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)

SURMA RIGHT BANK PROJECT

November 1993

NOT FOR CIRCULATION

Shawinigan Lavalin (1991) Inc.
Northwest Hydraulic Consultants

in association with

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

Canadian International Development Agency

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
AST	Agriculture Sector Team
BBS	Bangladesh Bureau of Statistics
BFRSS	Bangladesh Fisheries Resource Survey System
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
DOF	Department of Fisheries
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
FAP	Flood Action Plan
FCD	Flood control drainage
FCDI	Flood control drainage irrigation
FW	future with project scenario
FWO	future without project scenario
IEE	Initial environmental evaluation
LLP	low-lift pump
LT	local transplanted
MPO	Master Planning Organization
NERP	Northeast Regional Water Management Plan Project (FAP 6)
NFMP	New Fisheries Management Policy
NHC	Northwest Hydraulic Consultants
NPV	net present value
NWP	National Water Plan
PD	person-day
PWD	Public Works Department
SLI	SNC-Lavalin
STW	shallow tube well
Tk	Taka
WARPO	Water Resources Planning Organization (formerly Master Planning Organization)

US$1 = Tk 38

EXECUTIVE SUMMARY

The proposed project aims to increase monsoon and *boro* season agricultural production without compromising the integrity of the wetlands and fisheries production systems.

The project evolved out of discussions with people living in the project area. They expressed concern that agriculture is being damaged by both flash and seasonal floods; that siltation appears to be filling in some boro areas, such that cropping on them will have to shift to lower-yielding b aman; and that there is little scope to expand irrigation because of limited ground and surface water supplies. The overall result is that under the present flood regime there is little scope to increase food production. In general, the solution which people favour involved protecting the boro crops while maintaining the existing drainage system into the Surma River. Therefore, navigation and fish passage between Bara *Haor* and the Surma River would not be obstructed.

The proposed initiative will provide flood protection for the project area from upper Surma and Lubha River spills. This will be achieved by constructing full embankments along the right bank of the Surma River from Kanairghat up to Lubha Tea Garden and along the Lubha right bank. Rustampur and Bagha Khals will be closed to prevent overbank spills in the area between Kanairghat and Sylhet. In addition, to mitigate displacement of Lubha spills onto areas behind its left bank, a full flood embankment along the Lubha's left bank would be provided. The estimated cost of the Project is US $1.6 million. Project physical works are:

- Full flood embankments (13 km)
- Closure dams (2)
- Drainage regulator (1)

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1. INTRODUCTION

1.1 General Information

BWDB Sub-division(s):	Sylhet O & M
District:	Sylhet
Thana(s):	Kotwali (Sylhet Sadar), Kanaighat, Jaintiapur, Gowainghat, and Golapganj
MPO Planning Area:	24, Catchment 7
Gross Area:	40,000 hectares

1.2 Scope and Methodology

This is a pre-feasibility study that was undertaken over a period of one month in early 1993.

The field study team consisted of a water resources engineer, socioeconomist, agronomist, and wetland resources specialist. Additional analytical support was provided by an environmental specialist, fisheries specialist, and economist.

1.3 Data Base

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

The sources of information and data used are listed below:

- **Engineering Analysis**. Existing topographic maps and those developed by MPO with elevations on a one square kilometer grid, historical climatological and hydrological records, river and khal cross-sections surveyed by BWDB Morphology Directorate as well as by the Surface Water Modelling Centre, BWDB reports, MPO reports, personal field observations and interviews with beneficieries, recommendations by BWDB officials and local representatives.

- **Agricultural Analysis**. Data published in the Land Resources Appraisal for Agricultural Development in Bangladesh (AEZ Reports) for soils; Water Resources Planning Organization (WARPO) for agricultural inputs, interviews with individual and groups of farmers in different areas and on each land type, and hydrological data developed by the hydrology and engineering sections of NERP.

- **Fisheries Analysis**. Topographic maps, BFRSS data, NERP Fisheries Specialist Study, field observations and local interviews, information provided by local representatives during field seminars held at Sylhet in June, 1992.

- **Wetlands Analysis**. Topographic maps, local revenue department records, personal field observations and interviews with local people.

- **Socio-economic Analysis**. BBS data for demographic features, education, and agriculture; reports of the Directorate of Public Health and Engineering (DPHE), and NERP data base on population and human development, personal field observations and field interviews with cross-sections of local people, suggestions from local and political representatives originating out of the series of meetings held throughout the region.

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 peoples perceptions of the types of problems they face. Chapter 4 briefly reviews previous studies and Chapter 5 list trends that are occurring in the project area. Chapter 6 reviews water resource development options concluding with a suggested option, and Chapter 7 describes the suggested option. The annexes consist of detailed tables, figures, and the initial environmental assessment, in support of the main report text.

2. BIOPHYSICAL DESCRIPTION

2.1 Project Boundaries

The project is located in an area bounded in the south and east by the right bank of the Upper Surma River, and the right bank of the Lubha River to the Bangladesh border. The western border is the Sylhet to Sarighat road and the northern border is the Lain Nadi.

2.2 Climate

Bangladesh Meteorological Department (BMD) has a climatological station at Sylhet. The climate of the area based on data from this station is summarized in Table A.3. Maximum temperatures vary from about 28 C to over 40 C with highest temperatures experienced during April and May. Minimum temperatures range from 6 C to 25 C.

The project is located in one of the highest rainfall areas in Bangladesh. The mean annual rainfall over the project area was 5000 mm for the period 1891-1989. About 93% of the total annual rainfall falls during the April - October period. November through February is dry; March has slightly more rainfall with 150 mm (3% of total) rainfall.

Relative humidity is high throughout the year, with averages ranging from 65% to 89%. Humidity is highest in the monsoon season from June to September. Average wind speed varies from 3.0 to 4.0 km/sec, with the highest speeds occurring between March and June. Potential evapotranspiration rates vary seasonally. Highest rates (5.24 mm/day) occur the March-April pre-monsoon period and lowest rates (3.30 mm/day) occur during December in winter.

2.3 Land (Physiography)

2.3.1 General Description

The area's topography consists of low ridges (maximum elevation 60 m PWD) to the north and southwest, apparently associated with echelon faulting along the base of the Shillong Plateau escarpment. The rest of the area is gently undulating, with levels ranging from about 6 to 15 m (PWD), with the highest elevations located along the Surma River bank and along the Sarighat-Kanaighat road in the north. The land generally slopes from north to south and east to west into the saucer-shaped central depression (Bara Haor, Medhal Haor); this drains through the Sylhet-Jaintiapur road bridges to the west and through Kushi Gang to the south, and then into the Surma River.

Area-elevation and storage volume data and curves are presented in Table A.4 and Figure B.1.

2.3.2 Soils

The area, other than the hilly northern tip, is covered by subrecent alluvium of the Surma-Kushiyara Floodplain.

The main soils on the relatively high floodplain areas consist of a grey, massive, puddled silt loam or silty clay loam topsoil, strongly to medium acid, overlying a grey mottled yellowish brown silty clay loam to clay subsoil with coarse blocky structure. The main basin soils are similar but are generally clays throughout and have a very strongly acid topsoil. Stratified

Table 2.1: Present Land Types

Land Type	Flood Depth (metres)	Gross Area		Cultivated Area	
		(ha)	(%)	(ha)	(%)
F0	0.0 - 0.3	5000	12.5	843	2.5
F1	0.3 - 0.9	6000	15.0	4860	14.3
F2	0.9 - 1.8	7000	17.5	6792	20.0
F3	> 1.8	22,000	55.0	21,400	63.1
Total		**40,000**	**100.0**	**33,895**	**100**

material, medium acid to neutral, occurs below 0.8 to 1.6 m in most of the floodplain. Almost all soils are flooded during the rainy season and dry out strongly by the middle of the dry season. Most of them appear relatively slowly permeable in the subsoil and substratum. Just below the ploughed layer there is generally a massive and slowly permeable ploughpan, 5 to 10 cm thick. Organic matter contents are generally low. Natural fertility is moderate, but appears to be maintained quite well in spite of continuous cultivation without much manuring. In most areas, the topsoil becomes neutral in reaction after a few weeks of flooding, and then becomes acidic again during the dry season.

Water level data of Sarighat, Sarigoyain, Salutikar, Kanaighat, Sylhet, and Lubha were analyzed. These were superimposed on the area-elevation curve of the Surma right bank basin to compute the area under different land types. These are shown in Table 2.1.

2.4 Water (Hydrology)

2.4.1 Runoff Patterns

The principal water courses governing the area's hydrology are the Sarigoyain, Lubha, and Surma Rivers. These rivers mainly spill to the project area through the Lain Nadi, Pora Khal, Kushi Gang, Amri Khal, and Kapna Nadi (Figure B.5). All the principal water courses are flashy and flash peaks can occur several times during pre-monsoon and monsoon seasons (Figure B.2). In some years these peaks occur simultaneously.

The recorded mean and extreme daily discharges for the Surma and Sarigoyain Rivers is presented in Table 2.2. This table illustrates a wide fluctuation in runoff patterns from 2.2 m^3/sec to 2730 m^3/sec.

Observed minimum and maximum discharges for the Lubha River are 1.84 m^3/sec and 800 m^3/sec over a period of 11 years. Details of mean monthly flows (mean and extremes) are provided in Table A.5.

The Sarigoyain River spills to the project area through the Lain Nadi and Pora Khal around Sarighat during the pre-monsoon and monsoon seasons, damaging crops. The Lain Nadi spills

Table 2.2: Recorded Mean and Extreme Daily Discharges (m^3/sec)

River	Station Number and Name	Range of Daily Discharge			Period (Years)
		Minimum	Mean	Maximum	
Surma	266: Kanaighat	2.2	524	2730	1969-89
Surma	267: Sylhet	2.6	548	2480	1964-89
Sarigoyain	251: Sarighat	2.5	130	1730	1964-89

Source: NERP

upstream of the the Sarigoyain River gauge at Sarighat (where maximum recorded daily discharge is 1730 m^3/sec), and no measurements have been taken at the Lain Nadi. However, this channel's cross-section would suggest that flows of about 250-300 m^3/sec enter the Lain Nadi, pass through Pabijuri Nadi, and then flow into the project area.

Table 2.2 shows that the maximum daily discharge at Sylhet is lower than at Kanaighat. This indicates that there are spills from the Surma between Kanaighat and Sylhet. Comparison of mean monthly discharge between these stations also shows that spills occur during both the pre-monsoon and monsoon seasons (see Table A.5). There are several spill channels from the Surma River between Kanaighat and Sylhet. Most are reported closed except Kushi Gang, Fatehganj Khal, Rustampur Khal, and Bagha Khal.

There is a road between Kanaighat and the Lubha Tea Garden that also serves as an embankment. This road embankment was breached in 1990 about 1 km upstream of Kanaighat and has not yet been repaired. Local people say flood water flows through this breach during the pre-monsoon and monsoon seasons and causes crop damage.

Amri Khal, a small hilly stream that originates in the Shillong hills, flows to the Lubha River about 2 km upstream of the Lubha River's outfall into the Surma River. During the pre- and monsoon seasons, water from the Lubha River backs up through this khal and flows to the central depression. This water damages crops and infrastructure.

2.4.2 Flooding

The project area is subjected to both pre-monsoon (before 15 May) flash flood and monsoon flooding from the Surma, Lubha and Sarigoyain Rivers. Flash floods occur in late April or early May (Figure B.2) and damage standing boro crops — often just before harvest. Monsoon flooding generally occurs during July or August.

Peak pre-monsoon and monsoon water levels for various return periods at six gauging stations are presented in Table A.6. Averages of these six stations are presented in Table 2.3. The project monsoon peak water level is about 2.9 m higher than the pre-monsoon water level for a 1:2 year return period. Water level analysis also shows that flooding from the Surma and Lubha

Table 2.3: Peak Water Levels for Various Return Periods (m PWD)

Flood condition	Return periods			
	1:2	1:5	1:10	1:25
Pre-monsoon	9.93	11.08	11.57	11.98
Monsoon	12.83	13.10	13.21	13.31

Source: NERP

Table 2.4: Area Flooded by Depth Category

Flood condition	Peak water level (m PWD)	Return period	Flooded Area (ha)				
			F0	F1	F2	F3+F4	TOTAL
			<0.3 m	0.3 to 0.9 m	0.9 to 1.8 m	>1.8 m	
Pre-monsoon	9.93	1:2	26,000	5700	2200	6100	14,000
	11.08	1:5	18,000	8000	5400	8600	22,000
	11.57	1:10	13,000	8000	8000	11,000	27,000
Monsoon	12.83	1:2	5000	6000	7000	22,000	35,000
	13.10	1:5	4000	7000	5000	24,000	36,000
	13.21	1:10	4000	6000	4000	26,000	36,000

Source: NERP

Rivers is most acute (Table A.6).

Comparison of pre-monsoon water levels (15 May) and topography (Figure B.1) shows that about 14,000 ha are inundated by the 1:2 year return period flood. Inundated area increases substantially with higher return periods, ranging from about 22,000 ha for the 1:5 year flood to about 27,000 ha for the 1:10 year flood (Table 2.4).

During the monsoon season, about 35,000 ha (88%) of the project area is inundated by floods having a 1:2 year return period. About 22,000 ha (55%) is flooded to depths exceeding 1.8 m (Table 2.4). This table also shows that the 1:2 year flood is the most critical since the flooded area does not increase significantly with the increased water levels.

2.4.3 Drainage

The project area drains to the Surma and Sarigoyain Rivers, through the Kushi Gang in the pre-monsoon season, and through the Kapna Nadi in the monsoon season. Pre-monsoon drainage is to both the Surma and Sarigoyain, though sometimes flow reverses through the Kushi Gang (see water levels for the Surma at Sylhet, #267, and the Sarigoyain at Salutikar, #252.1, and Figure B.3). During this period (April and May), the Surma (#267) mean monthly water levels are about 0.5 m higher than Sarigoyain (#252.1) levels (Table A.7). In contrast, monsoon season drainage is mainly to the Sarigoyain, since the Surma remains high — over 1.5 m higher,

Table 2.5: Summary of Ponds by Thana

Thana	Total number of ponds	Combined pond area (Ha)	Average pond size (Ha)	Pond concentration (nos/km2)
Sylhet	412	31	0.075	10.06
Goyainghat	294	23	0.078	9.18
Jaintiapur	1453	112	0.077	9.04
Kanaighat	2591	200	0.077	9.18
Golapganj	301	23	0.071	9.18
Total	5051	389	0.077	

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

comparing #267 and #252.1 — during August and September (Table A.7).

The Kushi Gang, Naya Gang, and a branch of Amri Khal are reported to have infilled with sediment. Local people indicated that these channels should be re-excavated; that Fatehganj Khal should be kept open for navigation; and that the Rustampur and Bagha Khals should be closed immediately.

2.4.4 Water Bodies

Open water bodies
The area contains an important haor complex. Key haors include: Bara haor, Medhal haor and Chhekurir haor. The haor system is closely integrated with the Sarigoyain, Lubha, and Surma Rivers and their tributaries. The system has over 30 perennial beels covering an estimated area of about 370 ha during the dry season. The most important beels are Ruila beel, Medhar beel, Katanga beel, Bara Haor, Kalamati beel, and Rangauti beel. Most of the beels are shallow (dry season depth ranging from 1.5 to 3 m). In addition, there are the rivers and interconnecting channels. From 55 to 85% (22,000 to 35,000 ha) of the area is flooded in average years (1:2 year return period flood; source: NERP). During the flooded period, fish can move relatively freely between rivers, canals, and beels.

Ponds
A large number of ponds exist within the proposed project area of which the highest pond concentration is in Sylhet Sadar thana (10 per km^2) and the lowest concentration is in Jaintiapur thana (9 per km^2). The ponds per thana are provided in Table 2.5.

2.4.5 Surface Water Availability

Surface water availability for irrigation (80% dependable low flow) for the month of January, February, and March is provided in Table 2.6. The table shows available flow of about 4 m^3/sec in the Surma and over 4 m^3/sec in the Sarigoyain during the critical month of March. These flows indicate that there is very limited scope for expansion of surface water irrigation. Moreover, the

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Table 2.6: Surface Water Availability

River	Location	Decade	Low flow, 80% dependable (m^3/sec)		
			January	February	March
Surma	Kanaighat	I	6.63	4.37	4.60
		II	5.51	4.09	3.63
		III	4.74	4.17	3.89
Surma	Sylhet	I	7.84	5.16	4.53
		II	6.56	4.59	4.55
		III	5.57	4.97	5.75
Sarigoyain	Sarighat	I	7.14	5.34	4.42
		II	6.65	4.91	4.67
		III	5.92	4.82	5.44

Source: NERP

Table 2.7: Estimated Ground Water Recharge

Useable Recharge (Mm^3)			Available Recharge (Mm^3)		
STW	DSSTW	DTW	STW	DSSTW	DTW
0.00	6.44	50.74	0.00	3.93	27.74

Source: NWP (WARPO), Phase II, 1991

Sarigoyain River is a considerable distance from the project area. Surface water irrigation could only be increased by conserving water during the dry season — a practice which already exists in the area.

2.4.6 Ground Water

Estimated useable ground water recharge[1] within the project area is 51 Mm^3. An estimated usable recharge of about 28 Mm^3 is within the depth range accessible by force mode (deep tube well) technology. Deep-set shallow tube wells could be used to abstract up to 4.0 Mm^3 (Table 2.7). Standard suction mode (shallow tube well) technologies are not suitable at all because of aquifer constraints.

1 Thana Recharge Volume Estimates, National Water Plan, Phase II, 1991.

2.5 Wetlands and Swamp Forest Trees

2.5.1 Wetlands

There are three important wetlands situated within this project area.

The most important is *Bara Haor* which consists of nineteen perennial beels having an area of about 217 ha, and 250 ha chhon-producing (*Vetiveria zizanioides*) area nearby. Some of the major beels are Salusari (40 ha), Ular (30 ha), Melan (50 ha), and Kata (15 ha). The second most important wetland is *Medhal Haor* which consists of five perennial beels having an area of about 60 ha. However, the fish lessee has constructed a small embankment (boundary) to hold water in area of 280 ha. The third most important wetland is *Chhekurir Haor* which consists of at least ten perennial beels with an area of about 80 ha.

These wetlands are similar in nature. They are generally very large flat wetlands with many deeper pockets (beel). The unique feature of these wetlands are their grasslands which are dominated by *Vetiveria zizanioides* (binna or chhon). Other important species are *Phragmites karka* (khagra or nol), *Ficus heterophyla* (bonolat or babdumur), *Lippia javanica* (bhuiokra), *Calamus tenuis* (jalibet) and various *Polygonum* (bishkatali or kukra). This grassland supports many small birds like the endangered Jordan's Bush Chat. Due to the presence of swamp forest in some of the beels, other resident birds like Great Cormorant *Phlacrocorax carbo*, Cotton Pygmy Goose *Nettapus coromandelianus* and Ruddy Shelduck *Tadorna ferruginea* are more frequent then in many of the other wetlands. The haor also acts as an important stopover for migratory waterfowl. Other wildlife such as Fishing Cat and Indian Civet are also found.

Many other less important wetlands (haor and beel) exist within this project area. These include: Dhalair Haor, Uttar Elakunji Haor, Dhaleswral Haor, Dupani beel, Bandarkuri beel, Satkuri beel, Manika beel and Moiain beel.

2.5.2 Swamp Forest Trees

There are at least ten patches of swamp forest existing within this project each having an area ranging from 5 to 15 ha. The dominant species in these forests are *Barringtonia acutangula* (hizal). Other important species are *Pongamia pinnata* (koroch), *Trewia nudiflora* (gotogamar or panidumur) and *Cretaeva nurvala* (barun). The important undergrowing woody shrubs are *Ficus heterophylla* (bonolat or baludumur), *Asparagus racemosus* (satamuli or hilum), *Phyllanthus disticha* (chitki) and *Asclepias* sp. (Bangla name not known).

3. SETTLEMENT, DEVELOPMENT, AND RESOURCE MANAGEMENT

3.1 Land Use, Settlement, and Human Resources

3.1.1 Land Use and Settlement Pattern

General Description
Current land use is summarized in Table 3.1. Settlements within the project area are mainly found in the form of villages along the levees of the rivers and along various road sides. Exceptions are Sylhet town and along the hills of Sylhet-Khadimnagar-Horipur area. The portion of Sylhet town which falls within the project area is densely settled, while in the hills, settlements are mainly scattered along the foot of the hills. While settlements are also found along the various roads, settlements along the right side of the Sylhet-Jaintiapur road and around the periphery of Bara Haor are extremely sparse. These are areas where the land elevation is very low.

Flood Damage to Housing
Historically, households located on higher lands were not generally damaged by floods. More recently, however, many villages of Kanaighat and Jaintiapur thanas, especially along the Sarighat-Kanaighat road are reporting damage to homesteads as a result of flashy monsoon floods during July-September. The damage mainly occurs when the embankments of Lain Nadi are overtopped. Sometimes the villages along Kapna Nadi, Kushi Gang, and the Khorish River are also affected by monsoon floods in July and August. Obviously, the lower the elevation of the homesteads, the worse the risk of flooding.

Coping Strategies
Homestead platforms are usually raised to one meter or more to avoid monsoon flooding. However, within villages in the low-lying Bara Haor areas, homesteads are raised even higher to avoid flooding. Unlike the haor areas of Sunamganj and Netrokona districts, wave action which erodes homestead platforms is almost non-existent here. Flood waters from the monsoon flash floods usually recede from the homesteads within two or three days. If there is severe flooding, villagers generally make platforms inside their houses and shift their belongings to safer places, if available. However, in such a situation, the poor suffer the most.

Table 3.1: Land Use

Use	Area (ha)
Cultivated	33,895
Homesteads	1010
Beels	365
Ponds	390
Channels	208
Hills	3432
All-Season Fallow[1]	250
Infrastructure[2]	450
TOTAL	**40,000**

[1]Multi-use land, wetlands, grazing land, village grounds. Includes F4 land.
[2]Government-owned land (developed and undeveloped) not appearing elsewhere.

3.1.2 Demographic Characteristics

Table 3.2: Population Distribution by Age Group (%)

Sex	Population Age Group (years)						Total
	0-4	5-9	10-14	15-54	55-59	>60	
Male	16.4	15.9	14.0	45.7	2.0	6.0	100.00
Female	16.9	16.4	13.8	45.9	1.6	5.4	100.00
Total	16.65	16.10	13.90	45.85	1.8	5.7	100.00

Source: BBS, 1981 Population Census

The total population of the project area is estimated to be 269,400 of whom 130, 600 are female. The gender ratio is calculated to be 106 (males to 100 females). The total number of households is estimated to be 43,100 in 433 villages. The population increased by about 28% between 1981 and 1991 in the district of Sylhet, an annual increase of 3.3%.

The cohort distribution for males is: 32% are below 10 years of age, 46% are between 15 and 54 years of age, and 6% are above 60 years of age. The distribution for females is 33%, 46% and 5% respectively for the same age groups (see Table 3.2).

The average population density is 492 persons per km^2, with a maximum density of 1041 persons per km^2 in Sylhet Sadar which includes part of Sylhet town. The most sparsely populated is Jaintiapur thana which has 353 persons per km^2. The average household size in the area is estimated to be 6.25 persons. Details are provided in Table A.1.

3.1.3 Quality of Life Indicators

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

Literacy

In the project area the literacy rate is found to be extremely varied. According to the 1981 census, the literacy of the population at 5 years of age and above varied from 11% in Gowainghat thana to 31% in Kotwali (Sylhet Sadar) thana. The corresponding figures for females were 5% and 23% respectively for the same thanas. However, the rate is found to have increased over last 10 years. According to the 1991 census, the literacy rate of all ages of the population of Sylhet district is found to be 25% for both male and female.

According to the 1981 census, school attendance in the project area for all children 5 to 9 years of age varies from 14% in Gowainghat thana to 30% in Golapganj thana. Attendance for females in this age cohort in these two thanas is 10% and 27% respectively. Attendance for all youths between the ages of 5 and 24 is 11% and 26% for these thanas while the corresponding attendance for females is 6% and 20%.

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

Access to Health Services
The district headquarters of Sylhet has a medical college with a hospital and all thanas have hospital facilities located only at their headquarters. Access to health services are generally limited for rural villagers and for the poor, out of reach. According to the Directorate General of Health Services (1992), there is one hospital for every 162,190 persons and one doctor for every 9915 persons in the district of Sylhet. One hospital bed is meant for 2351 people. Immunization coverage of children below two years of age is quite high for the project area. The rate varies from 49% in Kanaighat thana to 65% in Golapganj thana (1990).

Rural Water Supply
Detailed information on access to rural water supply for drinking purposes is not available for the project area. However, for the rural areas of the district of Sylhet, DPHE[1] reports the availability of one working tube well for 134 persons. In 1990, 59% of the households had access to potable water in the district. It is noted that most tube wells are located in the houses of the rich. This results in the poor having very limited access to potable water.

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

3.1.4 Employment and Wage Rates

Village employment opportunities are mainly limited to agricultural activities, except for Sylhet town. T aman is the major crop in higher lands of the area; on these lands, employment is mainly limited to transplanting in August and September and harvesting in late November and December. Employment during boro cultivation is limited to the labourers living in low-lying villages — mainly around Bara Haor.

The wage rates for male agricultural activities varies from Tk 40 to Tk 50 with or without a daily meal during peak agricultural months. During lean months, the wage rate varies from Tk 20 to Tk 25. It is reported that during the monsoon months, many labourers (20-50 per village) migrate to Companiganj and Kanaighat thanas to work on sand and stone quarrying activities. They are usually involved in transporting these materials from the quarries to various construction and sale centres throughout Sylhet district. The average daily income from this activity varies from Tk 60 to Tk 100 depending on the season. During months when employment opportunities in agricultural are limited, some poor people migrate to Sylhet town to work as rickshaw pullers, as construction workers, or sometimes in household activities.

Women's employment includes post-harvest in agriculture and homestead-based activities; wage rates for these activities are not known. Except for the Rural Maintenance Program of CARE, formal employment opportunities for women are very limited in the area. CARE employs

[1] DPHE, 1991-92

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women at the rate of Tk 25 per day. Some women migrate to Sylhet town to perform household tasks but their numbers are very limited. Many villages have no such migrant woman labourers.

Migration by men to other countries, particularly to the U.K., is common in Golapganj and Kotwali (Sylhet Sadar) thanas. This type of migration is less common in other thanas of the project area.

There is seasonal in-migration into the project area, particularly to Sylhet town from Comilla, Faridpur, Mymensingh, Manikganj, and Noakhali. Migrants come to Sylhet town mainly to work as rickshaw pullers and construction workers. Immigrants to other parts of the project area stay seasonally to work in the rice harvest.

3.1.5 Land Ownership Pattern

Land ownership is extremely skewed in the project area. Nearly half of the households are landless (with cultivable land less than 0.20 ha). Among the landless, about 2% have no homesteads of their own. The situation is further increased by 10% when households with land holdings of up to 0.40 ha of cultivable land are included in the definition of landlessness. Of all households, 28% are small farmers (0.21 - 1.00 ha), 17% are medium farmers (1.01 - 3.00 ha) and 6% are large farmers (more than 3.00 ha) (Table A.2). Women own an insignificant portion of the land.

There is an estimated 250 ha around Bara Haor that is reportedly government-owned (khas). It produces *Vetiveria zizanioides* (chhon), a wild grass used for roof thatching, and is also used for communal grazing by villagers living nearby. In certain areas, influential people are reportedly appropriating this land for rice cultivation, and conflicts over this are occurring.

3.1.6 Land Tenure

Owner-operation is the common practice in the area. A few large land owners, specially from Golapganj and Sylhet Sadar thana share out their lands to tenants for operation. The share cropping system is that one-half of the produce is retained by the land owners but they provide no inputs. Land is seldom leased out for cash (chukti) in the area. However, some land is leased out for a predetermined fixed amount of the crop (rangjama). The usual leasing rate averages between Tk 400 - 700 per bigha (Tk 3,300 - Tk 5,800 per ha) paid in advance to the land owner for a particular crop season. Landless people have very little access to land under any tenurial system because of their inability to provide cash for both the lease and the agricultural inputs.

3.1.7 Fishermen

Traditional fishermen are found throughout the project area, though their numbers are small (varying from 2% to 4% of the population). Such fishermen are reported to be more in Kanaighat and Sylhet Sadar thanas. However, fishing is now practised as a profession by many poor people in the area, especially during monsoon months when they can fish in open water. The numbers of such non-traditional fishermen are continually increasing, with the greatest numbers fishing in the deeply-flooded Bara Haor areas.

There are a few major fisheries (jalmohal) in the project area, of which the Medhar beel and Kora Khal Group Fishery in Bara Haor are most important. Most of the large fisheries are leased by a few rich influential persons for a period which varies from three to nine years. They generally reside in Sylhet town. At best, local fishermen derive employment from these fisheries. To a large degree even that is denied them: the final catch is mainly performed by fishermen from outside areas, mainly Kishoreganj and Brahmanbaria, who are brought in as labourers for this purpose.

Conflicts and tension are common over the issue of fishing the jalmohals in the area, particularly in Medhar beel and Kora Khal Group Fishery. The lessee of Medhar beel constructs and maintains water retention dams on the beels drainage canals and this prevents timely boro cultivation in the peripheral zone of the beel. However, it is also reported that the lessee allows the farmers to cultivate boro during the third year of the lease, when he reduces water level for the final catch. On the other hand, water was completely drained during the last week of December 1992 to fish Kora Khal Group Fishery and as a result large areas remain uncultivated this winter. It was also reported that lessees do not allow fishing by either traditional or non-traditional fishermen in the vicinity of the jalmohals even during monsoon months. This assertion was not cross-checked. The extent of lessees' control over the needs to be investigated during feasibility, as this will have a significant bearing on the outcome of any intervention.

3.1.8 Situation of Women

The strict gender division of labour in farming households dictates that to complete the full cycle of agricultural production requires a high degree of inter-dependance between women and men. Women's contribution, however, tends to be devalued and less recognized than that of men. In Kanaighat, Jaintiapur, and Gowainghat thanas, female seclusion is enforced more strictly than elsewhere in Sylhet. In these thanas, female and male eductaion is markedly low, indeed one of the lowest in Bangladesh. Contraceptive acceptance is also low. Women are not very mobile in the area except for Sylhet town. However, poor women are reported to be working outside their homes, mainly for the Road Maintenance Program of CARE and activities like gathering wild vegetables, collecting fuel and sometimes catching fish with small fishing traps. Women who generate incomes outside the home generally lower their families prestige — this may be the reason that available statistics seem to under-report these activities.

Since women are not readily accessible to outsiders, particularly if they are men, an accurate understanding of their situation requires time and an appropriate focus. It is anticipated that women's work and responsibilities, their assets and income, and their family situation will be examined in greater depth at feasibility with a view to establishing more accurately how the project would impact on them.

3.1.9 People's Perception

General

Local peoples perception of their problems were solicited. These were related mainly to water and its impact on their livelihood and their suggestions as to the nature of interventions which could solve these problems. Information was collected through personal interviews, group discussions, and meetings with a cross-section of people during the ten-day field work period.

Problems

Flooding, both pre-monsoon and monsoon, was described as a major problem of the area. This flooding mainly damages rice crops. Boro rice is affected almost every year by pre-monsoon floods between April and May. Flash floods enter through the Pabijuri, the Khorish, Kushi Gang, and Amri Khal, a distributary of the Lubha River. The most affected areas are the boro fields in and around Bara Haor in Kanaighat and Sylhet Sadar thanas. A number of other smaller pockets throughout the project area are also affected.

In Gonaighat, Kanaighat, and around Bara haor, homesteads are heavily flooded. Family gardens are often destroyed and peoples movement is hampered. Women's household activities such as cooking, caring for small children, and fetching drinking water are made especially difficult.

T aman is damaged by flash floods during July and September, particularly in Kanaighat, Jaintiapur and Gowainghat thanas. The flood waters enter mainly through the Pabijuri and Amri Khal as well as from the Lain and Surma, overtopping roads and embankments. Sometimes there is back water flow from the Surma through the Kushi Gang and Fatehganj khal. Floods generally last for three to five days in the upper areas, and two to three flood events occur each monsoon period.

Drainage congestion in boro rice areas is another important issue as perceived by the farmers, around Bara Haor and in other areas. Silting up of the internal drainage canals, in particular Kushi Gang, as well as the external rivers, particular the Surma, is reported.

Jalmohal leasees prohibit poor and subsistence fishermen from open water fishing in the zone around their jalmohals. The fishermen cooperatives under the New Fisheries Management Policy (NFMP), however, do not prevent this type of fishing.

Over-fishing and practices such as de-watering the jalmohals are detrimental to sustaining a reasonable fish stock and are responsible for lower fish catch. In this connection, it was stated that where jalmohal were leased to local fishermen, they took greater care to ensure the longer term sustainability of the fish resources.

Proposed Suggestions
Local people put forward many suggestions. However, some of their suggestions focused on very small and localised issues. The most common are:

- Re-excavate Kushi Gang, and provide a sluice gate that will allow boat passage.
- Develop the Surma right bank to protect intrusion of monsoon flood water into the area.
- Dredge the Surma river from the outfall of the Lubha River to Sylhet town.
- Stop the intrusion of pre-monsoon and monsoon flood water from Amri Khal. However, some people indicated that Amri Khal should be kept open to navigation.
- Lakhipur village is situated opposite Amri Khal, on the left side of the Lubha River. If Amri Khal is closed, it should be protected from displaced flooding.
- Conserve sufficient fish habitat in the kanda for normal reproduction.
- Impose strict measures to ensure that laws governing fish harvesting are followed.
- Allow poor, poor children and subsistence fishermen to catch fish in the flood plain.

Table 3.3: Present Cropping Patterns

Cropping Pattern	F0		F1		F2		F3		Total
	ha	%	ha	%	ha	%	ha	%	ha
b aman-fallow					5434	80	4280	20	9714
fallow-l boro					0	0	17120	80	17120
fallow-hyv boro	0	0	0	0	1358	20	0	0	1358
b aus-lt aman	379	45	2430	50	0	0	0	0	2809
b aus-hyv aman	84	10	0	0	0	0	0	0	84
lt aman-fallow	253	30	0	0	0	0	0	0	253
lt aman-wheat	0	0	486	10	0	0	0	0	486
lt aman-potato	0	0	729	15	0	0	0	0	729
lt aman-rabi	0	0	1215	25	0	0	0	0	1215
fallow-hyv aman	126	15	0	0	0	0	0	0	126
Total	**842**	**100**	**4,860**	**100**	**6,792**	**100**	**21,400**	**100**	**33,894**

- Give preference to local fishermen in awarding a jalmohal lease.

- Fish migration routes; from the Sarigoyain River through the Pajiburi River into the project area, and from the Surma River through the Kushi River need to be maintained.

- Navigation routes; from the Surma River through the Kushi River, from Lain River through the Pabijuri River, and from the Lubha River through the Amri Khal need to be maintained.

3.1.10 Local Initiatives

Information on specific local initiatives to avert flood-related problems in the project area were not collected during the field visit. In general, however, people stated that it is their traditional practice to organise local people to counteract crises that arise as a result of flash floods. The main activity is to construct dams on various localised canals to stop the intrusion of pre-monsoon flash floods and thereby save the boro crop. This is generally done on a voluntary basis by villagers around a particular canal when flooding threatens their property.

During the field visit, on 4 January 1993, the study team observed a group of about 20 persons from the village of Turukbag in Golapganj thana working voluntarily to repair the road in front of their village which is primarily used by public buses. One old man (55) said that he had organised the group to do the job and was thus inspiring the younger generation to undertake volunteer work for the public. Similar initiatives were found in another sections of the same road. The villagers volunteer one day for this work. The experience of people's initiatives to

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Table 3.4: Present Crop Production in Surma Right Bank Basin

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	2894	1.3	3,762				3,762
b aman	7714	1.75	13,500	2000	1.5	3000	16,500
lt aman	3992	2.0	7,984	1500	1.5	2250	10,234
hyv aman	211	3.25	686				686
l boro	15370	2.25	34,583	1750	1.75	3063	37,646
hyv boro	1208	4.25	5,134	100	3.50	350	5,484
hyv wheat	486	1.75	851				851
potato	729	12.0	8,748				8,748
pulses	182	0.80	146				146
oilseeds	607	0.70	425				425
spices	61	2.75	168				168
vegetables	364	4.50	1,638				1,638

Source: NERP estimates.

protect the public interest through organised effort is quite common in the Northeast region.

3.2 Water Resources Development

3.2.1 Flood Control & Drainage

A road embankment has been constructed from Sylhet to the Lubha Tea Garden (about 60 km) which partially protects the project area from overbank spills of the Surma and Lubha Rivers. The height of this roadway ranges from 1.5 to 2.0 m and the crest width is about 2.5 m. The project area does not have BWDB projects; nor are there any other discernable interventions to manage the flooding.

3.2.2 Irrigation

Surface Water

LLPs and traditional technologies combined irrigate about 2300 ha of boro rice within the five thanas covered by the project (AST Irrigation Census, 1991). About 470 ha (20%) of the total is irrigated by 36 LLPs. While the specific location of the various units are not known, many were observed to be operating outside the area impacted by the project.

Ground Water

Present ground water abstraction for irrigation use is not significant. There are 17 STWs and 17 DTWs in Kotwali (Sylhet Sadar), Golapganj, Kanaighat, Jaintiapur, and Gowainghat thanas (AST, 1991). Areas irrigated by ground water are reported to be 155 and 322 hectares for STW and DTW respectively. This corresponds to an irrigation water use of about 3.0 Mm3 based on a water duty of 160 ha/Mm3. The specific location of these irrigation units is not known.

3.3 Agriculture

Crop production practices in the Surma right bank basin are dictated by the hydrologic regime. Local as well as high yielding varieties of aus and aman rice are grown on F0 and F1 land types. Deep water rice, which has the ability to elongate rapidly with rising flood levels, is grown on F2 land. Moderately to deeply flooded F2 and F3 land types are devoted mainly to local boro rice; a lesser amount is planted with high yielding varieties of boro rice.

The data on present cropping patterns by land types were collected by walking several transects which cut across all land types. Groups of farmers were interviewed to collect information on percent coverage of each crop pattern by land type. These percentages were then applied in each land type to compute the area under the various crop patterns in the Surma right bank project. the results are presented in Table 3.3.

Flash floods in the Lubha River back up and enter the project area through the Amri Khal. This water flows overland with sufficient velocity to cause damage to the b aman rice and then accumulates in Bara Haor where it damages boro rice. The monsoon flood water damages local varieties of t aman rice during its vegetative growth stage. Table 3.4 shows estimated total production in the Surma Right Bank project area. The estimates reflect an analysis of information collected from farmers regarding average yields without damage, crop damage, percent of total area affected by crop damage, yield reduction due to crop damage, and so on.

3.4 Fisheries

Beel operators habitually construct bunds to increase the water retention during the dry season, so conjunctive use of beels for fish as well as irrigation is likely occurring. Most of the important fish-producing beels are interconnected by narrow channels. Uplands (kanda) occur between the beels. During the rainy season, the beels are inundated and merge into a single, large sheet of water. At this time fish are widely dispersed throughout the area. During the dry season the individual beels act as an overwintering habitat for many fish species. Permanent and semi-permanent beels are mainly operated by the lease holders on a commercial basis, harvesting their catch during the dry season and guarding the beels throughout the monsoon. However, because of the extent of inundation, a large number of subsistence fishermen are able to fish during the wet season.

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Table 3.5: Major Fish Species in the Bara Haor Complex

BOROMACH	CHOTOMACH
Rui, catla, mrigel, kalibaus, ghonia, carpio, boal, air, chital, gazar, shoal.	Koi, singi, magur, puti, bheda, kaikka, tengra, taki, gulsha, mola, chanda, cirka, napit, fali, darkina, sarputi, laso, pabda, kani pabda, chapila, tara baim, boicha, bailla, icha.

Table 3.6: Species Breeding Within Bara Haor Area

BOROMACH	CHOTOMACH
Boal, ghania, gazar, shoal, air, ghagot.	Puti, mola, chanda,tengra, gulsha, boicha, koi, singi, magur, taki, darkina, bheda, cirka, fali, icha.

3.4.1 Species

Of the 260 freshwater species in Bangladesh, about half of the species are assumed to inhabit the water bodies within the project area. The most important of these are shown in the Table 3.4. In the seasonal beels, livefish (species that survive out of the water and are marketed live) and miscellaneous fish are the major catch; in the permanent beels, carps and large catfish predominate.

3.4.2 Fish Breeding and Fish Sources

It is generally understood that most of the species that inhabit the haor also breed there, except for major carps and chital. During pre-monsoon and early monsoon flooding, these fish migrate from the Surma and Lubha through open channels into the haor and its internal channel network to breed. Species reported to breed in the area are shown in Table 3.5.

It is also reported that boromach fry (the majority of which are carp) directly enter the haor area through the Lain Nadi (a tributary of the Sarigoyain River) near Chatul bazar swimming with the current and a large number of carp fingerling migrate from the Sunamganj-Kaliajuri area through the Kapna River. It is also assumed that some of the carp fry enter through Amri Khal.

3.4.3 Production

Based on field interviews, it has been ascertained that overall fish production of the area has been reduced by 20-30% over the last 10 years period. It is assumed that beel and floodplain production constitutes about 87% of the overall production in the project area. It was also noted that pond culture is increasing. Estimated production data are given in Table 3.6.

Table 3.7: Present Fish Production

Types of water body	Area (Ha)	Rate of production (kg/ha)	Total production (mt)
Beel	365	550	201
Floodplain	35,000	66	2,310
Pond	389	919	357
Total	35,754		2,868

Source: BFRSS data, 1988/89 and NERP

3.4.4 Fishing practice

Piles are maintained only in the Medhal-Ruila beel complex. Other than this, fishing is done on an annual basis. Like the other areas of the region, katha installation is a common practice to attract fish in the beels. Hizal, jarul, and koroch tree branches are widely used in constructing the katha. In most cases, shallower beels are harvested first, about one month after flood recession; deeper beels are harvested during the month of December/January. Kona ber jal, ber jal, jhaki jal, polo, and bamboo baskets are commonly used to catch fish from the beels and floodplain.

3.4.5 Current Fisheries Projects

Within the project area, there are several initiatives aimed at enhancing fisheries.

Second Aquaculture Development Project

This ADB financed project is managed by DOF. The major project components are:

- Stocking of native and exotic species in Medhal Haor.
- Carp culture extension.
- Rehabilitation of Khadimnagar fish seed multiplication farm (see below).

Within the project, two road-side ponds have been constructed (36 ha) with World Food Program assistance. In addition, Bagha Beel has recently been re-excavated. These artificially enhanced water bodies can produce 15 million carp fingerling (10-15 cm) per year. Under the project, these are to be released into Bara Haor with the rising flood. In 1992, an estimated 20 kg of carp spawn were reared in these ponds.

Integrated Fisheries Development Project

This Government of Bangladesh financed project is designed to:

- Establish mini hatcheries at the thana level.
- Establish fish sanctuaries.
- Implement the New Fisheries Management Policy (NFMP) in borrow pits belonging to BWDB.

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- Survey public water bodies in urban centres.

Under this program, two fish sanctuaries are being established near the project area:

- *Lubha River*: From Mulajal to the Surma river near Lakhipur. The total area is about 6.4 km^2.

- *Sari River*: From Jaintia hill to Cotigram. The total area is about 13 km^2.

The sanctuaries have a number of important duars, the depth of which ranges from 25 to 30 m during the rainy season. These duars are apparently stable structurally and are carved out of hillside bedrock. They act as refuges for boromach (mostly carp). It is assumed that overwintered boromach migrate to upstream rocky areas to breed during the pre-monsoon and monsoon period. Uniformed fish guards have been posted at these sanctuaries to prevent fishing in the sanctuary areas.

Medhar Beel Fishery Project

The project consists of a dwarf embankment around Medhar Beel to retain water in the beel for fish throughout the dry season. It was started at the initiative of local individual who obtained a loan from the government to construct the dwarf embankment. The Medhar Beel fishery has been under pile fishery management since 1945. In addition to the natural canals, there are a number of small canals that have been constructed by the lessee. Two types of canals exists within the system: shallow canals that act as spill channels during the pre-monsoon flooding, and deeper canals that facilitate catching fish during pile harvest. The total area (including embanked floodplain) is about 283 ha. About 196,000 kg of fish were produced in the 1991/92 harvest season (equivalent to Tk 11.5 million).

Fish Seed Multiplication Farm

DOF operates a fish seed multiplication farm which is located in Khadimnagar — near the project area. The farm is producing carp spawn and fingerling. The farm's production capacity is:

- Carp spawn - 50-60 kg per year.
- Fingerling - 0.5 million per year.

The farm was rehabilitated in 1990/91 to ensure sufficient spawn under the ADB Second Aquaculture Project, to support the Bara Haor stocking program and to provide more support to private fish farmers of the area.

3.5 Navigation

A primary navigation route of concern is between the Surma and Bara Haor via two openings in the Surma bank, at Kushi Gang and Fatehganj Khal. Local people have indicated that these channels should be left open for navigation purposes.

3.6 Wetland Resource Utilization and Management

The most important natural wetlands product is *Vetiveria zizanioides* (chhon), which is used for roofing, walls, and mats. Since it is one of the key materials used in the construction of homes, it has a good market value. About 250 ha near Bara Haor is producing this plant. In nearby

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markets people sell the grass for from Tk 10 to 15 per bundle, which corresponds to up to Tk 150 per hectare. The estimated gross value of the grass harvested from the wetlands is Tk 37,500 per year.

Second in importance is the production of hizal branches. Fish lease holders usually buy these branches for making katha. The cost of a branch ranges from Tk 30 to 150, depending on size. A single tree can produce at least two such branches every year. Consequently, a garden with 300 trees, which would occupy about 10 ha, can generate from Tk 30,000 to 50,000 per year. The estimated gross annual production value of hizal from the project area is Tk 500,000.

Another important end use of wetland resources is for fuel. The scarcity of fuel wood around homesteads has resulted in people becoming increasingly dependent on the swamp forest as a source of fuel. Swamp forest trees other than hizal are in greatest demand, but all woody shrubs as well as grasses are used for this purpose. Saplings of swamp forest trees are also used, which is contributing to the poor regeneration rates of these species. The estimated total gross annual value of this fuel material is Tk 1 million.

Other end uses of wetland products are:

- Fodder. Mostly used are various rooted floating herbs and grasses. These are badly needed because of the scarcity of grazing land.

- Food. Poor people are heavily dependent on the wetlands as a food source.

- Bio-fertilizer. Many farmers are using green manure instead of chemical fertilizer.

- Medicinal. Mostly from *Polygonum, Asparagus* and *Limnophila.*

No formal management exists, except for some of the swamp forest patches.

These common property resources are of some importance to the poor, who are the most likely to engage in wetland gathering, to eat wetland food in times of scarcity, to depend on income from wetland products, and so on. Fodder and building materials tend to be collected by men, and food and medicinal materials tend to be collected by women.

Some of the swamp forest patches are protected and maintained through local community management systems; the remainder are controlled through the revenue department of the local government. No one is protecting the saplings of these trees with a view to further developing this forest, though natural regeneration rates are very good.

Information on management practices for other wetland resources is not available.

4. PREVIOUS STUDIES

4.1 Gravity Diversion — Bara Haor Project

The Surma Right Bank project area includes the area of the Gravity Diversion — Bara Haor Project study. The project area of this study is bounded by the Pabijuri-Kapna Nadi in the east and south and Sylhet-Jaintiapur road in the west. The study was prepared by Berger Engineers — Pakistan and a feasibility report was prepared in 1963.

The project was formulated to divert the dependable natural flow of the Sarigoyain River during the winter months to the higher lands (gravity diversion) of Bara Haor for boro rice expansion. Three alternatives were evaluated:

- pumping versus gravity diversion;
- dikes for early spring floods; and
- dikes for monsoon floods

The study revealed that dikes for monsoon floods were not feasible because pondage from rainfall within the protected area builds up very quickly to an elevation within about 4 feet of the maximum water level in the Sarigoyain River. This indicates that free drainage is not possible until the monsoon season is over. The study also showed that pump drainage for the protected area is not economically viable.

Dikes for early spring floods were also not economically attractive, particularly in relation to the development of gravity diversion. The study showed that both pumping and gravity diversion are feasible but from a long range standpoint the gravity diversion plan was considered preferable.

4.2 National Water Plan Project, MPO

The Surma Right Bank project area is located in Catchment 7, MPO Planning Area 24. Catchment 7 has a gross area of about 66,000 ha of which 45,000 ha is net cultivable. Total flood-vulnerable area in Catchment 7 is over 33,000 ha, of which 19,000 ha is recommended for FCD development during the Fifth Five Year Plan period (page 8-55, Vol-II, NWP,1991).

5. WITHOUT PROJECT TRENDS (NULL OPTION)

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

- Net population growth of approximately 2.5% per year (down from the 3.3% experienced over the past 10 years) resulting in a population of 320,000 by the year 2000 and a population of 623,000 by the year 2020.

- Past observations indicate that fish production is declining at a rate of 1-3% per year overall. Conversely, estimates of future production, taking into account interventions to improve biological fisheries management suggest that great increases in fish production are possible. If the FWO trend is assumed to be negative, project negative impacts on fish production will be of significantly smaller magnitude than if the FWO trend is assumed to be positive. In the absence of any means to decide between these two scenarios, it is assumed that FWO production will equal present production.

- Agriculture in the Surma Right Bank project area would continue to be affected by both flash and seasonal floods. As a result, damage to different varieties of rice would continue. Also, siltation is reportedly filling in some boro areas, such that cropping on them will have to shift to lower-yielding b aman. HYV aman may increase marginally in areas presently not being damaged by seasonal floods. There is little scope to expand irrigation because of limited ground and surface water supplies. In general, then, without any intervention, cereal production is not expected to change. The future without-project scenario for agriculture is detailed in Tables 5.1 and 5.2.

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Table 5.1: FWO Cropping Patterns

Crop Patterns	F0		F1		F2		F3		Total
	ha	%	ha	%	ha	%	ha	%	
b aman - fallow	0	0	0	0	5434	80	5350	25	10,784
fallow - l boro	0	0	0	0	0	0	16050	75	16,050
fallow - hyv boro	0	0	0	0	1358	20	0	0	1,358
b aus - lt aman	169	20	2430	50	0	0	0	0	2,599
b aus - hyv aman	295	35	0	0	0	0	0	0	295
lt aman - fallow	169	20	0	0	0	0	0	0	169
lt aman - wheat	0	0	486	10	0	0	0	0	486
lt aman - potato	0	0	729	15	0	0	0	0	729
lt aman - rabi	0	0	1215	25	0	0	0	0	1,215
hyv aman - fallow	211	25	0	0	0	0	0	0	211
Total	844	100	4,860	100	6,792	100	21,400	0	33,896

Table 5.2: FWO Crop Production

Crop	Damage Free Area			Damaged Area			Total Production (t)
	Area (ha)	Yield (t/ha)	Total (t)	Area (ha)	Yield (t/ha)	Total (t)	
b aus	2894	1.3	3,762				3,762
b aman	8984	1.75	15,722	1800	1.5	2,700	18,422
lt aman	3897	2.0	7,794	1300	1.5	1,950	9,744
hyv aman	506	3.25	1,645				1,645
l boro	14550	2.25	32,738	1500	1.75	2,625	35,363
hyv boro	1258	4.25	5,347	100	3.50	350	5,697
hyv wheat	486	1.75	851				851
potato	729	12.0	8,748				8,748
pulses	182	0.80	146				146
oilseeds	608	0.70	426				426
spices	61	2.75	168				168
vegetables	364	4.50	1,638				1,638

Source: NERP estimates.

6. DEVELOPMENT OPTIONS

6.1 Overview

There were three basic options considered for development of the project area. The first was full flood protection, the second was partial flood protection using submersible embankments, and the third, the outcome of discussions with area residents, was the construction of full embankments only at strategic locations combined with maintaining the natural drainage system. The first two options are described briefly in this chapter. The third option, which was the adopted solution, is described more fully in the following chapter.

6.2 Option A: Full Flood Protection

Full flood protection could be provided to the 40,000 ha by constructing full flood embankments along the right banks of the Surma and Lubha Rivers.

The embankment crest elevation required would be 13.5 m PWD at the Sylhet, 17.1 m PWD at the Lubha Tea garden, and 15.5 m PWD along the Sylhet-Jaintiapur road (all include freeboard of 1.52 m), and are based on the 1:25 year return period peak water levels (Table A.6).

A discontinuous embankment would also be required along the left bank of the Lain Nadi, from Sarighat to the hills near Saruthel village, to prevent overbank spill and back flows. Elevation of this embankment based on Sarighat water level (1:25 years) is 14.90 m PWD including 0.90 m free board. Five drainage structures would be required (Figure B.6).

The water balance computation shows that pondage due to rainfall is much higher than the maximum storage volume (20,000 ha-m) corresponding to the full flood embankment design height (Tables A.4 and A.8). This serves to indicate that full flood protection would not benefit the area.

6.3 Option B: Partial Flood Protection By Submersible Embankment

Protection of *boro* crops from pre-monsoon flooding could be provided to the 40,000 ha area by constructing submersible flood embankments along the right banks of the Surma and Lubha Rivers.

Average design crest levels of submersible embankment along the Lain Nadi, Sylhet-Jaintiapur road and the Surma-Lubha river would be 14.0 m PWD, 11.6 m PWD and 14.9 m PWD respectively including a freeboard of 0.90 m for a 1:10 year return period.

The water balance computation shows pondage of over 15,000 ha-m due to rainfall in the month of May which corresponds to a water level of 9.5 m PWD (Table A.8 and Figure B.4). The water level at Sylhet (#267) on 15 May in 1:2 year return periods is 8.75 m PWD. This indicates that drainage will be impeded and the resultant build up of water in the basin would jeopardize boro crops.

In addition, protection against pre-monsoon flooding will obstruct navigation and prevent the entry of spawn into the area which is unacceptable. Complete empoldering with submersible

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embankments are also not a preferred option because of the potential to increase the level of conflict among various interest groups. Localized pre-monsoon protection is useful and local people are providing this protection on their own initiative. It should be left up to them.

6.4 Option C: Strategic Placement of Embankments

After evaluating available alternatives, the strategic placement of embankments was the solution adopted as the one most appropriate for the area. This option is described as the proposed project in Chapter 7.

7. PROPOSED PROJECT

7.1 Rationale

The concept evolved out of discussions with people living in the project area. It consists of providing full flood embankments along the upper Surma River and along a short reach of the Lubha River to prevent overbank spill into the area. It potentially provides protection to boro crops while maintaining the existing drainage system into the Surma River; it does not obstruct navigation between Bara Haor and the Surma River; and it allows free passage for fish between Bara Haor and the Surma River.

7.2 Objectives

The objective of the project is to reduce flood damage to the boro crop without negatively affecting fisheries, navigation, or wetland resources.

7.3 Description

The proposed project consists of flood protection for the project area from upper Surma and Lubha River spills, to be achieved by providing full embankments along the upper Surma Right Bank from Kanaighat up to Lubha Tea Garden and along the Lubha right bank. Rustampur and Bagha Khals would be closed to prevent over bank spills in the area between Kanaighat and Sylhet (Figure B.7). In addition, to mitigate displacement of Lubha spills onto areas behind its left bank, a full flood embankment along the Lubha's left bank would be provided. Project physical works are:

- Full flood embankments (13 km)
- Closure dams (2)
- Drainage regulator (1)

7.3.1 Analysis of Flood Protection

The project's peak water levels — with and without embankments — corresponding to different return periods are given in Table 7.1. The table shows that the proposed intervention reduces the flood depth during pre-monsoon and monsoon season by 0.70 m and 1.0 m respectively for an average year (1:2 year return period). The reduced flood levels would increase flood-free land by 5000 ha during the pre-monsoon season and 7000 ha during the monsoon season (see Table 7.2).

Both full flood and submersible embankments were considered, and full flood embankments were found to be the better alternative. The average height for full flood embankments was 3.8 m, and for submersible embankments 1.87 m (Table A.9), and costs for full flood embankments are some Tk 10 million higher. But:

- Submersible embankments along the Lubha would be susceptible to large-scale erosion correspondingly high annual maintenance costs, because the Lubha is very flashy and has high peak velocities; and

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Table 7.1: Peak Water Levels With and Without Embankments

	15 May Water Levels (m)				Monsoon Flood Levels (m)			
	1:2	1:5	1:10	1:25	1:2	1:5	1:10	1:25
Without Embankments	9.93	11.08	11.6	12.0	12.83	13.1	13.21	13.31
With Embankment	9.17	10.26	10.69	10.96	11.77	12.08	12.22	12.33
Decrease	0.76	0.82	0.89	1.02	1.06	1.02	1.0	0.98

Source: NERP

Table 7.2: Flooded Areas — With and Without Embankments (1:2 year)

	Pre-Monsoon (ha)				Monsoon (ha)			
	F0	F1	F2	F3	F0	F1	F2	F3
Without Embankments	26000	5700	2200	6100	5000	6000	7000	22000
With Embankment	31600	4800	2000	1500	12800	5400	7900	13900

Source: NERP

- Full flood protection is expected to reduce flooding to the west of the Sylhet-Jaintiapur road by about a meter.

Also, the public stated that any flood protection on the Lubha's right bank would displace flooding to left bank areas and that this would be unacceptable, which indicates that flood protection must be provided to both banks of the Lubha or not at all (Figure B.7).

7.3.2 Expected Benefits and Achievement of Objectives

The proposed embankments combined with the regulator are expected to result in changes in land types to those shown in Table 7.3. These change in land type combined with preventing the entrace of flash flood water are expected to be associated with changes in area under different cropping patterns (Table 7.4). Projected crop production (Table 7.5) was determined based on these changes to the cropping patterns, and the assumption that present yield levels in the damage-free areas can be obtained throughout the project.

Table 7.3: FW Land Types

Land Type	Flood Depth (metres)	Gross Area		Cultivated Area	
		(ha)	(%)	(ha)	(%)
F0	0.0 - 0.3	11,660	29	7503	22
F1	0.3 - 0.9	6,540	16	5400	16
F2	0.9 - 1.8	7,900	20	7692	23
F3	> 1.8	13,900	35	13,300	39
Tot		**40,000**	**100**	**33,895**	**100**

Table 7.4: FW Cropping Patterns

Cropping Pattern	F0		F1		F2		F3		Total
	ha	%	ha	%	ha	%	ha	%	ha
b aman-fallow					3538	46	0	0	3538
fallow-l boro					2615	34	13034	98	15649
fallow-hyv boro	0	0	0	0	1538	20	266	2	1804
b aus-lt aman	1501	20	2700	50	0	0	0	0	4201
b aus-hyv aman	1125	15	0	0	0	0	0	0	1125
fallow-lt aman	4127	55	0	0	0	0	0	0	4127
lt aman-wheat	0	0	540	10	0	0	0	0	540
lt aman-potato	0	0	810	15	0	0	0	0	810
lt aman-rabi	0	0	1350	25	0	0	0	0	1350
lt aman-hyv boro	0	0	0	0	0	0	0	0	0
hyv aman-fallow	750	10	0	0	0	0	0	0	750
Total	**7503**		**5400**		**7692**		**13300**		**33895**

Table 7.5: FW Crop Production

Crop	Damage free area			Damaged Area			Total
	ha	t/ha	t	ha	t/ha	t	t
b aus	5326	1.3	6924				6,924
b aman	3538	1.75	6192				6,192
lt aman	11027	2.0	22055				22,055
hyv aman	1876	3.25	6096				6,096
l boro	15649	2.25	35211				35,211
hyv boro	1804	4.25	7669				7,669
wheat	540	1.75	945				945
potato	810	12.0	9720				9,720
pulses	202	0.8	162				162
oilseeds	675	0.7	472				472
spices	68	2.75	186				186
vegetables	405	4.5	1822				1,822

The project achieves the objectives stated in Section 7.2, subject to some qualifications:

- *Objective:* reduce flood damage to the boro crop. It is expected that the project will eliminate flood damage to this crop, increase l boro area by a few percent, and increase hyv boro area by about half. The production increases so gained amount to only 1800 tonnes per year, however. This is only about a fifth of total incremental paddy production, which is dominated by increases in monsoon-season production, in particular shifts from b aman to lt aman and an increase in hyv aman.

- *Objective:* avoid negative effects on fisheries, navigation, and wetland resources. It is expected that negative effects in these areas have been minimized, but not avoided entirely. Floodplain fisheries habitat would be reduced by 20%. Three major channels would remain open for navigation, but a fourth of possibly lesser importance would be closed. Winter wetland area (the area that can support natural wetland vegetation in winter) would be reduced by 87%, but summer wetland area (natural vegetation in summer) would be unaffected. Additional information is given in Section 7.8.

The production, per capita consumption, employment, and other impacts of these agricultural changes are discussed in Section 7.8, Evaluation, as are the project's other benefits and disbenefits.

7.3.3 Mitigation Measures Incorporated

To minimize potential negative impacts, the project was conceptualized such that three existing rivers (the Fatehganj, Lain, and Kushi Gang channels) entering the area remain unobstructed. The preliminary field investigation indicated that these channels variously serve as primary navigation routes into the area, they provide passage for fish entering the area, and they are the main drainage points. In accordance with the expressed wishes of the local community, no structures would be constructed across these channels.

To mitigate project-induced flooding impacts on people living outside the proposed project area, a short reach of the Lubha River left bank will need to be embanked. This embankment will be constructed from Satipur to the Lubha's outfall into the Surma River and will protect the Lakhipur area. There was a general consensus, which the analysis confirmed, that without the mitigation the project would increase flooding on about 800 ha of land in this area.

7.4 Operation

The operational requirements of the project will be minimal since the project is aiming only to provide controlled flooding. There is only one regulator — for drainage.

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. The client group would be composed of representatives from the local farming community, fishing community, and would include relevant Thana level technical officers. The group would be responsible to 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. The groups would be briefed periodically as the feasibility work was carried out and would need to confirm the conclusions of the exercise. They would also be informed as to details of designs being proposed by BWDB design engineers which designs, in the end, would require their approval. The groups would also monitor the construction program which would be carried out by BWDB.

7.6 Cost Estimate

The project's main physical components are 13 km of full flood embankments, 24 km of drainage channel re-excavation, one drainage regulator, and two closure dams (Tables A9 to A.11 and Figure B.7). The estimated capital cost is Tk 63.7 million while annual O&M cost is Tk 2.4 million. Details on physical components and capital and O&M costs are given in Table A.12.

7.7 Project Phasing and Disbursement Period

Three years are required to implement the project (Table 7.6). One year (year zero) is required for completion of feasibility studies, conducting field surveys and completion of designs. Land acquisition would be initiated in year one and be completed in year two. Embankment construction and canal re-excavation will start in year one and be completed in year two. Regulator

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construction would be started in year one and completed in year two. Project benefits would begin to accrue in year three.

7.8 Evaluation

A summary of salient data is provided in Table 7.12.

7.8.1 Environmental

Land Use
Land use changes are summarized in Table 7.7. A total of 18 ha of land (about 0.05% of the project gross area) will be required. Of this:

- 16 ha will be taken from cultivated area. Assuming average yields and that this is all under rice, this corresponds to incremental cereal production foregone of about 38 tonnes per year or about 0.5% of total incremental cereal production.

- 2 ha will be taken from homestead area. This is 0.2% of total homestead area, which implies that about 100 households or about 600 persons will be displaced. Also, homestead agricultural production from these sites will be lost. Roughly estimating homestead agrcultural production at Tk 1000 per decimal or Tk 200,000 per ha, this comes to Tk 0.4 million per year.

Agriculture
The project is expected to facilitate annual cereal production to increase from 75,482 tonnes (FWO) to 85,089 tonnes (FW), an increase of 9607 tonnes (13%), inclusive of the impacts of land use changes described above. The production increase implies a per person increase in cereal availability from 463 (FWO-2015) to 522 (FW-2015) gm per person per day (allowing 10% for seed, feed, and waste, and 65% for conversion of paddy

Table 7.6: Implementation Schedule

Activity	Year (% Completion)		
	0	1	2
Preconstruction Activities			
Feasibility Study	100		
Engineering Investigation	100		
Detail Designs	100		
Land Acquisition		50	50
Construction Activities			
Construction of Embankments		60	40
Excavation of Channels		40	60
Construction of Structures		30	70

Table 7.7:: Changes in Land Use

Use	Change in area (ha)
Cultivated	-16
Homesteads	-2
Beels	—
Ponds	—
Channels	—
Hills	—
Fallow[1]	—
Infrastructure[2]	+18

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

to rice; Table 7.8). Current Bangladesh average consumption is 440 gm per person per day.

Non-cereal production is expected to increase from 11,126 tonnes (FWO) to 12,363 tonnes (FW) (+11%). This results from an increase in area cultivated to potatoes, oilseeds, and vegetables. Availability of non-cereals is expected to increase from 68 (FWO-2015) to 76 (FW-2015) grams per person per day (Table 7.8).

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

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	709	705	522	463
Non-Cereals	108	102	76	68
Fish	16	11	8	10

Fisheries

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

The major system processes about which some insight exists are:

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

- Overwintering (dry season) habitat extent.

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

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

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

The foregoing is represented quantitatively here as:

FWO production =

$$(R_0 * P_{R0}) + (B_0 * P_{B0}) + (W_0 * P_{W0})$$

FW production =

$$[M * Q * (R_1 * P_{R0})] + [M * Q * (B_1 * P_{B0})] + [M * (W_1 * P_{W0})]$$

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 7.9. 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 7.9: Fisheries Parameters

Var	Value	Stnd value?	Comments
M	1.0	0.8	Migration routes remain open
Q	1.0	0.8	Lubha spills will be protected. Sedimentation will be reduced.
R_0	208		
R_1	249		
B_0	365		About 24km of silted up channel will be re-excavated which will provide water linkage with the central depression.
B_1	365		
W_0	33,052		
W_1	26,392		Decrease in flooded land along the Surma-Lubha River above Kanaighat. Little potential exists here for flood plain fishery.
P_{RO}	175	175	
P_{BO}	410	410	
P_{WO}	44	44	
A_M	—		

The floodplain habitat will be reduced by 6660 ha or 20% (Table 7.10). The total annual openwater fisheries production impact is -286 tonnes, which is 20% of the FWO annual production of 1640 tonnes. This implies an decrease in openwater-source fish availability per person due to the project from 10 (FWO) to 8 (FW) gm per person per day (included in Table 7.9).

It is expected that there will be increased incidence of fish disease though the impact is not quantifiable. The project is expected to lead to an intensification of agriculture and thus to an increase in the use of fertilizers and pesticides. Case studies in the area indicate that agricultural run-off water containing insecticides and fertilizer causes increased incidence of disease in fish.

The project will not disrupt carp breeding (as distinct from migration) since the declared fish sanctuaries (Sarigoyain and Lubha Rivers) are unaffected by project infrastructure.

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It is estimated that two person-days are required to capture one kilogram of fish on the flood plain, implying that project-related fishing employment losses would be about 0.58 million person-days per year.

Homestead flooding

Homestead flood damage would be reduced. Due to the lack of historical data on flood damage costs, a simple model was used to estimate future costs. There are an estimated 43,100 homesteads in the area, and the average plinth level is at about the 1:5 year flood level. About 25% of the homesteads are affected by flooding of 10-20 cm in the 1:10 to 1:25 year floods. The estimated annualized economic value of reduced flood damage is Tk 2.9 million.

Table 7.10: Floodplain Fishery Area Changes

Land Type	Floodplain Fisheries Area			
	FWO	FW	Change	%
F0	-	-	-	
F1	4,860	5,400	540	
F2	6,792	7,693	900	
F3	21,400	13,300	-8,100	
C/A ch			-18	
Total	33,092	26,392	-6,678	-20

C/A ch: change in cultivable area (see Table 7.7).

Winter Grazing Area and Wetland Habitats

Impacts are difficult to quantify, but a general impression is given by Table 7.11, which shows the impact on:

- "Winter grazing area." Defined as F0, F1, and F2 lands that lie fallow in the dry season (winter), plus any perenially-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 perenially-fallow lowlands (i.e. F4 land), beel, and channel areas. This land would likely have considerable residual moisture and could support sedge/meadow wetland plant species such as chhon.

- "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 increase "winter grazing area" significantly (+57%), and almost eliminate "winter wetland" (-87%) and have essentially no impact on "summer wetland".

There would be no impact on swamp forest trees. Evidently the reed swamp community does not currently exist within the project area; its dominant species are perennials adapted to ridges (kanda) in the lowland areas that are dry in winter and deeply flooded in summer.

Economic and employment impacts of the project on wetland production can only be very roughly estimated. Assuming an annual economic production of Tk 100 per hectare for both summer and winter wetland areas gives a total annual loss of Tk 0.5 million per year. The employment impact would be -2700 person-days per year, assuming that 0.5 pd $ha\text{-}yr^{-1}$ are required for harvesting.

Transportation/navigation
The project would eliminate flood damage from 19 km of roads. It is assumed that annualized flood damage is 15% of total capital costs.

As mentioned above in Sec. 7.3.3, the three main rivers (the Fatehganj, Lain, and Kushi Gang channels) entering the area will remain unobstructed, in accordance with the expressed wishes of the local community. Amri Khal will however be closed; some comments were received requesting that this channel be kept open for navigation. Re-excavation of the Kushi Gang was also requested; the project described here does not include this, but further investigation at feasibility may be warranted.

Higher Surma flood levels
There is a potential for cumulative impact on Surma flood levels. This would affect the project area, and also areas outside the it. In particular, a project to upgrade the Surma left bank embankment is also under consideration. Surma River water levels would be expected to rise if both projects are implemented and the Surma is confined to its channel. Depending on how far Surma water levels rise, the lowest parts of Sylhet town could be threatened with inundation. Preliminary analysis[1] indicates that water levels could rise on the order of 0.6 m in Kanaighat and 0.2 m at Syhlet town. While not serious, this may cause some difficulties, and if both projects are to be built, this estimate will need to be refined.

Table 7.11: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	884	7503	6,619	
sc/wf F1	2430	2700	270	
sc/wf F2	5434	3538	-1,896	
Fallow Highland	0	0	0	
Total	8748	13741	4993	57

Land Type	Winter Wetland			
sc/wf F3	5350	0	-5,350	-100
F4, Beel, Channel	823	823	0	0
Total	6173	823	-5,350	-87

Land Type	Summer Wetland			
wc/sf F1	0	0	0	
wc/sf F2	1358	4153	2,795	
wc/sf F3	16050	13300	-2,750	
F4, Beel, Channel	823	823	0	
Total	18,231	18,276	45	0

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.

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.

[1] Analysis was carried out using the MIKE 11 hydrodynamic model.

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Employment
There will be an overall increase in employment of 0.249 million person-days per year. This is composed of:

- an increase in owner-labour employment of 0.549 million pd yr^{-1}, of which very roughly 20% is post-harvest processing activities traditionally done by women of the household. This increase is partially cancelled out by . . .

- a decrease in employment opportunities for landless people of -0.30 million pd yr^{-1}, composed of changes in the following areas:

  - Agricultural hired labour: +0.282 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: -0.58 million pd yr^{-1}; of which about 10% is for support activities such as net-making and post-catch processing (mainly drying) much of which is done by women.

  - Wetland labour (gathering wetland products): -0.0027 million pd yr^{-1}. Fodder and building material is gathered mainly by men. Food, fuel, and medicine is gathered mainly by women.

Displacement impacts due to land use changes
Households whose homestead land is acquired, for proper cash compensation, by the project may have difficulty relocating. This is because suitable homestead lands are so scarce that availability of replacement land for purchase is not assured.

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

Conflicts
Ongoing conflicts between fisheries and boro rice cultivation will continue to be an issue, and should be investigated further during the feasibility study.

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

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

Table 7.12: Qualitative Impact Scoring

Qualitative Impact	Impact Sign	Sensitive	Magnitude	Immediate	Sustainable Pos Impact/ Irreversible Neg Impact	No Mitigation Required/ Possible	Score
		True=1 False=0					
Ecological Character of Bara Haor	-1	0	0	1	1	0	-2
Regional Biodiversity	-1	0	0	1	1	1	-3
Road Transportation	1	1	1	1	1	1	5
Navigation	-1	1	0	1	0	1	+3
Flood Levels Outside Project Area	1	0	0	1	1	0	-2
Conflicts	-1	1	1	0	0	0	-2
Socioeconomic Equity	-1	1	0	1	1	1	-4
Gender Equity	1	1	0	0	1	1	3

Who loses?

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

- Families involved in gathering wetland products. These families are mainly landless and tend to be very poor. However, this is also true without the project. *Regressive.*

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

Gender Equity
The net equity impact would appear to be somewhat *progressive*. Employment opportunities for women overall will increase, though this is net of an increase in employment for women in landowning households and a decrease in employment for women in laboring households. Reduced homestead flood damage will disproportionately favour women, given that most women still spend most of their lives within the homestead. By the same token, the adverse effects of acquisition of homestead land may fall mainly on the women in those households.

Notes on 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 7.12. The scoring procedure is analagous to that used in the FAP 19 EIA case studies, but simplified to eliminate half-point scores (1.5, 2.5, 3.5, etc). Here, each score sums across five equally weighted logical (true/false) criteria, with each 'true' counting for a value of one and each "false" for zero. The sign reflects whether the impact is positive or negative.

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7.8.3 Economic

The project has an economic rate of return of 47%, which well above the required rate of 12% prescribed by government. It is a relatively small investment project, at Tk 66 million or Tk 1951 per hectare, and it covers a large geographic area (40,000 ha gross). The rate of return is most sensitive to delayed benefits, with a 2 year delay reducing the rate of return to to 31%. The next most sensitive variable is value of benefits, with a 20% decrease reducing the rate of return to 42%.

Foreign costs associated with the project are low at 7% (excluding FFW contributions), making it a very small project from a donor perspective.

Almost all of the benefits of the project relate to a 13% increase in rice production, mostly resulting from shifts from b aman to lt aman, and from local aman and boro varieties to hyvs. Non-cereal production would increase by 11%. Average crop yields would increase as a result of reduced flood damage. Floodplain fish production would fall by about 20% of future-without-project production. The value of the lost fisheries output amounts to about 15% of the value of increased agricultural output. About 10% of project benefits would result from reduced homestead flooding. A small amount of disbenefits would result from loss of food, shelter, and tree products that are currently harvested from the seasonal wetlands. A summary of salient data is provided in Table 7.13.

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

A significant caution is that the economic benefits are based largely on assumed shifts in cropping patterns, and if these did not occur, the project would not be viable. Lessons of the past have shown that producers have not always responded as predicted, in particular monsoon season agriculture, the source of most of this project's benefit stream, seems not to benefit from flood control as much as expected. Particular efforts should be made to verify whether producers are indeed likely to respond as described here.

7.8.4 Summary Analysis

From a multi-criteria perspective (Table 7.14), the project has a number of negative attributes:

- Benefits derive almost entirely from increased monsoon-season rice production, at the expense of fisheries and wetlands.
- Hired labor employment, especially in fishing, will be reduced.
- A small number of households would lose homestead land to project land acquisition.
- The ecological character of Baro Haor — a wetland of mainly local importance — would be altered.
- Surma flood levels would increase, if the Surma Left Bank project is also constructed.
- Conflicts between farmers and fishermen would increase.

- The project has a high dependency on central government for implementation.

The positive aspects of the project would be:

- Rate of return is very high.
- Moderate increase in rice production.
- Increased economic returns to land owners.
- Owner labor employment will increase.
- Reduced flood damage to homesteads and roads.
- Small increment in non-cereal production.
- Gender equity of impacts is somewhat progressive.
- Project responds to public concerns.

Table 7.12: Summary of Salient Data

Economic Rate of Return (ERR)	47%			
Capital Investment (Tk million)	66			
Maximum O+M (Tk million / yr)	2			
Capital Investment (Tk/ha)	1951			
Foreign Cost Component	7%			
Net Project Area (ha)	33895			
Land Acquisition Required (ha)	18			

AGRICULTURAL IMPACTS		**Present**	**FWO**	**FW**
Incremental Net Econ Output (Tk million / yr)	42			
Cropping Intensity		1.2	1.2	1.2
Average Yield (tonnes/ha)		2.2	2.2	2.3
Average Gross Margins (Tk/ha)		12339	12318	12818
Owner Labour (md/ha)		118	117	123
Hired Labour (md/ha)		24	24	29
Irrigation (ha)		2998	2998	3627
Incremental Cereal Prod'n (' 000 tonnes / yr)	10			
Incremental Non-Cereal (' 000 tonnes / yr)	1			
Incremental Owner Labour (' 000 pd / yr)	549			
Incremental Hired Labour (' 000 pd / yr)	282			

FISHERIES IMPACTS		**Flood plain**	**Beels**	**Spawning**
Incremental Net Econ Output (Tk million / yr)	-6.43	-6.75	0	0.32
Impacted Area (ha)		6660	0	41
Average Gross Margins (Tk/ha)		1540	28700	12250
Remaining Production on Impacted Area, %		0%	100%	100%
Incremental Fish Production (tonnes / year)		-286	0	7
Incremental Labour ('000 pd / yr)	-0.58			

FLOOD DAMAGE BENEFITS				
Households Affected		10778		
Reduced Econ Damage Households (Tk M / yr)	4			
Roads/Embankments Affected -km		19		
Reduced Econ Damage Roads (Tk M / yr)	0.4			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	-0.5			
Wetland Incremental Labour ('000 pd / yr)	-2.7			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	-3			
Persons Displaced by Homestead Acquisition	600			

Table 7.14: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	47
EIRR, Increase Capital Costs by 20%	per cent	42
EIRR, Delay Benefits by Two Years	per cent	31
EIRR, Fisheries reduced by 20%	per cent	42
Net Present Value	Tk '000	156,985

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	9607	+13
Incremental Non-Cereal Production	tonnes	1237	+11
Incremental Fish Production	tonnes	-268	-20
Change in Floodplain Wetland/Fisheries Habitat	ha	-5350	-87
Homesteads Displaced Due to Project Land Acquisition	homesteads	100	0.2
Homesteads Protected From Floods	homesteads	11000	100
Roads Protected From Floods	km	19	100
Surma Flood Levels (if Surma Left Bank Project also built)	m PWD	0.6	
Owner Employment	'000 pd/yr	+549	
Hired Employment (Agri+Fishing+Wetland)	'000 pd/yr	+249	

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

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

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

ANNEX A: TABLES

Annex A: Table of Contents

Table A.1: Project Area Population

Thana	Area (km^2)	No. of Villages	No. of Households	Project Population			Population Density (per km^2)
				Male	Female	Total	
Sylhet Sadar	41.38	52	6893	22,193	20,884	43,077	1041
Gowainghat	32.28	18	1883	6,064	5,706	11,770	365
Jaintiapur	159.95	133	9020	29,044	27,331	56,375	353
Kanaighat	279.68	198	20436	65,805	61,921	127,727	457
Golapganj	34.15	32	4878	15,707	14,781	30,488	893
Total	547.44	433	43110	138,813	130,624	269,437	492

Source: NERP estimates based on 1981 and 1991 Population Census (BBS)

Table A.2: Land Ownership Distribution (% by Holding Category)

Thana	No Cultivable Land	0 - 0.2 ha	0.2 - 1 ha	1 - 3 ha	<3 ha	Total
Sylhet Sadar	24.3	47.0	13.0	12.8	2.9	100
Gowainghat	28.9	19.6	21.3	24.0	6.2	100
Jaintapur	18.3	27.0	22.2	24.9	7.6	100
Kanighat	12.1	36.1	23.5	22.2	6.1	100
Golapgonj	17.2	38.7	24.0	16.1	4.0	100

Source: BBS, 1983/84 Agricultural Census

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Table A.3: Climate

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature °C												
Maximum	27.6	30.9	34.1	34.9	35	34.8	34.5	34.8	34.6	33.6	31.9	28.8
Minimum	9.2	9.7	13.5	17.2	19.2	21.5	22.8	22.9	22	19.1	14.6	10.6
Average	18.7	20.5	24.3	25.6	26.6	27.6	27.7	28.1	27.6	26.5	23.5	20
Relative Humidity												
Max	86	84	86	91	94	97	97	96	96	96	90	88
Min	59	51	46	57	68	75	78	76	75	73	66	64
Ave	72	65	65	76	82	87	89	87	87	83	77	75
Sunshine Hours												
(Hrs/Day)	8.6	8.9	8.3	7.0	6.5	4.1	3.7	4.7	5.1	7.6	8.5	8.6
Wind Speed												
(m/hrs)	2.07	2.12	2.49	2.29	2.13	2.15	1.99	1.96	1.73	1.8	1.83	1.75
Potential Evapotranspiration[1/]												
(mm/day)	3.41	4.44	5.24	5.24	4.95	4.17	4.03	4.21	4.05	4.14	3.82	3.31

Source: *BMD*
1/ NERP

Table A.4
Area - Elevation and storage volume

EL (m,PWD)	Area (ha)	Storage (ha-m)
5.03	103.57	0.00
5.50	103.57	48.68
6.00	310.71	103.57
6.50	517.85	207.14
7.00	1967.84	621.42
7.50	3003.54	1242.84
8.00	3624.96	1657.12
8.50	6628.50	2563.37
9.00	8596.34	3806.21
9.50	10460.60	4764.23
10.00	14369.24	6214.22
10.50	18331.94	8182.05
11.00	22681.90	10253.46
11.50	27238.99	12480.22
12.00	29828.25	14266.81
12.50	33349.64	15794.47
13.00	35938.90	17322.13
13.50	37285.31	18306.05
14.00	37699.59	18746.23
14.50	38631.73	19082.83
15.00	38942.44	19393.54
15.50	38942.44	19471.22
16.00	39356.72	19574.79
16.50	39460.29	19704.25
17.00	39460.29	19730.14
17.50	39563.86	19756.04
18.00	39563.86	19781.93
18.50	39563.86	19781.93
19.00	39563.86	19781.93
19.50	39563.86	19781.93
20.00	39563.86	19781.93
21.50	39563.86	19781.93
22.00	39563.86	19781.93
23.50	39563.86	19781.93
24.00	39563.86	19781.93
24.50	39563.86	19781.93
25.00	39667.43	19807.93
25.50	39667.43	19833.71
26.00	39667.43	19833.71
26.50	39667.43	19833.71
27.00	39667.43	19833.71
27.50	39667.43	19833.71
28.00	39667.43	19833.71
28.50	39667.43	19833.71
29.00	39667.43	19833.71
29.50	39667.43	19833.71
30.00	39667.43	19833.71
30.50	39667.43	19833.71
31.00	40081.71	20040.85
31.50	40081.71	20040.85
32.00	40081.71	20040.85
32.50	40081.71	20040.85
33.00	40081.71	20040.85
33.50	40081.71	20040.85
34.00	40081.71	20040.85
34.50	40081.71	20040.85
35.00	40081.71	20040.85
35.50	40081.71	20040.85
36.00	40081.71	20040.85
36.50	40081.71	20040.85
37.00	40081.71	20040.85
37.50	40081.71	20040.85
38.00	40081.71	20040.85
38.50	40081.71	20040.85
39.00	40081.71	20040.85
39.50	40081.71	20040.85
40.00	40081.71	20040.85
40.50	40081.71	20040.85
41.00	40081.71	20040.85
41.50	40081.71	20040.85
42.00	40081.71	20040.85
42.50	40081.71	20040.85
43.00	40081.71	20040.85
43.50	40081.71	20040.85
44.00	40081.71	20040.85
44.50	40081.71	20040.85
45.00	40081.71	20040.85
45.50	40081.71	20040.85
46.00	40081.71	20040.85
46.50	40081.71	20040.85
47.00	40081.71	20040.85
47.50	40081.71	20040.85
48.00	40081.71	20040.85
48.50	40081.71	20040.85
49.00	40081.71	20040.85
49.50	40081.71	20040.85
50.00	40081.71	20040.85
50.50	40081.71	20040.85
51.00	40081.71	20040.85
51.50	40081.71	20040.85
52.00	40081.71	20040.85
52.50	40081.71	20040.85
53.00	40081.71	20040.85
53.50	40081.71	20040.85
54.00	40081.71	20040.85
54.50	40081.71	20040.85
55.00	40081.71	20040.85
55.50	40081.71	20040.85
56.00	40081.71	20040.85
56.50	40081.71	20040.85
57.00	40081.71	20040.85
57.50	40081.71	20040.85
58.00	40081.71	20040.85
58.50	40081.71	20040.85
59.00	40081.71	20040.85
59.50	40081.71	20040.85
60.00	40081.71	20040.85
60.50	40081.71	20040.85
61.00	40081.71	20040.85
61.4	40185.28	20066.75

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Table A.5: Mean Monthly Discharges (m^3/sec)

Gauge 251 SARIGOYAIN at Sarighat

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Minimum	5.2	27.6	93.8	176.1	155.2	90.4	32.9	11.6	7.8	5.2	4.1	4.3
Mean	69.3	146.1	294.6	387.7	281.2	212.0	98.9	21.7	12.7	7.7	6.6	14.8
Maximum	164.9	303.0	555.5	563.1	431.5	391.8	286.5	59.2	52.1	12.1	17.8	59.6

Gauge 266 SURMA at Kanaighat

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Minimum	6.0	107.4	385.5	981.3	750.4	504.9	162	13.9	8.2	5.0	2.8	2.7
Mean	227.4	479.3	1064.6	1428.2	1273.5	1031.2	551.8	119.2	25.0	8.6	6.4	37.5
Maximum	621.3	961.1	2239.0	1903.9	1960.3	1724.0	1300.8	506.7	105.8	17.9	17.0	231.9

Gauge 267 SURMA at Sylhet

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Minimum	31.6	107.8	318.9	1038.9	825.9	554.0	211.6	19.6	6.6	4.5	4.2	3.9
Mean	238.1	489.9	1109.8	1471.3	1322.8	1074.7	614.5	130.2	32.9	11.9	7.8	36.2
Maximum	677.6	933.3	1829.3	1918.7	1667.1	1447.2	1302.4	406.6	123.5	33.0	22.8	193.4

Table A.6: Estimation of Flood Levels and Improvements

15 May Peak Water Levels; mPWD

Station	1:2	1:5	1:10	1:25
Sarighat : #251	11.31	12.53	13.03	13.43
Sarigoyain: #252	8.88	10.22	10.81	11.08
Salutikar : #252.1	7.75	8.65	8.96	9.18
Kanaighat : #266	11.36	12.73	13.25	13.65
Sylhet : #267	8.75	9.64	9.94	10.14
Lubha : #326	11.54	12.7	13.45	14.4
Average Six Stations:	9.93	11.08	11.57	11.98
Ave without #266 & #326	9.17	10.26	10.69	10.96
Improvement	0.76	0.82	0.89	1.02

Annual Flood Level; mPWD

Station	1:2	1:5	1:10	1:25
Sarighat : #251	13.51	13.8	13.91	14
Sarigoyain: #252	11.71	12.05	12.19	12.32
Salutikar : #252.1	10.64	10.95	11.08	11.18
Kanaighat : #266	14.63	14.85	14.92	14.97
Sylhet : #267	11.22	11.53	11.68	11.82
Lubha : #326	15.27	15.42	15.49	15.55
Average Six Stations:	12.83	13.10	13.21	13.31
Ave without #266 & #326	11.77	12.08	12.22	12.33
Improvement	1.06	1.02	1.00	0.98

Table A.7: Mean Monthly Water Levels, mPWD

Gauge 251 SARIGOYAIN at Sarighat

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Minimum	5.842	6.39	8.198	10.458	9.65	8.617	6.74	5.992	5.8	5.702	5.614	5.584
Mean	7.282	8.752	10.546	11.292	10.69	10.066	8.446	6.404	5.997	5.817	5.751	5.967
Maximum	9.046	11.224	12.062	11.989	11.541	11.185	10.087	7.041	6.845	6.117	6.203	7.532

Gauge 252.1 SARIGOYAIN at Salutikar

Minimum	2.12	4.67	5.98	8.88	8.44	7.46	5.94	4.18	2.79	1.91	1.48	1.4
Mean	4.36	6.5	8.56	9.57	9.22	8.68	7.25	5	3.49	2.34	1.84	2.02
Maximum	6.77	8.46	9.98	10.11	9.9	9.91	8.79	7.09	4.74	3.28	2.61	3.71

Gauge 252.1 SARIGOYAIN at Goyainghat

Minimum	2.5	4.69	6.71	9.69	9.12	7.98	6.14	4.16	2.99	2.25	2.06	2.07
Mean	5.13	4.2	9.41	10.47	9.98	9.36	7.67	5.09	3.66	2.71	2.39	2.57
Maximum	8.23	9.28	10.98	11.09	10.6	10.42	9.48	6.18	4.94	3.44	3.11	4.57

Gauge 266 SURMA at Kanaighat

Minimum	4.43	5.97	7.79	11.41	10.83	9.4	7.45	4.96	4.5	4.34	4.07	3.97
Mean	6.72	8.66	11.59	13.11	12.51	11.65	9.57	6.27	5.02	4.57	4.44	4.75
Maximum	10.12	11.34	14.06	14.11	14.01	13.21	12.41	9.46	6.26	4.92	5.03	6.74

Gauge 267 SURMA at Sylhet

Minimum	2.64	4.85	6.18	9.28	8.98	7.87	6.3	4.09	2.95	2.36	2.07	2.03
Mean	4.94	6.98	9.18	10.3	9.93	9.37	7.8	5.15	3.62	2.73	2.47	2.84
Maximum	8.13	8.96	10.79	10.95	10.76	10.47	9.82	7.18	5.01	3.14	3.34	4.65

Table A.8: Water Balance

	Unit	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Rainfall	mm	16	38	145	473	569	1112	1058	702	517	210	40	11
Storage	ha-m	640	1520	5800	18920	22760	44480	42320	28080	20680	8400	1600	440
Data :													
ETO	mm	105.62	124.4	162.42	157.12	153.41	124.95	125.05	130.6	121.49	128.38	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
Lossess:													
Boro 19000 ha	ha-m	2408	2955	3857	3582								
Aus 4700 ha	ha-m				886	793	646	558					
Aman 19000 ha	ha-m								2730	2539	2683	2393	1121
ETO (natural)	ha-m	2218	2612	3411	2514	5369	4373	4377	3017	2806	2966	2645	2479
Deep Percolation	ha-m	2480	2240	2480	2400	1240	1200	0	0	0	0	0	1240
Total Loss:	ha-m	7106	7807	9748	9382	7402	6219	4935	5746	5346	5649	5038	4840
Accumulated Storage	ha-m	-6466	-6287	-3948	9538	15358	38261	37385	22334	15334	2751	-3438	-4400

Note: Accumulated storage is total volume without drainage. Negative values imply no storage.

Table A.9: Surma Lubha Embankment Design (Length 10km)

Design Parameter	Full Flood Embankment (Data)	Partial Flood Embankment (Data)
Peak Water Level Frequency	1:25 years	1:10 year
Freeboard	1.52 m	1.52 m
Confinement	50 cm	50 cm
Design Crest Level		
at Kanaighat	17.0 mPWD	15.27 mPWD
at Lubha Tea Garden	17.6 mPWD	15.47 mPWD
Average Crest Level	17.3 mPWD	15.37 mPWD
Average Ground Level	13.5 mPWD	13.5 mPWD
Average Embankment Height	3.8 m	1.87 m
Crest Width	4.27 m	4.27 m
Side Slopes	1:2 & 1:3	1:2 & 1:3

Table A.10: Lubha Left Embankment Design (3km length)

	Design Data
Peak Water Level Frequency	1:25 year return period
Freeboard	1.52 m
Confinement	50 cm
Design Crest Level	
at Lakhipur	17.45 m PWD
at Satipur	17.60 m PWD
Average Crest Level	17.52 m PWD
Average Ground Level	14.20 m PWD
Average Height of Embankment	3.32 m PWD
Crest Width	4.27 m PWD
Side Slopes	1:2 country side; 1:3 river side

Table A.11: Drainage Channel Design

	Length
Kushi Gang	9 km
Nawa Gang	8 km
Amri Khal Branch	7 km

Table A.12: Estimated Capital and O&M Costs

Iteam of Works	Quantity		Unit Price		Capital Cost (mtk)	O&M Costs (%)	O&M Costs (mtk)
Surma-Lubha embankment; 10 km	502000	m3	25.66	tk/m3	10.3	6	0.62
Lubha left embankment; 3 km	188000	m3	25.66	tk/m3	4.8	6	0.29
Fine dressing and turfing	255000	m2	2.27	tk/m2	0.6	6	0.03
Closures; 2	15000	m3	33.02	tk/m3	0.5	6	0.03
Drainage channel re-excavation	24	km	0.87	mtk/km	20.9	3	0.63
Regulator (1-vent; 5'*6')	1		3.5	mtk	3.5	2	0.07
Project Buildings	-		-		-	-	-
Sub-Total:					40.6		1.67
Physical contingency 25%					10.1		0.42
Sub-Total:					50.7		2.09
Eng & Admin 15%					7.6		0.31
Land Acquisition	18	ha	0.3	mtk/ha	5.4		-
Total:					63.7		2.40

ANNEX B: FIGURES

Annex B: Table of Contents

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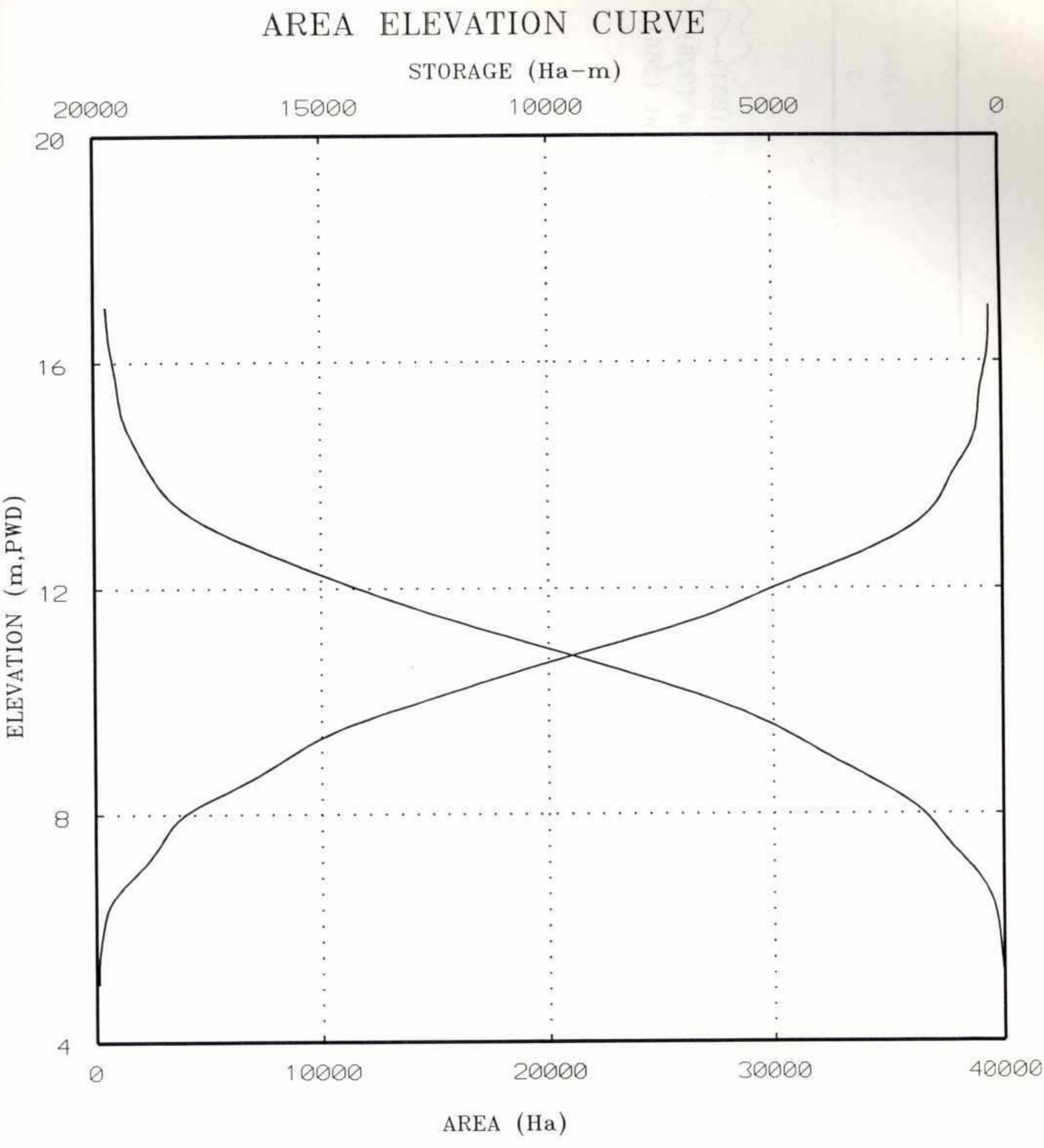
Figure 1


AREA ELEVATION CURVE
STORAGE (Ha-m)
20000
15000
10000
5000
0
20
16
12
8
4
ELEVATION (m,PWD)
0
10000
20000
30000
40000
AREA (Ha)

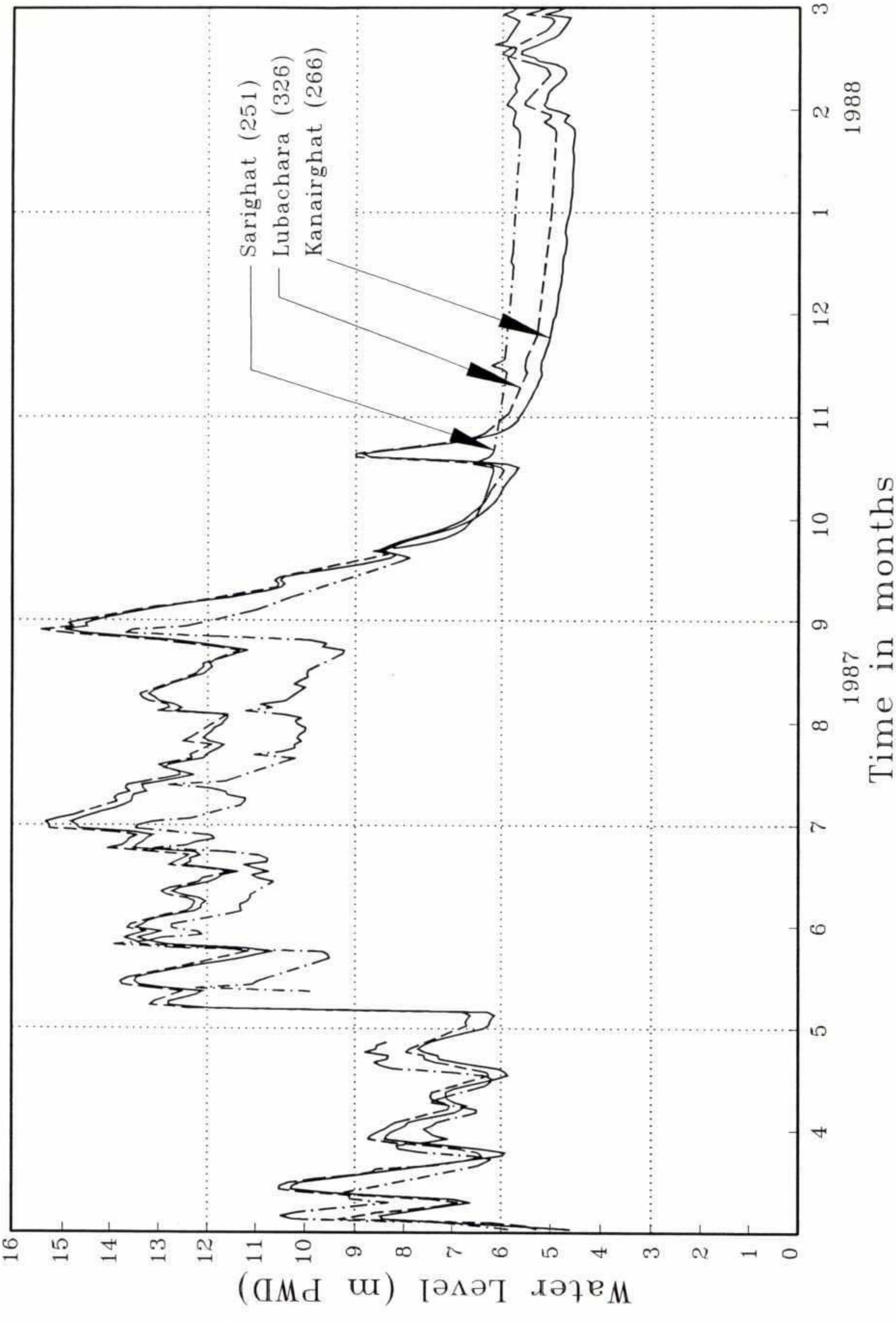
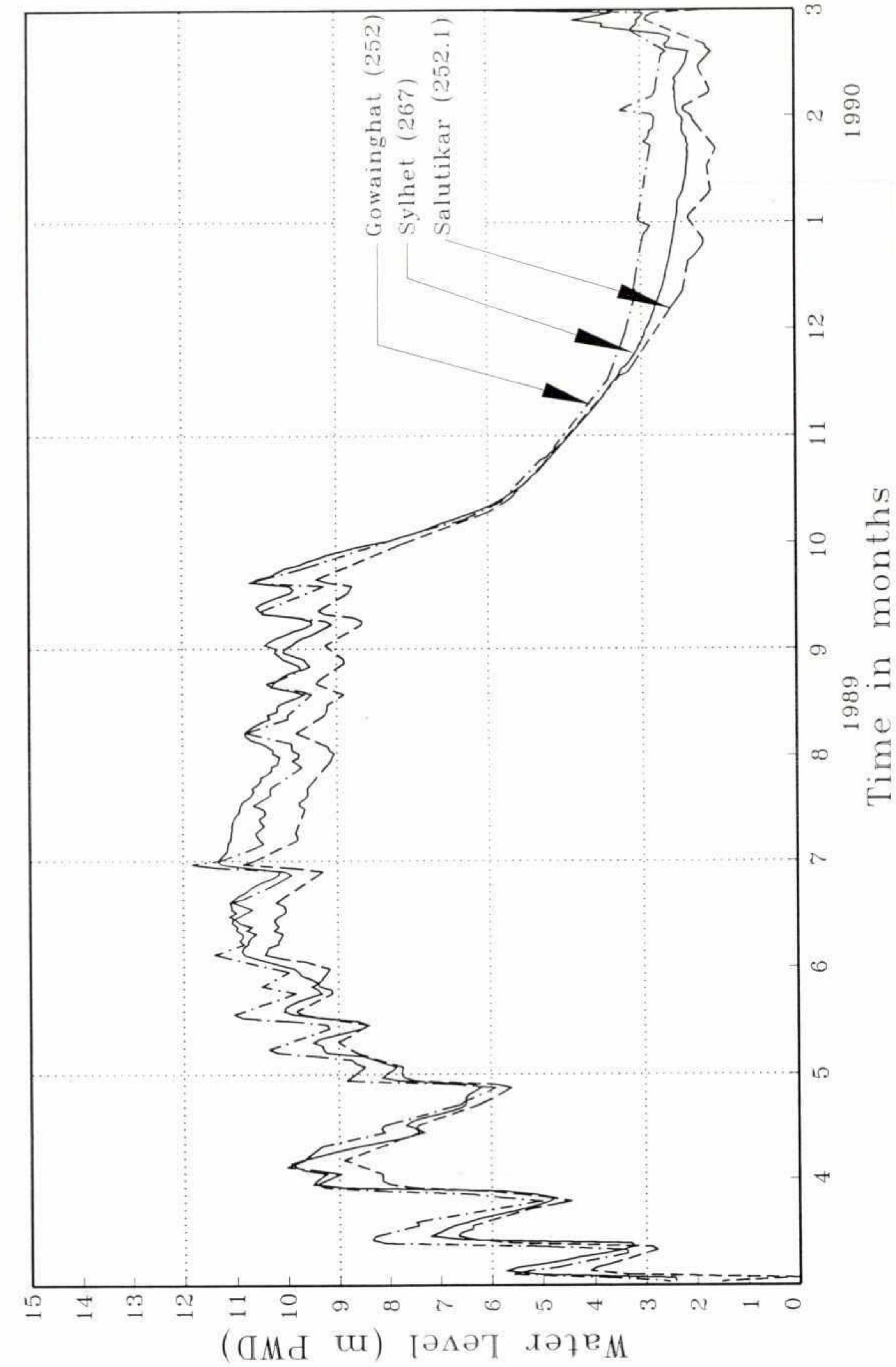

Sarighat (251)
Lubachara (326)
Kanairghat (266)
Water Level (m PWD)
Time in months
1987
1988

Figure 3


Gowainghat (252)
Sylhet (267)
Salutikar (252.1)
Water Level (m PWD)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
4
5
6
7
8
9
10
11
12
1
2
3
1989
1990
Time in months

70

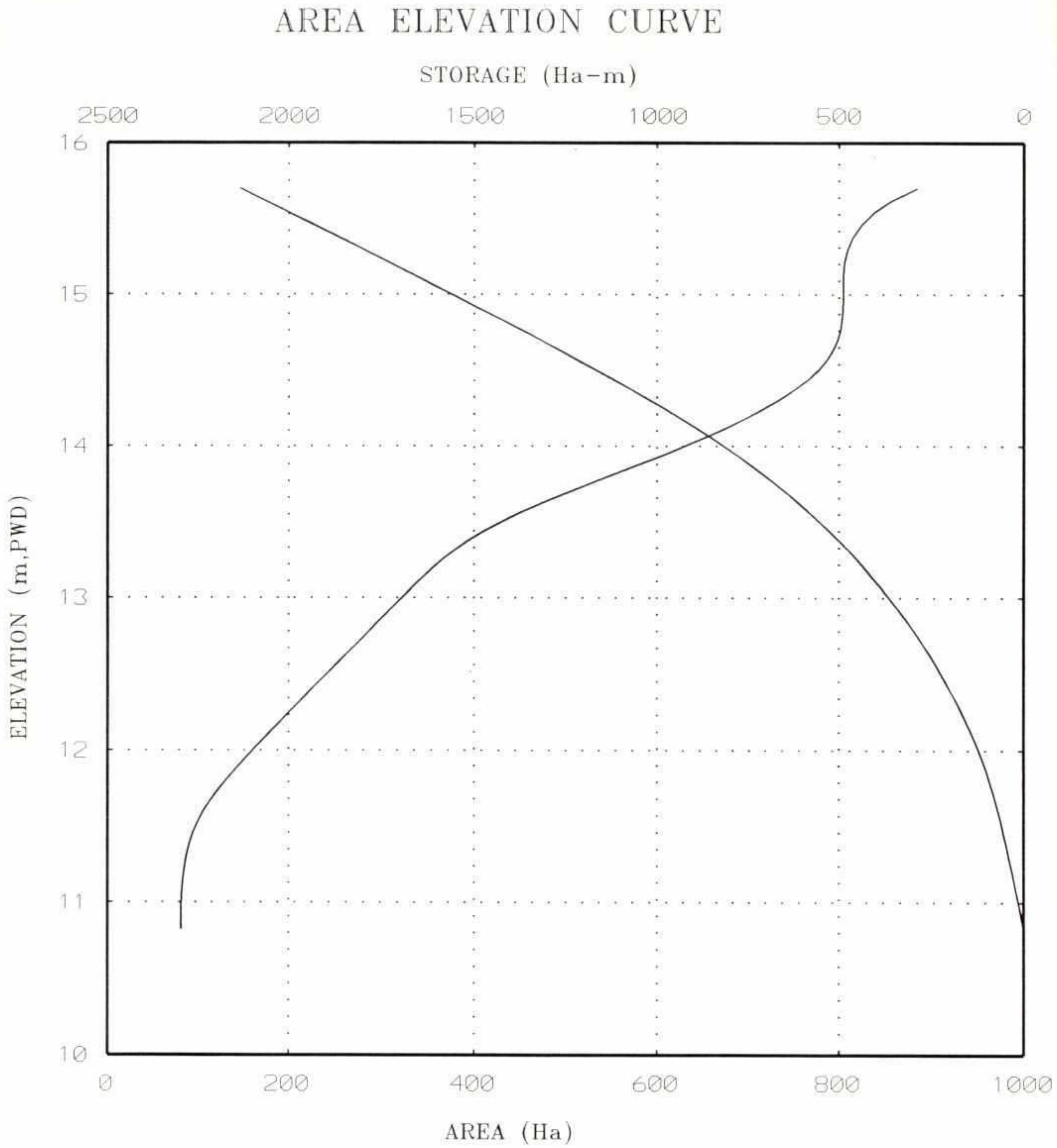

AREA ELEVATION CURVE
STORAGE (Ha-m)
2500
2000
1500
1000
500
0
16
15
14
13
12
11
10
ELEVATION (m,PWD)
0
200
400
600
800
1000
AREA (Ha)

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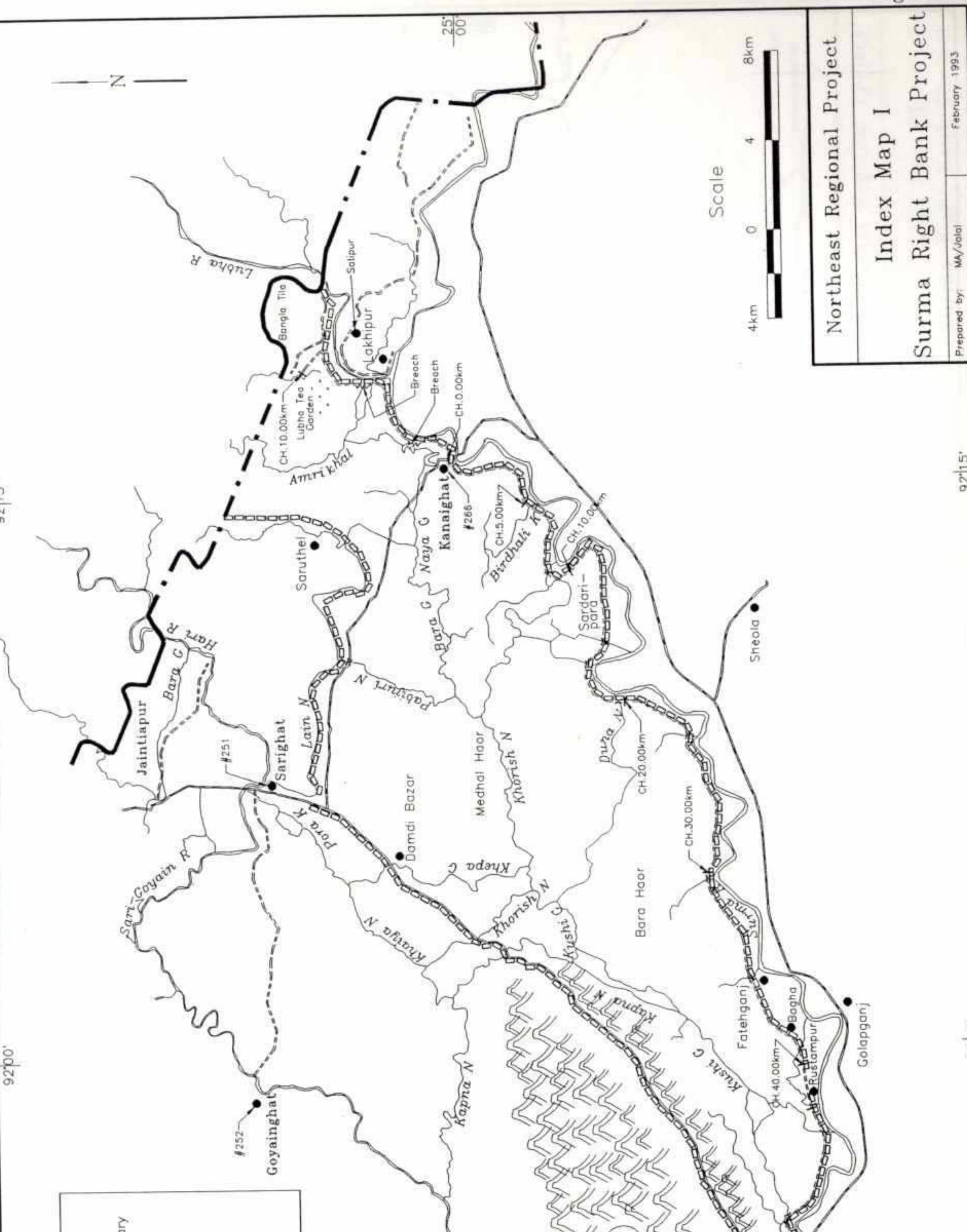
Figure 5



Northeast Regional Project
Index Map I
Surma Right Bank Project
Prepared by: MA/Jalal
February 1993
Scale
4km
0
4
8km
N
LEGEND
International Boundary
River/Khal
Metalled Road
Unmetalled Road
Railway
Project Boundary
Breach
#251
Hydrological Station
25°00'
92°15'
92°00'
Lubha R
Satipur
Bangla Tila
Lakhipur
Breach
Breach
Lubha Tea Garden
CH.10.00km
CH.0.00km
Amri Khal
Kanaighat
#266
CH.5.00km
Birdhali K
CH.10.00km
Naya G
Saruthel
Bara G
Sardari-para
Hari R
Bara G
Jaintiapur
Pabijuri N
Lain N
Sarighat
#251
Medhal Haor
Khorish N
Dupa K
CH.20.00km
Sheola
CH.30.00km
Damdi Bazar
Pora K
Sari-Goyain R
Khapa G
Khatiya N
Khorish N
Kushi G
Bara Haor
Surma
Kapna K
Fatehganj
Bagha
Golapganj
Rustampur
CH.40.00km
Kushi G
Goyainghat
#252
Kapna N
Hill
Hill
Sonapur
CH.50.00km
Sylhet
#267
Sari-Goyain R
Salutikar
#252.1
Sadi K
FILE: NERP-094.DWG

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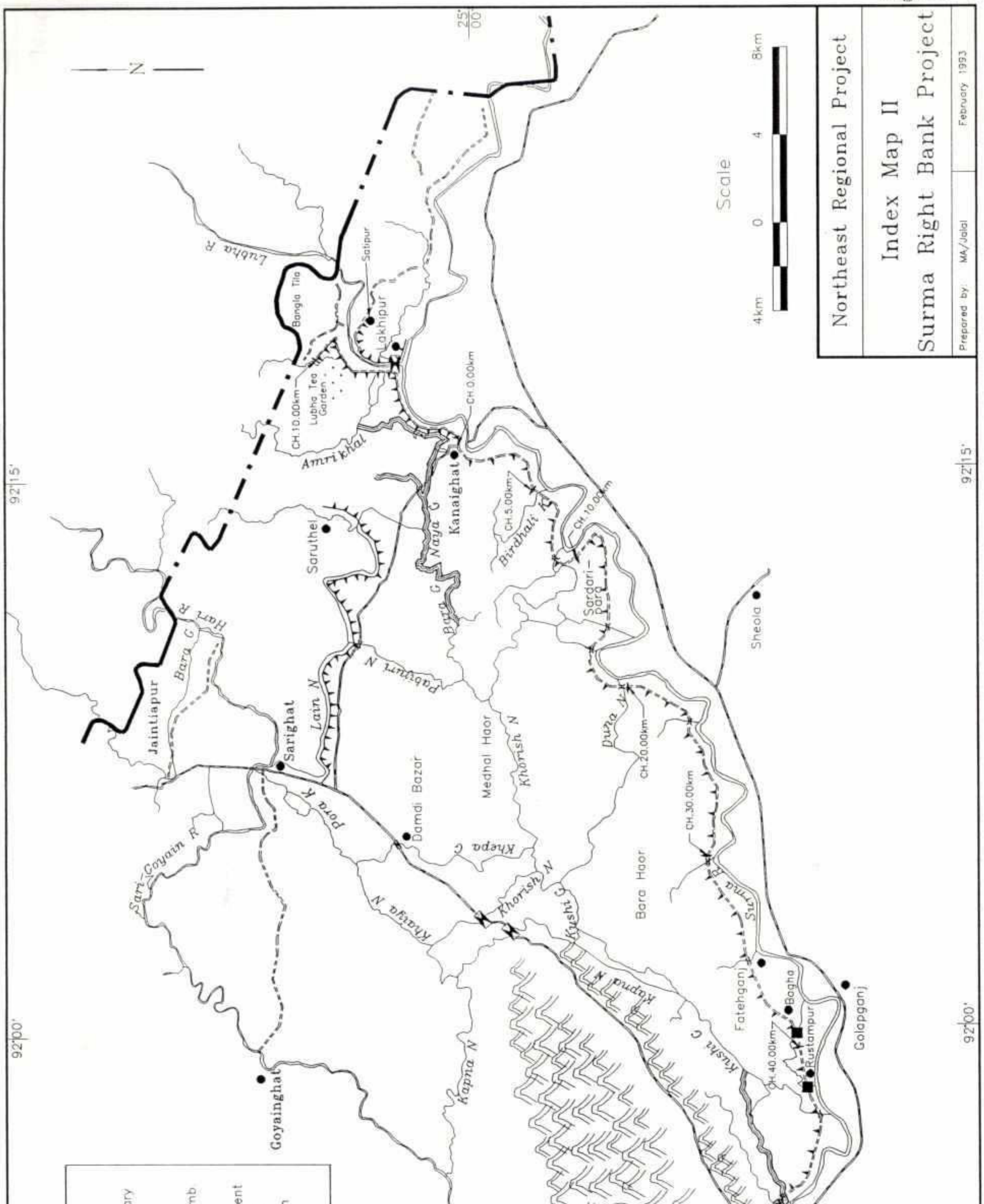
Northeast Regional Project
Index Map II
Surma Right Bank Project
Prepared by: MA/Jalal
February 1993
Scale
4km 0 4 8km
N
LEGEND
International Boundary
River/Khal
Metalled Road
Unmetalled Road/Emb
Railway
Proposed Embankment
Proposed Regulator
Proposed Excavation
Proposed Closure
Lubha R
Bangla Tila
Satipur
Lakhipur
Lubha Tea Garden
CH.10.00km
CH.0.00km
Amri Khal
Kanaighat
Naya G
CH.5.00km
Birdhali K
CH.10.00km
Saruthei
Sardari-para
Sheola
Hari R
Bara G
Bara G
Jaintiapur
Sarighat
Lain N
Pabijuri N
Medhal Haor
Khorish N
Duna N
CH.20.00km
Damdi Bazar
Pora K
Khepa G
CH.30.00km
Sari-Goyain R
Khaiya N
Khorish N
Kushi G
Bara Haor
Surma R
Kapna N
Kapna N
Fatehganj
Bagha
Golapganj
Rustampur
CH.40.00km
Kushi G
Goyainghat
Hill
Hill
Sonapur
CH.50.00km
Sylhet
Sari-Goyain R
Salutikar
Sadi K
92°00'
92°15'
25°00'
FILE: NERP-D9.1.DWG

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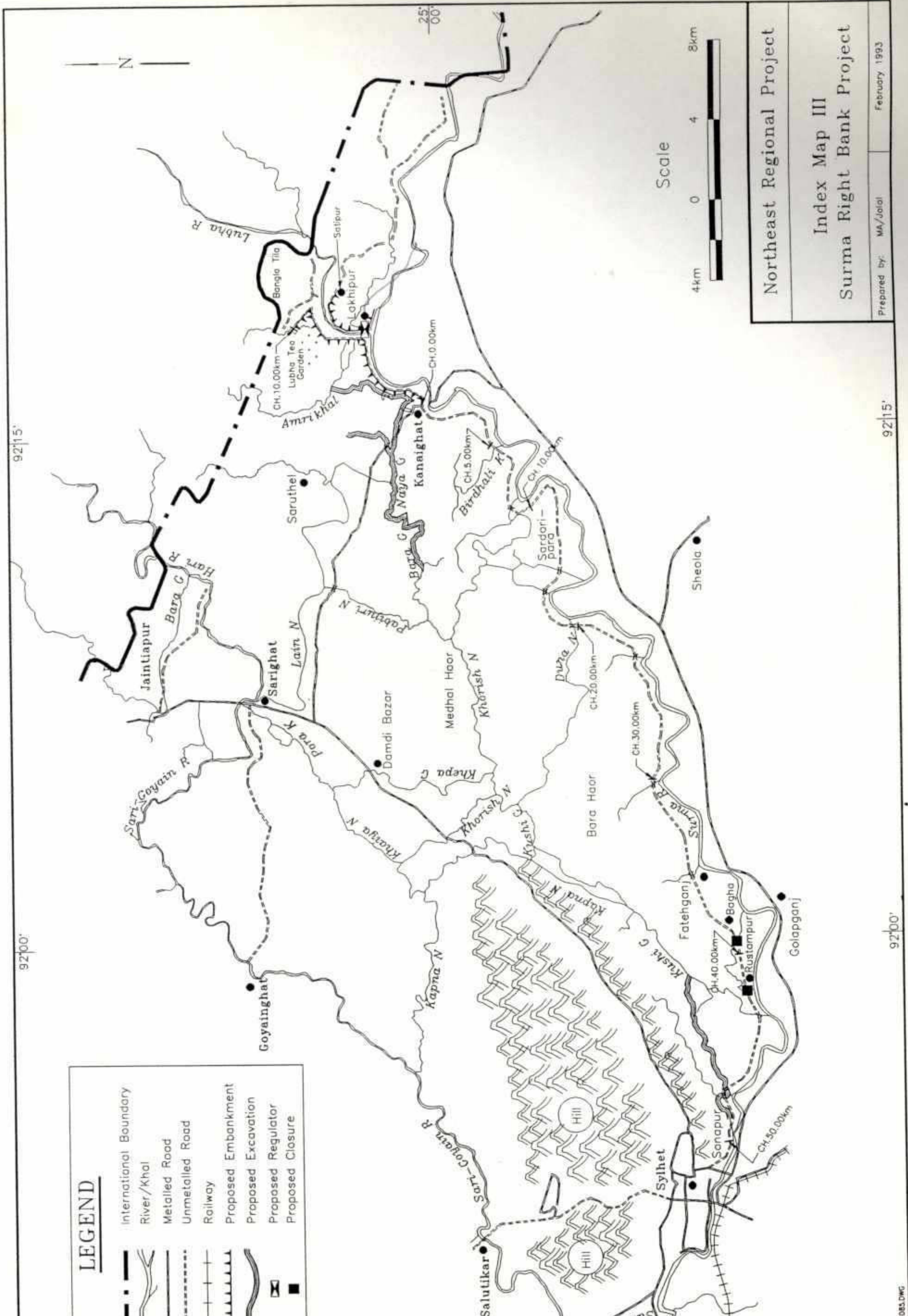
Figure 7



N
25° 00'
92° 15'
92° 00'
LEGEND
International Boundary
River/Khal
Metalled Road
Unmetalled Road
Railway
Proposed Embankment
Proposed Excavation
Proposed Regulator
Proposed Closure
Scale
4km
0
4
8km
Northeast Regional Project
Index Map III
Surma Right Bank Project
Prepared by: MA/Jalal
February 1993
FILE: NERP-083.DWG
Lubha R
Bangla Tila
Satipur
Lakhipur
Lubha Tea Garden
CH.10.00km
CH.0.00km
Amrikhal
Kanaighat
Naya G
Saruthel
CH.5.00km
Birdhali K
CH.10.00km
Hari R
Bara G
Jaintiapur
Sarighat
Lain N
Pabijuri N
Sardari-para
Sheola
Medhal Haor
Khorish N
Dura N
CH.20.00km
Damdi Bazar
Pora K
Khepa G
Sari-Goyain R
CH.30.00km
Bara Haor
Khorish N
Kushi G
Surma R
Khaiya N
Kapna N
Fatehganj
Bagha
Golapganj
Goyainghat
Kapna N
Rustampur
CH.40.00km
Kushi G
Hill
Sari-Goyain R
Sonapur
CH.50.00km
Sylhet
Salutikar
Hill
Sadi K

ANNEX C

INITIAL ENVIRONMENTAL EXAMINATION

ANNEX C: INITIAL ENVIRONMENTAL EXAMINATION

C.1 Introduction

This Initial Environmental Examination (IEE) (pre-feasibility level Environmental Impact Assessment or EIA) follows the steps specified in the *Bangladesh Flood Action Plan Guidelines for Environmental Impact Assessment* (ISPAN, 1992). These steps are illustrated in Figure 2 of ISPAN (1992).

Much of the information required for the IEE/EIA appears in the main body of the study. The section and chapter references given below cite this information.

C.2 Alternative 1: Proposed FCD Project

C.2.1 Project Design and Description (Step 1)

As in Section 7.3, Project Description.

C.2.2 Environmental Baseline Description (Step 2)

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

C.2.3 Scoping (Step 3)

Technical:

Literature review: Presented in Chapter 4, Previous Studies.

Local community: As described in Section 3.1.9, People's Perception.

C.2.4 Bounding (Step 4)

Physical:

Gross area: 40,000 ha.
Impacted (net) area: 33,895 ha.
Impacted area outside project: Surma River levels could rise by as much as 0.2 m to 0.6 m if this project and the proposed Surma Left Bank project were both implemented. Further study of this scenario is ongoing as part of the preparation of the Regional Plan. During feasibility studies, this impact must be re-assessed.

Temporal:

Preconstruction: years 0 through year 2 (see Table 7.6).
Construction: year 1 through year 2
Operation: year 3 through year 20.
Abandonment: after year 20.

Cumulative impacts:

With other floodplain infrastructure: with Surma Left Bank project; this will be looked at in the context of the Regional Plan.
With pre-existing no-project trends. Described in Chapter 5.

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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 7.11 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 7.3.3, Mitigation Measures Incorporated.

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.

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

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

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

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

Environmental Screening Matrix

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

Environmental Screening Matrix

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