs[1] (15% of Subtotal)	16,800
TOTAL	**129,000**
Net Area (ha)	17,004
Unit Cost (Tk/ha)	7,583

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

The estimate of the land acquisition requirement for physical works is based on preliminary designs and lay-out plans prepared using four inch to one mile topographic maps, and historic hydrological data. The total footprint of the embankment and borrow pits, before deducting for high land, villages, and roads already in place along the alignment, is roughly 100 ha (50 km x 20 m). The land acquisition requirement for the embankment was estimated to be 20 ha of single-cropped land (0.1% of cultivated area) at a current price determined from field interviews of Tk 120,000 per ha. Channel re-excavation (50 km x 6 m) is assumed to fall entirely within existing channels' plan areas. Deposition of re-excavation spoil would occupy roughly 30 ha; costs for purchase of this area were not included.

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

The summary of total costs is presented in Table 7.5 with details provided in Table A.6.

7.7 Project Phasing and Disbursement Period

Four years are required to implement the project. One year (year zero) is required for completion of feasibility studies and conducting field surveys. Preparation of detail designs should start in year one and be completed in year two. Land acquisition should commence in year one, be implemented in phases preceding construction, and completed in year three. Construction activities should start in year one and be completed in year three. An itemized implementation schedule is shown in Table 7.6.

7.8 Evaluation

7.8.1 Environmental

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

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Table 7.6: Implementation Schedule

Activity	Year (% Completion)			
	0	1	2	3
Preconstruction Activities				
Feasibility Study	100			
Engineering Investigation	70	30		
Detail Designs		70	30	
Land Acquisition		40	50	10
Construction Activities				
Construction of Embankments		40	50	10
Excavation of Channels		30	30	40
Construction of Structures		20	40	40

Land Use

Land use changes are summarized in Table 7.7. Channel re-excavation is assumed to fall entirely within existing channels' plan areas. Spoil deposition would occupy about 30 ha. The total footprint of the embankment and borrow pits, before deducting for high land, villages, and roads already in place along the alignment, is roughly 100 ha (50 km x 20 m). Of this, an estimated 20 ha is single-cropped land (Section 7.6). Assuming average yields this corresponds to incremental annual cereal production foregone of about 25 tonnes or about 0.5% of the total incremental cereal production. This impact is incorporated into the economic analysis.

Agriculture

Incremental cereal and non-cereal production are given in Section 7.3.4 above.

The cereal production increase implies a per person increase in cereal availability from 519 (FWO) to 617 (FW) gm per person per day, an increase of +19% (Table 7.8), allowing 10% for seed, feed, and waste, and 65% for conversion of paddy to rice. Current Bangladesh average consumption is 440 gm per person per day.

The non-cereal production increase implies an increase in the availability of non-cereals from 353 (FWO) to 382 (FW) grams per person per day (Table 7.8).

While both cereal and non-cereal production increase, cereal increases proportionately more, and in this somewhat restricted sense crop diversity decreases. Irrigated area increases by about 300 ha, which is supplied by surface water from the external rivers. This corresponds to total irrigation withdrawals on the order of 0.2 $m^3 s^{-1}$, or a total volume withdrawn annually of 4 Mm^3.

Water quality

Water quality would be affected by increased fertilizer and pesticide usage. Annual fertilizer usage would increase by 1276 tonnes. Pesticide usage would increase by 1 tonne.

Water quality would also be affected by the hydrologic interventions - delay of flood onset, enhanced post-monsoon drainage, water retention, and incremental irrigation.

Openwater fisheries production
In isolation, the partial flood control would:

- Significantly shorten the pre-monsoon fish migration window;
- Affect water quality adversely, by delaying flood onset and promoting increased inputs of agrochemicals; and
- Adversely affect fisheries habitat (decrease flow volumes, increase contaminant concentrations) in the external rivers by promoting increased irrigation water abstraction from them.

These negative fisheries impacts would be counter- (and possibly over-) balanced by mitigation impacts arising from the flood control infrastructure itself, channel re-excavation, water retention, and provision of fish passes, as has been explained in Section 7.3.5.

The magnitude and sign of expected net fisheries impacts is shown in Table 7.9, calculated using a very simple model. The model and parameter values used are documented in Annex B. This preliminary assessment must be regarded as something of a guess, given:

- The number of ways that the project could impact the openwater fishery (some positive and some negative) and possible interactions between them;
- Uncertainties about the future-without scenario for the river system and thus for local hydrology and sedimentation; and
- Uncertainties about FWO fisheries production.

In summary, annual open water fisheries production would decrease by -58 tonnes (3%) from 1646 tonnes (FWO) to 1588 tonnes (FW). This implies a change in fish availability per person from 38 (FWO) to 37 (FW) grams per person per day (Table 7.8).

Table 7.7: Changes in Land Use

Use	Change in area (ha)
Cultivated	-20
Homesteads	
Beels	
Ponds	
Channels	
Hills	
Fallow[1]	
Infrastructure[2]	+20

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

Table 7.8: Indicators of Food Availability

Food Group	Present (1993)	FWO (2015)	FW (2015)
Cereals	800	519	617
Non-Cereals	526	353	382
Fish	61	38	37

Table 7.9: Fish Production Indicators

Regime	Production '000 kg			Net Value Tk '000
	FWO	FW	Impact	
Flood Plain	562	506	-56	-1850
Beels	1021	1023	+2	+117
River/ Channels	63	59	-4	-253
Total	1646	1588	-58	-1986

Homestead flooding
The project does not significantly protect homesteads from flooding.

Wetland habitats and grazing area
Table 7.10 shows the impact on:

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

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

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

The impact of the project would be to change winter grazing area by -6%, winter wetland area by -8%, and summer wetland area by +3%.

Table 7.10: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	2338	2253	-85	
sc/wf F1	1616	1292	-324	
sc/wf F2	2880	2880	0	
Fallow Highland	50	40	-10	
Total	6,884	6,465	-419	-6

Land Type	Winter Wetland			
sc/wf F3	256	0	-256	
F4, Beel, Channel	2953	2953	0	
Total	3,209	2,953	-256	-8

Land Type	Summer Wetland			
wc/sf F1	0	0		
wc/sf F2	665	665	0	
wc/sf F3	4859	5114	255	
F4, Beel, Channel	2953	2953	0	
Total	8,477	8,732	255	3

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

There would be no significant impact on swamp forest trees.

Economic and employment impacts of the project on wetland plant and animal production would be small (at Tk50 ha^{-1}, Tk8100 yr^{-1} and 160 pd yr^{-1}).

Transportation/navigation
Dry season road communication will be improved in that the submersible embankment will also function as a road at this time. Dry season navigability of main drainage channels would improve. Pre-monsoon navigation across the project boundary would be restricted to the two regulators equipped with boat passage facilities; monsoon navigation across the boundary would be less affected — draughts would be reduced.

Higher flood levels

External water levels were not subjected to model studies, but this should be done during feasibility. Modelling experience elsewhere in the region suggests that increases in pre-monsoon flood levels of 0.5 m or more are possible. The areas to the east and downstream are all within existing submersible embankment projects, and areas to the west include the proposed initiatives *Updakhali Project* and the ongoing *Singar Beel Project* (Figure 6). The area south of the project, between the Kangsha and the Mogra, and north of the project, across the Gunai, would remain unprotected under current proposals.

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

- an increase in owner-labour employment of 0.055 million pd yr^{-1}, of which very roughly 20% is post-harvest processing activities traditionally done by women of the household.

- a net increase in employment opportunities for landless people of +0.027 million pd yr^{-1}, composed of changes in the following areas:

  - Agricultural hired labour: +0.055 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: -0.028 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): negligible loss. Fodder and building material is gathered mainly by men. Food, fuel, and medicine is gathered mainly by women.

Displacement impacts due to land use changes

Homesteads along the project boundary will be linked up by the submersible embankment. No homestead land will be acquired or altered.

Conflicts

The project, in increasing water management options and providing operable structures, probably increases the potential for conflicts between fisheries and *boro* rice cultivation interests. This issue will require further investigation during feasibility studies.

Equity

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

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

Table 7.11: Qualitative Impact Scoring

		True=1 False=0					
Qualitative Impact	Impact Sign	Sensitive	Magnitude	Immediate	Sustainable Pos Impact/ Irreversible Neg Impact	No Mitigation Required/ Possible	Score
Road Transportation	+	0	0	1	0	1	+2
Navigation	-	1	0	1	1	0	-3
Conflicts	-	1	1	1	0	0	-3
Socioeconomic Equity	-	1	1	1	0	0	-3
Gender Equity	+	1	0	1	0	0	+2

- Owner-labour opportunities and hired labour opportunities both increase, the former about twice as much as the latter. Distribution of employment opportunities is *regressive*.

Who loses?

- Families dependent upon fishing labour. These families mainly landless and tend to be poorer than average. Some, but not all, can be provided with replacement employment as agricultural labourers. *Regressive*.

Gender Equity
The net equity impact would appear to be somewhat *progressive* in that net employment opportunities for women will increase.

Qualitative Impact Scoring
The qualitative criteria shown in Table 7.13 are scored on an 11 level scale of -5 to +5. Scoring of those criteria that are impacts (some are not, like "responds to public concerns") is shown in Table 7.11. The scoring procedure is analogous to that used in the FAP 16 EIA case studies, but simplified to eliminate half-point scores (1.5, 2.5, 3.5, etc). Here, each score sums across five equally weighted logical (true/false) criteria, with each 'true' counting for a value of one and each "false" for zero. The sign reflects whether the impact is positive or negative.

7.8.3 Economic

The project has an economic rate of return of 31%, which compares well to the required rate of 12% as prescribed by government. It is a relatively low investment project, at Tk 129 million or Tk 7600 per hectare, and it covers a fairly large geographic area (20,500 ha gross). The rate of return is sensitive to: increases in capital costs (20% increase reduces ERR to 27%); timing of benefits (two year delay reduces ERR to 21%); decreases in net (agriculture+ fish) benefits (20% reduction reduces ERR to 26%).

The foreign costs associated with the project are low, at 9% (excluding FFW contributions). Donor funding considerations would clearly need to include funding some local costs.

All of the economic benefits of the project relate to agriculture; rice production would increase (19%), as would non-cereal production (8%). Floodplain fish production would decrease slightly (3%). The value of lost fisheries output amounts to about 3% of the value of increased agricultural output. A summary of salient data in provided in Table 7.12.

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.

An issue for further investigation at feasibility is farmer response to the project. Economic benefits are strongly dependent upon farmers' responses (cropping shifts etc.). The economic benefits indicated here assume that farmers can and will take reasonable advantage of improved hydrologic conditions.

7.8.4 Summary Analysis

From a multi-criteria perspective (Table 7.13), the project is fairly attractive. The positive aspects of the project would be:

- Rate of return is attractive.
- Rice production increases.
- Non-rice production increases.
- Fisheries losses are relatively small, and this is highly uncertain; at feasibility, fisheries impacts could turn out to be zero or positive.
- Employment opportunities for both owner and hired labour would be created.
- Increased economic returns to land owners.
- Gender equity of impacts is somewhat progressive.
- Project responds to some public concerns.

The negative aspects of the project would be:

- Benefits derive almost entirely from increased rice production. Crop diversity decreases (within the context of cereal and non-cereal production both increasing).
- External pre-monsoon water levels could increase 0.5 m or more (more study is needed).
- Equity of benefit distribution is somewhat regressive.
- Fisheries impacts could be much more negative than indicated here, if mitigation measures do not work as expected or if operation is not as intended.

- Conflicts between farmers and fishermen could increase.
- The project has a high dependency on central government for implementation.

Table 7.12: Summary of Salient Data

Economic Rate of Return (ERR)	31			
Capital Investment (Tk million)	129			
Maximum O+M (Tk million / yr)	5			
Capital Investment (Tk/ha)	7,583			
Foreign Cost Component (%)	9			
Net Project Area (ha)	17,000			
Land Acquisition Required (ha)	20			

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (Tk million / yr)	45.51			
Cropping Intensity		1.5	1.5	1.5
Average Yield (tonnes/ha)		2.2	2.2	2.6
Average Gross Margins (Tk/ha)		10563	10737	12554
Owner Labour (md/ha)		114	113	114
Hired Labour (md/ha)		20	21	23
Irrigation (ha)		6784	6807	7134
Incremental Cereal Prod'n (' 000 tonnes / yr)	8			
Incremental Non-Cereal (' 000 tonnes / yr)	1			
Incremental Owner Labour (' 000 pd / yr)	55			
Incremental Hired Labour (' 000 pd / yr)	55			

FISHERIES IMPACTS		Flood plain	Beels	Channel/ River
Incremental Net Econ Output (Tk million / yr)	-1.39	-1.29	+0.08	-0.253
Impacted Area (ha)		0	+30	0
Average Gross Margins (Tk/ha)		1540	28700	12250
Incremental Fish Production (tonnes / year)		-56	+2	-4
Incremental Labour ('000 pd / yr)	-28	-110	+1	+4

FLOOD DAMAGE BENEFITS				
Households Affected		8061		
Reduced Econ Damage Households (Tk M / yr)	0			
Roads/Embankments Affected -km		45		
Reduced Econ Damage Roads (Tk M / yr)	0			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	0			
Wetland Incremental Labour ('000 pd / yr)	0			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	-0.11			
Persons Displaced by Homestead Acquisition	0			

Table 7.13: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	31
EIRR, Increase Capital Costs by 20%	per cent	27
EIRR, Delay Benefits by Two Years	per cent	21
EIRR, Decrease Benefits by 20%	per cent	26
Net Present Value	Tk '000	140,328

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	8	+19
Incremental Non-Cereal Production	tonnes	1	+9
Incremental Fish Production	tonnes	-58	-3
Homesteads Displaced Due to Project Land Acquisition	homesteads	0	0
Homesteads Protected From Floods	homesteads	0	0
Roads Protected From Floods	km	0	0
Increase in External Pre-Monsoon Flood Levels	m PWD	up to 0.5	-
Owner Employment	million pd/yr	+0.055	-
Hired Employment (Agri+Fishing+Wetland)	million pd/yr	+0.027	-

Qualitative Impacts (ranked from -5 ...0... +5)	
Impact	**Rank**
Road Transportation	+2
Navigation	-3
Conflicts	-3
Socioeconomic Equity	-3
Gender Equity	+2
Decentralized Organization and Management	-2
Responds to Public Concerns	+4

8. OUTSTANDING ISSUES

8.1 Future Changes in the River System

The river system is actively changing in a number of places, and several initiatives have been proposed to influence these processes (Atrakhali closure) or to mitigate siltation related to them (Gunai re-excavation; Section 2.4.1 and Chapter 5). The future configuration and stability of the system will have important implications for conditions in the Dharmapasha-Rui Beel area.

8.2 Cultivable and Fallow Areas and Land Acquisition

Cultivable area, and thus agricultural benefits, may have been overestimated and fallow area underestimated here (Section 3.1). The land acquisition estimate used here may be optimistic (Section 7.6).

8.3 Benefit Realization

The agricultural benefits estimated here assume that farmers can and will respond to the hydrologic changes associated with the project. Careful consultation with them should be undertaken to determine if this is correct, or if additional measures (e.g. credit) will be required.

8.4 Fisheries and Navigation Mitigation and Impact Assessment

The fisheries and navigation mitigation measures will require considerable additional study, and costing. Assessing the impacts of the mitigation will be particularly important.

8.5 Conflicts

Farmers and fishermen should be consulted regarding potential conflicts and how these might be resolved.

8.6 External Water Levels

The impact of the project on external water levels will need to be investigated.

ANNEX A

TABLES

Table A.1: 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	21.5	128.4	114.5	102.6
Rainfall (mm) Mean monthly	9.2	36.5	101.4	397.1	514.0	916.5	747.2	555.0	282.2	198.7	53.7	30.2

Source: NERP

Table A.2: Mean Monthly Water levels (m PWD)

Month	Gauge 263.1: Someswari at Kalmakanda			Gauge 36.1: Kangsha at Mohanganj		
	Min	Mean	Max	Min	Mean	Max
Apr	1.82	3.27	5.41	2.39	3.46	4.91
May	3.22	4.81	6.25	3.22	4.95	6.23
June	4.70	6.30	7.67	4.97	6.28	7.09
July	6.36	7.20	8.52	6.53	7.12	7.76
Aug	6.24	7.20	8.43	6.63	7.16	7.85
Sept	5.39	6.87	8.19	6.36	6.92	7.65
Oct	4.03	6.06	7.58	5.36	6.13	6.84
Nov	3.05	4.82	6.70	3.76	4.64	5.34
Dec	1.78	3.67	5.76	2.86	3.81	4.90
Jan	1.49	2.65	4.96	2.58	3.49	4.66
Feb	1.17	1.97	4.46	2.35	3.14	4.51
Mar	0.98	1.94	4.31	2.25	2.85	4.07

Source: NERP

TABLE A.3: Present (1991) Irrigation Statistics

Thana		STW		DSSTW		DTW		MOSTI		LLP		Traditional
Name	Within Project (%)	#	ha	#	ha	#	ha	ha	#	#	ha	ha
Dharmapasha	48	34	266	0	0	0	0	0	0	166	2276	8201
Madhyanagar	18	0	0	0	0	0	0	0	0	0	0	0
Mohanganj	1	1	3	0	0	0	0	0	0	2	30	47
Barhatta	11	26	144	0	0	5	86	0	0	17	221	335
Total		61	414	0	0	1290	36	0	0	185	2527	8584

TABLE A.4: *DUARS* AROUND THE PROJECT AREA

Name of *Duar*	Approximate Dry Season Depth (m)	Boromach occurred*	Chotomach occurred*
RIVER: SOMESWARI			
Konapara Duar	8-9	LC, C, MC	B, Ch, Ca, R
Jagannathpur Duar	7-8	As above	As above
Saraswati Duar	7-8	As above	As above
Chanbarir Duar	7-8	As above	As above
Jaisree Duar	7-8	As above	As above
RIVER: KANGSHA			
Jalbhanga Duar	7-8	LC, C, MC	B, R, Ca, L
Nawagaon Duar	8-9	As above	As above
Durgapurar Duar	7-8	As above	As above
RIVER: GUNAI			
Kailsakanda Duar	7-8	C,LC,MC	B,L,Ch,Ca

*Echo sounding data (all other depths from interviewing with fishermen). B:Bacha; C:Chital; Ca:Chapila; Ch:Chela; LC:Large catfish; MC:Major carp. Source: NERP, 1992.

Table A.5: Water Balance

Items	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	mm	11	34	101	369	560	1055	1227	877	627	240	40	15
Storage	ha-m	226	697	2071	7565	11480	21628	25154	17979	12854	4920	820	308
Data :													
ETO	mm	105.6	124.4	162.4	157.1	153.4	124.9	125.0	130.6	121.4	128.3	114.5	102.64
KC factor		1.2	1.25	1.25	1.2	1.1	1.1	0.95	1.1	1.1	1.1	1.1	1.15
Deep Percolation	mm	62	56	62	60	31	30	0	0	0	0	0	31
Losses:													
Boro, 6777 ha	ha-m	859	1054	1376	1278								
Aus, 3974 ha	ha-m				749	671	546	472					
Aman, 4351 ha	ha-m								625	581	614	548	514
ETO (natural)	ha-m	781	920	1202	1162	1135	924	925	966	899	950	847	759
Deep Percolation	ha-m	1271	452	500	484	250	242	0	0	0	0	0	250
Total Loss	ha-m	2911	2426	3078	3674	2056	1713	1397	1591	1480	1564	1395	1523
Accumulated Storage	ha-m	-2686	-1729	-1007	3891	9424	19915	23756	16387	11373	3356	-575	-1216

Table A.6: Estimated Capital and O & M Costs

Item	Quantity	Unit	Unit Price (Tk)	Capital Cost (MTk)	O&M (%)	O&M Costs (Mtk)
Submersible Embankment	1300000	m^3	24.27	25.2	10	2.52
Closure Dams; 3 nos	105000	m^3	28.25	2.4	10	0.24
Fine Dressing and Turfing	975150	m^2	2.27	2.2	1	0.02
Drainage Channel Re-excavation	751100	m^3	23.5	17.7	3	053
Regulators:						
Six Vent (1.52m*1.63m)	2	unit	9000000	18.0	2	0.36
Four Vent (1.52m*1.63m)	1	unit	7000000	7.0	2	0.14
Two Vent (1.52m*1.63m)	1	unit	5000000	5.0	2	0.10
Three Vent (1.52m*1.63m)	1	unit	6000000	6.0	2	0.12
Inlet Structures (0.45m dia)	20	unit	60000	1.1	2	0.02
Pipe Sluice (0.9m dia)	5	unit	560000	2.8	2	0.06
Land Acquisition	20	ha	120000	2.4		-
BASE COST:				89.8		4.1
Physical Contingency 25%				22.4		1.03
SUB_TOTAL:				112.2		5.14
Engg & Admin 15%				16.8		0.77
TOTAL:				129.0		5.91
NET AREA (ha):				17024		
UNIT COST (Tk/ha):				7579		

Source: NERP

ANNEX B

FISHERIES MODEL

ANNEX B: FISHERIES MODEL

This annex briefly describes the model used to analyze fisheries impacts for the project.

The openwater fishery ecosystem is extremely complex. Impacts on production are assessed here using a highly simplified model. The limitations of the model mirror the limitations of the current understanding of and information about the system.

The major system processes about which some insight exists are:

- Migration access and timing. It seems to be accepted that:
  - a multiplicity of access points is desirable (i.e. that closing any or some channels is still deleterious,
  - the most important channels are those at the downstream end of the system (that with flood onset, fish mainly migrate upstream and onto the floodplain, and downstream out of the *beels* into the river), and
  - delay of flooding, as in partial flood control schemes, is highly disruptive

- Overwintering (dry season) habitat extent.

- Wet season habitat (floodplain grazing extent and duration). [It is expected that production also varies as a function of land type (F1, F2, F3) — probably such that shallower (F1, F2) land is more productive than deeper (F3) land — but as data to show this has been lacking it has been neglected from the model.]

- Habitat Quality. Habitat quality would include water quality, vegetation, and other conditions (presence of preferred types of substrate e.g. rocks, sand, brush). Water quality would appear to be most relevant during low volume/flow periods, and during the time of flood onset and recession when contaminants can disperse or accumulate.

- Spawning. Production outside the project area can also be impacted if habitats suitable for spawning within the project are adversely affected. It is believed that most of the region's fish production stems from spawning occurring in: mother fishery areas, which are those exhibiting extensive, well-interconnected, and varied habitats with good water quality; key *beels*; and river *duars*. *Duars* are somewhat a separate problem as they are located in rivers and larger channels, not on the floodplain.

The foregoing is represented quantitatively here as:

FWO production =

$$(R_0 * P_{RO}) + (B_0 * P_{BO}) + (W_0 * P_{WO})$$

FW production =

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

Thus,

Impact = FW - FWO production =

$$\{ [(M * Q * R_1) - R_0] * P_{R0} \} +$$

$$\{ [(M * Q * B_1) - B_0] * P_{B0} \} +$$

$$\{ [(M * W_1) - W_0] * P_{W0} \}$$

where

sub-0 and sub-1 refer to FWO and FW respectively

R, *B*, and *W* are river/channel, *beel*, and floodplain (F1+F2+F3) areas, in ha

P is the unit FWO production in kg/ha for the respective habitats. Estimated regional average values are 175, 410, and 44 respectively.

M is the FW quality-weighted migration access remaining, relative to FWO conditions (range 0 to 1 for negative impacts, >1 for positive impacts)

Q is the FW acceptability of habitat/water quality relative to FWO conditions (range 0 to 1 for negative impacts; >1 for positive impacts).

A_M is the area of mother fishery and key *beels* affected times a factor (range 0 to 1 for negative impacts, >1 for positive impacts) reflecting the degree of degradation/enhancement

T is the estimated annual regional fish production attributable to spawning exported from mother fisheries/key *beels* (a constant of 50,000 tonnes, which is 50% of the total regional fish production of 100,000 tonnes)

A_T is the estimated regional mother fishery/key *beel* area (a constant of 100,000 ha).

Estimated values for this project are shown in Table B.1. Where standard values, established for the region or for a particular project type, are used, this is noted. Comments on project-specific values are also shown.

Table B.1: Fisheries Parameters

Var	Value	Stnd value	Comments
M	0.9	0.7[a] 1.1[b]	Negative impacts of partial flood control on migration would be partially mitigated, as explained in Section 7.3.5.
Q	1.1	0.7	Negative impacts of partial flood control on water quality would be more than counterbalanced by other changes, as explained in Section 7.3.5.
R_0	362		
R_1	434		Re-excavation is within plan area of existing channels.
B_0	2491		
B_1	2521		Assumes water retention will increase perennial *beel* area by 30 ha.
W_0	12774		
W_1	12774		
P_{R0}	175	175	
P_{B0}	410	410	
P_{W0}	44	44	
A_M	—	100000	No "mother fishery" in this area.

[a]Standard value for partial flood control.
[b]Standard value for drainage improvement.

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 Submersible Embankment 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: 20,500 ha.
Impacted (net) area: 17,004 ha.
Impacted area outside project: An increase in external pre-monsoon flood levels with the project is possible. The status of adjacent flood control projects will also be a factor. In addition, increased irrigation withdrawals from external rivers will occur; zone of influence is unknown.

Temporal:

Preconstruction: years 0 through year 3 (see Table 7.6).
Construction: year 1 through year 3 (see Table 7.6).
Operation: year 3 through year 20.
Abandonment: after year 20.

Cumulative impacts:

With other floodplain infrastructure: Hydrologic interactions are being studied using regional and sub-regional numerical models; results have not yet sufficiently refined in this area to provide insight as yet.

With pre-existing no-project trends. Described in Chapter 5.

C.2.5 Field Investigations (Step 5)

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

C.2.6 Impact Assessment (Step 6)

At this level of detail, a screening matrix (Table C.1) was filled out by the project team. Impacts are designated by:

+ positive impact
- negative impact
• neutral impact (such as conversion from one productive land use to another)
? insufficient information to designate

Impacts are discussed in Section 7.8.

C.2.7 Quantify and Value Impacts (Step 7)

Quantification and evaluation of impacts is documented in Section 7.8 and Tables 7.7, 7.8, 7.9, and 7.11 through 7.13.

C.2.8 Environmental Management Plan (Step 8)

At a pre-feasibility level, this section focuses on "identification of broad management options and major constraints" (p. 28, ISPAN, 1992).

Mitigation and enhancement. Documented in Section 7.3.

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

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

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

Monitoring. There is a need to define monitoring needs and methodologies at regional, institutional (BWDB), and projects levels. This exercise should reflect (i) the need for greater people's participation in all project activities, which would include monitoring project function and opportunities for discussion with BWDB and (ii) the need for greater emphasis on operation and maintenance, of which monitoring can play an important role.

People's participation. There is a need at regional, institutional, and project levels to maintain enthusiasm for people's participation, and to develop effective and efficient public participation modalities.

Disaster management (contingency planning). Once the flood protection is operational, investment in agriculture will likely rise. This increases the total amount of farmers' assets that are at risk should an extreme flood event occur or the embankment fail for any reason. Currently in Bangladesh, these risks are borne by individual investors (in this case farmers). Unsustainable solutions (such as government subsidy of crop insurance) should be avoided however.

EMP institutionalization. Arrangements for sharing EMP responsibility between BWDB and local people would need to be worked out. Project implementation should be contingent upon agreement on this matter between BWDB and local people.

Residual impact description. This should be generated as part of the feasibility-level EIA.

Reporting and accountability framework. At a national or regional scale, there is a need to develop satisfactory reporting/accountability arrangements involving BWDB and DOE, probably through an Environmental Cell within BWDB linked to DOE. At the project level, the client committee and local BWDB staff should develop reporting/accountability arrangements satisfactory to themselves. Project implementation should be contingent upon development of satisfactory arrangements at the local level, at a minimum.

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

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Environmental Screening Matrix

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Preconstruction	Normal	Surveys & instrumentation: landmark, topographic, benchmark, hydrologic, climatic, socio-economic, land use, natural resource										
		Land acquisition										
		People's participation activities							+			
	Abnormal											
Construction	Normal	Site preparation: vegetation removal, infrastructure removal/relocation, resettlement, levelling, temporary structure installation (access roads, godowns, accommodations, garages and parking sites, cooking and eating facilities, waste disposal sites, water supply, drainage, sanitary facilities)	–						–			
		Canal excavation: labour and materials mobilization, crossdam construction, spoil transport, spoil disposal							+			
		Embankment construction: labour and materials mobilization, topsoil removal, soil taking and transport, compaction, turfing, paving							+			
		Structure (sluice gate, culvert, pump house, and so on) construction: labour and material mobilization, de-watering, excavation, pile driving, foundation works, structure construction, earthwork filling, turfing, paving										
		Tube well installation: boring, distribution facilities, electrification N/A										
	Abnormal	Suspension of construction before completion, construction delays										
		Incorrect construction practices or techniques										

Environmental Screening Matrix

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri- culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Construction (continued)	Abnormal (cont'd)											
Operation	Normal	Pre-monsoon flood protection		+	—		+				+	
		Monsoon flood protection		+	—		+			—		
		Surface water irrigation N/A										
		Ground water irrigation N/A										
		Drainage		+	?		+					
		Agriculture: operation of institutions, extension, credit, seed distribution, fertilizer and pesticide storage and use, farmer groups			—				+			
		Water management: activities of BWDB, subproject implementation committee, local water user groups, structure committees and guards							+			
	Abnormal (relative to FWO, not FW normal)	Pre-monsoon flooding (due to extreme event, infrastructure failure)									—	
		Monsoon flooding (due to extreme event, infrastructure failure)									—	
		Embankment overtopping										
		Under- and over-drainage										
		Improper operation (public cuts, mistiming of scheduled O&M events etc)										
		Riverbed aggradation/degradation										
Abandonment	Normal	Re-occupation of infrastructure sites										
		Reclamation of materials										
	Abnormal											

ANNEX D

FIGURES

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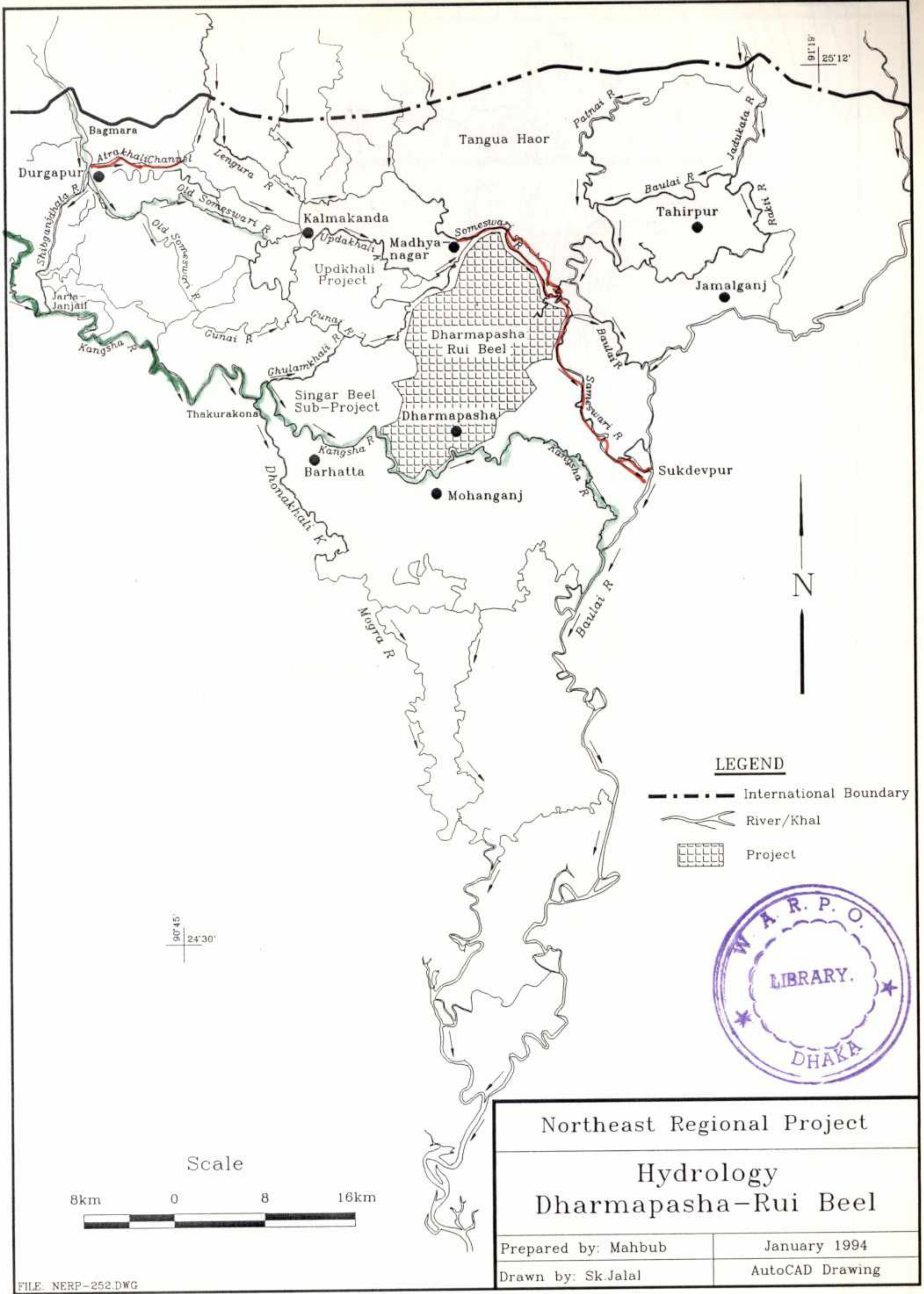
Figure 1



Bagmara
Durgapur
Atrakhali Channel
Lengura R
Old Someswari R
Shibganjdhala R
Kalmakanda
Updakhali R
Madhya nagar
Updkhali Project
Someswari R
Tangua Haor
Patnai R
Jadukata R
Baulai R
Tahirpur
Rakti R
Jamalganj
Jaria-Janjail
Gunai R
Kangsha R
Ghulamkhali R
Dharmapasha Rui Beel
Singar Beel Sub-Project
Thakurakona
Dharmapasha
Kangsha R
Barhatta
Mohanganj
Sukdevpur
Dhonakhali R
Mogra R
Baulai R
91°15'
25°12'
90°45'
24°30'
N
LEGEND
International Boundary
River/Khal
Project
Scale
8km
0
8
16km
Northeast Regional Project
Hydrology
Dharmapasha–Rui Beel
Prepared by: Mahbub
January 1994
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-252.DWG

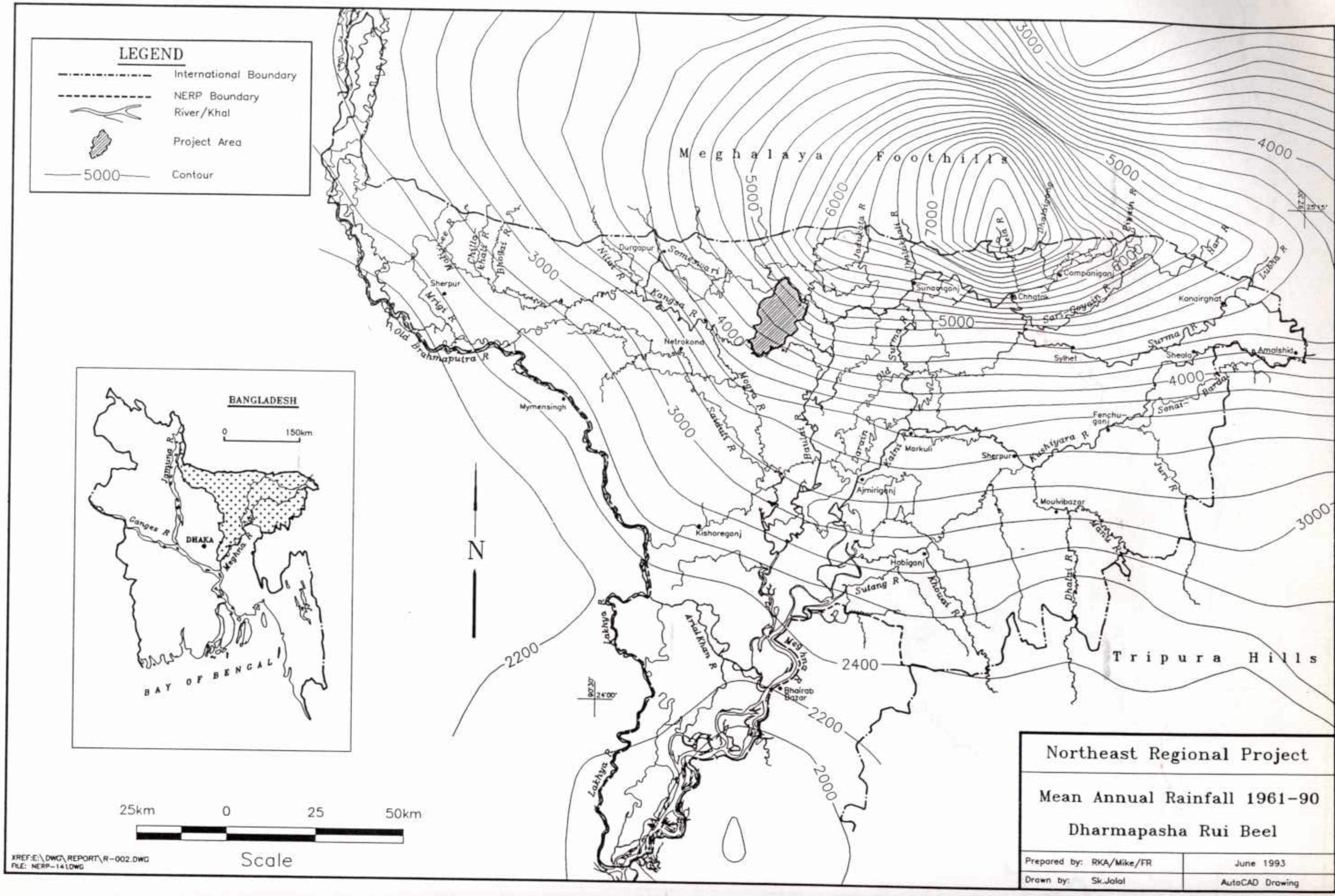
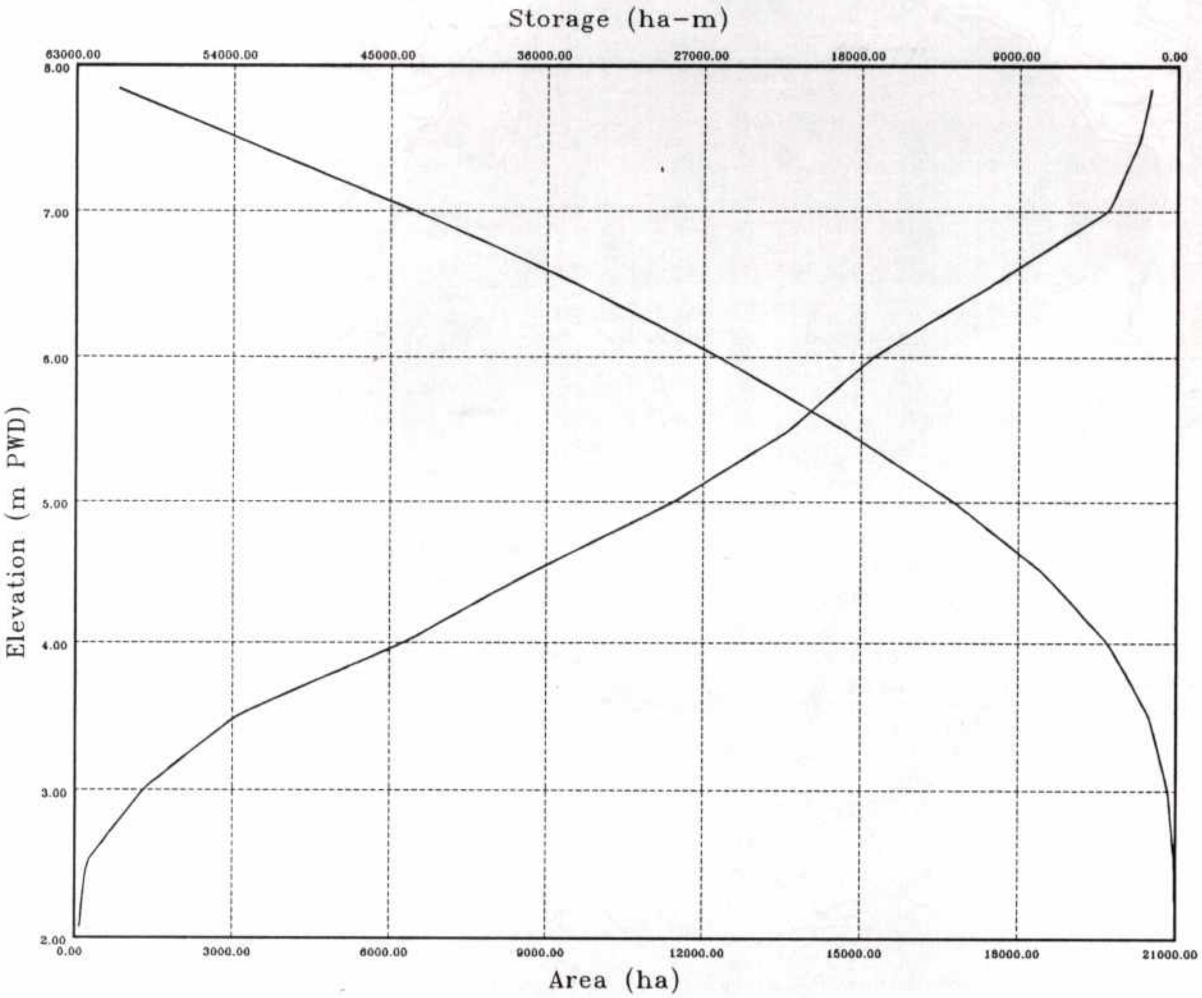

LEGEND
International Boundary
NERP Boundary
River/Khal
Project Area
5000 Contour
Meghalaya Foothills
Tripura Hills
BANGLADESH
0 150km
DHAKA
Jamuna R
Ganges R
Meghna R
BAY OF BENGAL
Sherpur
Durgapur
Netrokona
Mymensingh
Kishoreganj
Sunamganj
Chhatak
Companiganj
Kanairghat
Sylhet
Sheola
Amalshid
Fenchuganj
Markuli
Ajmiriganj
Habiganj
Moulvibazar
Bhairab Bazar
Old Brahmaputra R
Kangsa R
Mogra R
Surma R
Old Surma R
Kushiyara R
Manu R
Juri R
Dhalai R
Khowai R
Sutang R
Arial Khan R
Lakhya R
Baulai R
Kalni R
Someswari R
Nitai R
Bhogai R
Malijhee R
Chillakhali R
Jadukata R
Piyain R
Sari-Goyain R
Lubha R
Hari R
Dhalai R
Mrigi R
Sonai
Bardal R
N
2000
2200
2400
3000
4000
5000
6000
7000
25km 0 25 50km
Scale
Northeast Regional Project
Mean Annual Rainfall 1961-90
Dharmapasha Rui Beel
Prepared by: RKA/Mike/FR
June 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
XREF:E:\DWG\REPORT\R-002.DWG
FILE: NERP-141.DWG

Figure 2

Figure 3

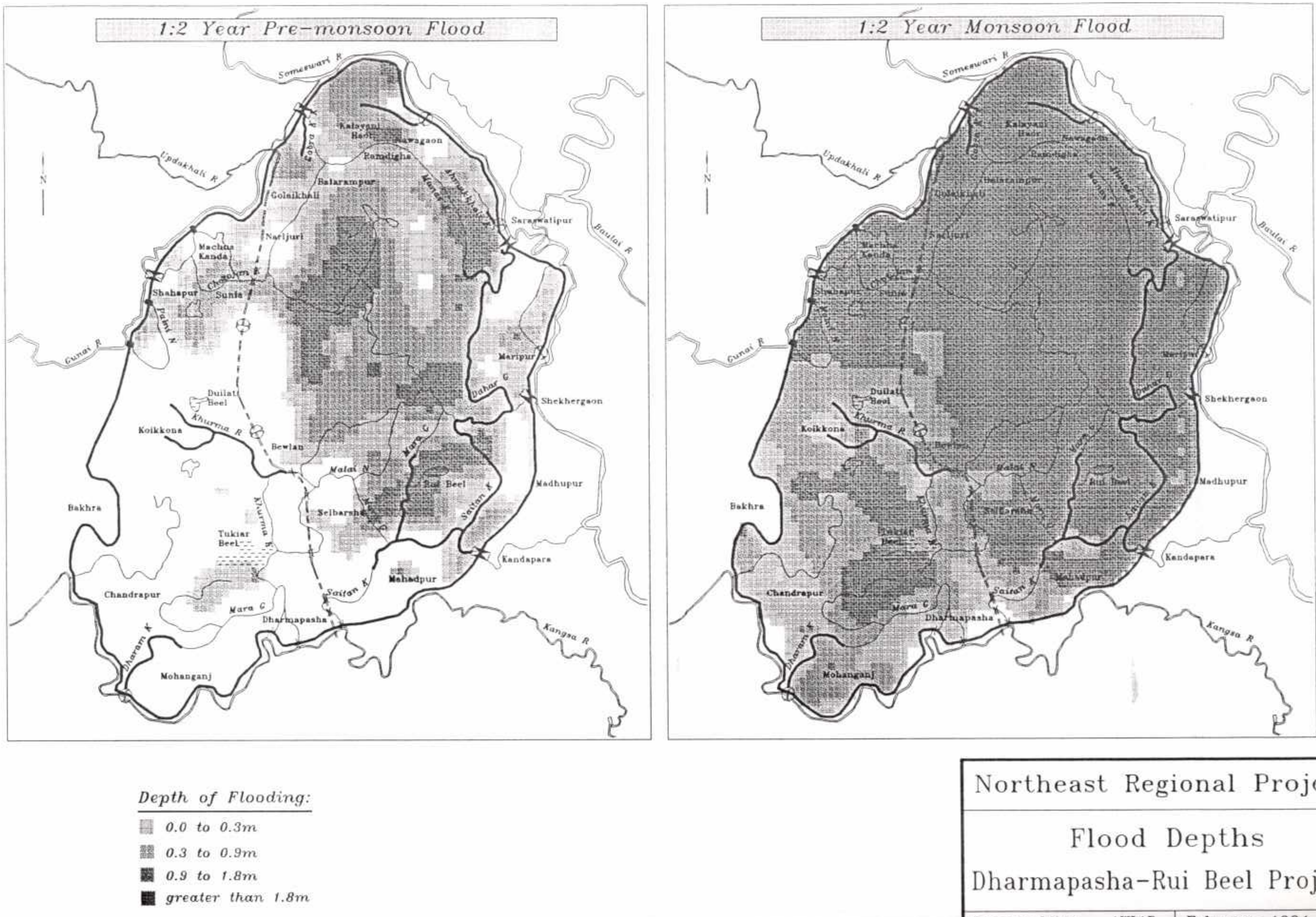
AREA ELEVATION AND STORAGE VOLUME CURVE

DHARMAPASHA-RUI BEEL PROJECT



Data:

Elevation (m PWD)	2.07	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	7.84
Area (ha)	99.489	198.978	1293.359	3084.164	6267.818	8755.047	11441.255	13630.017	15221.844	17510.095	19698.857	20295.792	20494.770
Volume (ha-m)	0.000	64.171	437.255	1531.636	3869.631	7625.348	12674.423	18942.241	26155.207	34338.191	43640.429	53639.091	60573.487

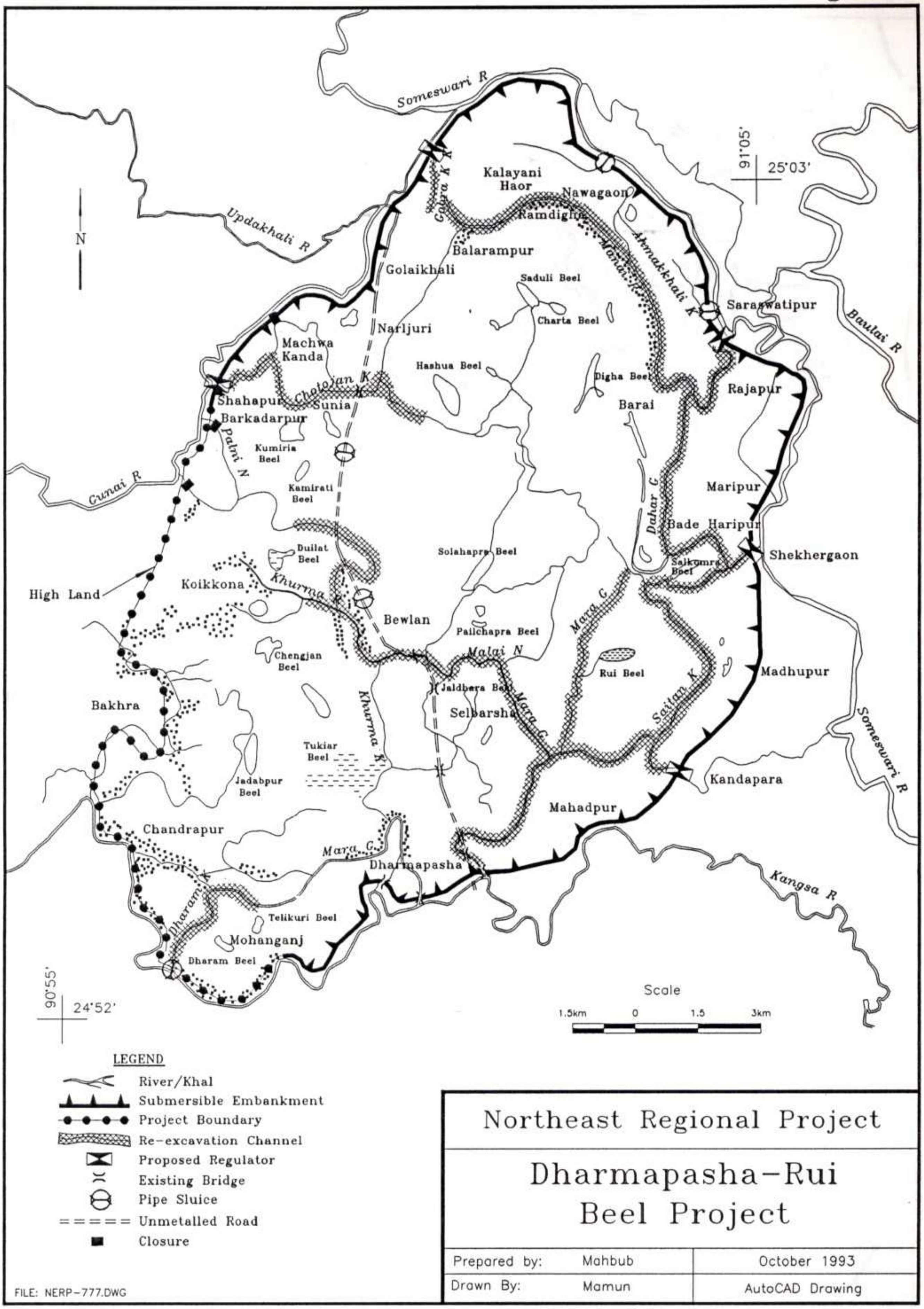


Northeast Regional Project	
Flood Depths Dharmapasha-Rui Beel Project	
Prepared by: AWLAD	February 1994

FILE: MODL-110.DWG

Figure 4

Figure 5



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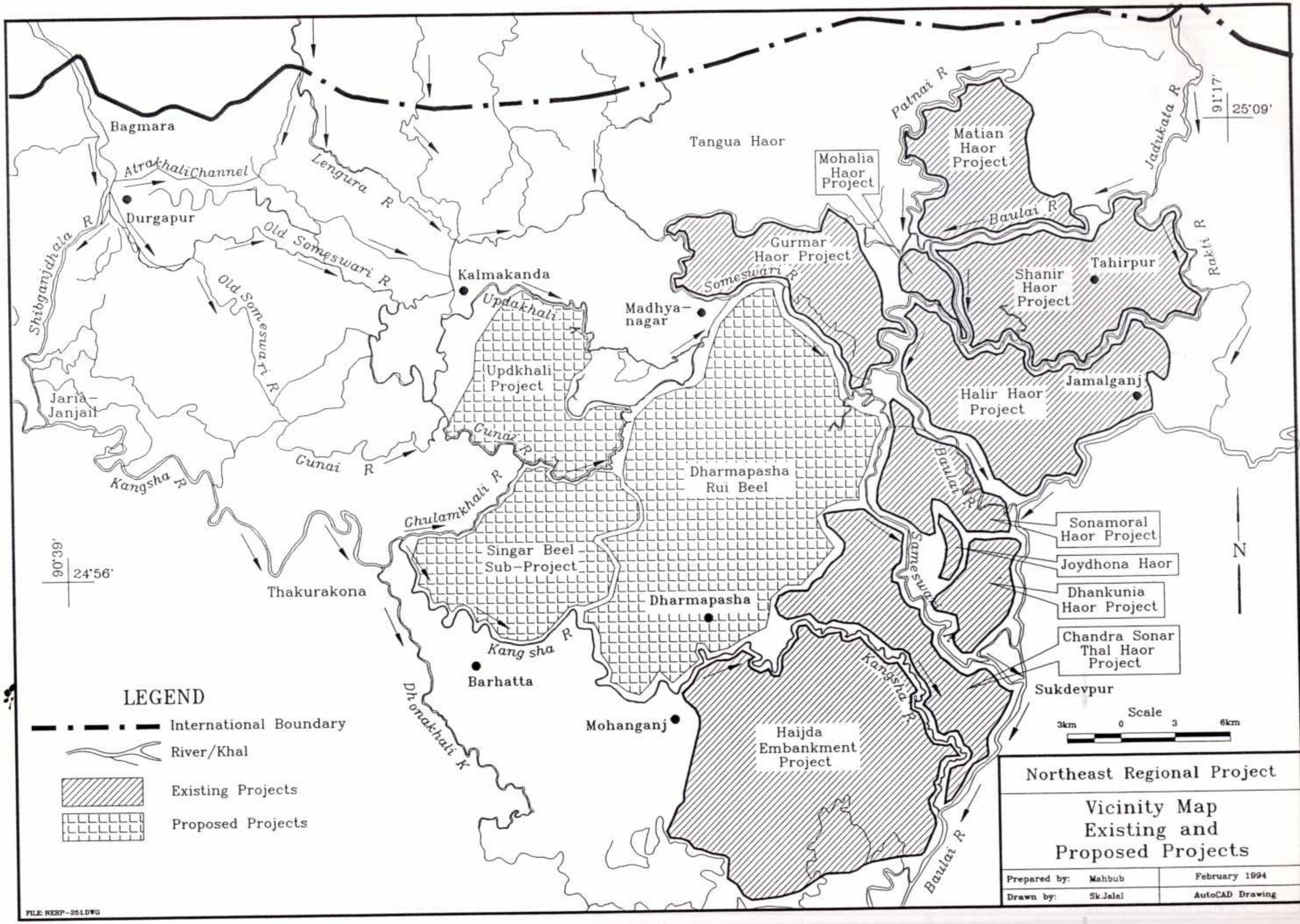
Bagmara
Atrakhali Channel
Durgapur
Shibganjdhala R
Lengura R
Old Someswari R
Old Someswari R
Kalmakanda
Updakhali K
Jaria-Janjail
Updkhali Project
Cunai R
Gunai R
Kangsha R
Chulamkhali R
Thakurakona
Singar Beel Sub-Project
Kang sha R
Barhatta
Dhonakhali K
Madhya-nagar
Tangua Haor
Mohalia Haor Project
Gurmar Haor Project
Someswari R
Dharmapasha Rui Beel
Dharmapasha
Mohanganj
Patnai R
Matian Haor Project
Baulai R
Shanir Haor Project
Tahirpur
Jadukata R
Rakti R
Halir Haor Project
Jamalganj
Baulai R
Sameswari R
Kangsha R
Haijda Embankment Project
Sonamoral Haor Project
Joydhona Haor
Dhankunia Haor Project
Chandra Sonar Thal Haor Project
Sukdevpur
Baulai R
N
91°17'
25°09'
90°39'
24°56'
Scale
3km 0 3 6km
LEGEND
International Boundary
River/Khal
Existing Projects
Proposed Projects
Northeast Regional Project
Vicinity Map
Existing and
Proposed Projects
Prepared by: Mahbub
February 1994
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-251.DWG

Figure 6