BANGLADESH FLOOD ACTION PLAN

Ministry of Water Resources
Flood Plan Coordination Organization (FPCO)

Environmental Impact Assessment
Case Study
Bhelumia-Bheduria Project

November 1994

Prepared by

Environmental Study (FAP 16)

Geographic Information System (FAP 19)

ISPAN

IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

Sponsored by the U.S. Agency for International Development

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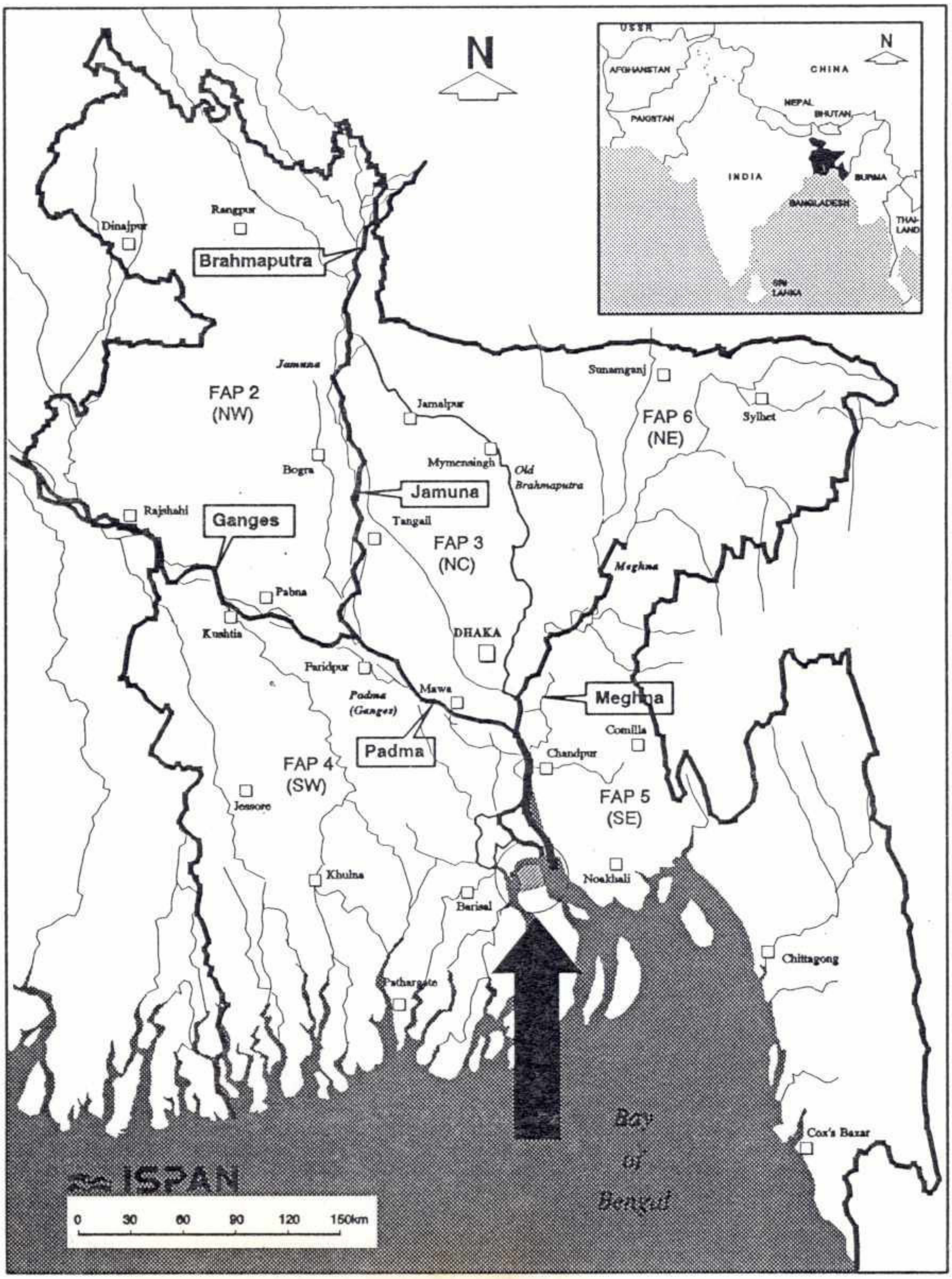
PART A:
CASE STUDY EVALUATION

FRONTISPIECE



Location of Proposed Bhelumia-Bheduria Project

1. Environmental Impact Assessment Within the Flood Action Plan

During the past two decades, Environmental Impact Assessment (EIA) has become an integral component of the feasibility plans prepared for development projects in many countries. The Flood Action Plan (FAP) in Bangladesh is no exception. Subsequent to the 1988 flood, a wide range of flood control-related development plans were proposed, ranging from major river training and embankment construction to community-based flood proofing. The sensitive Bangladesh environment, combined with the complex adjustments to flooding that rural people have historically established, has necessitated a careful review of the social and environmental impacts of proposed development plans. The purpose of EIA is to assist the planning and decision-making processes. EIAs are used to foster environmentally sound decisions and to aid in the development of Environmental Management Plans (EMP) for given development projects.

The 1989 G7 Summit Meeting determined that all FAP projects should be formulated with full consideration of socioeconomic, technical, and environmental aspects. Both the Bangladesh Environment Policy of 1992 and the National Conservation Strategy for Bangladesh incorporate a national requirement for EIA. The environmental concern was substantially emphasized at the Second Conference on the FAP in Dhaka, March 1992, where donors agreed that all FAP projects should be subject to EIA.

All five regional study components of the FAP, as well as the priority pilot projects, are addressing environmental and social factors in the prefeasibility and feasibility stages of project development. A set of guidelines to direct the EIA process has been produced (FPCO 1992a) to adopt, integrate, and localize applicable procedures and methodologies from a variety of international sources. The guidelines are intended to establish consistent standards for conducting and reviewing EIAs for FAP-related developments within the Ministry of Irrigation, Water Development and Flood Control and the Ministry of Environment and Forests. An EIA manual (ISPAN 1992a) is available to assist in conducting EIAs according to the guidelines. The guidelines are being tested and modified through implementation of several EIA case studies.

2. Objectives of EIA Case Studies

The purpose of the EIA case studies is to:

- test EIA guideline methodologies, approaches, and procedures under the environmental, social, and institutional conditions prevailing within the FAP, and
- provide on-the-job training for local professionals and technicians in EIA methods and procedures.

3. Selection of EIA Case Studies

FAP 16, in collaboration with other FAPs, has selected specific feasibility-stage projects for EIA case studies that meet the following requirements:

- covering as much environmental variation and as many physical, ecological, and social factors as possible;
- representing a range of FAP-related interventions including flood control, drainage, and irrigation (FCD/I) and water management;
- including projects that are in early stages of design but have developed to the point that the principal features and structural characteristics are identified and characterized in terms of location, size, and operating intentions;
- located in areas where information is adequate to establish the environmental baseline conditions.

The first EIA case study was carried out by FAP 16 in the Surma-Kushiyara area (ISPAN 1992b).

The second case study addressed the Compartmentalization Pilot Project at Tangail (ISPAN 1992c).

The current study, the third and final EIA case study, addresses a small coastal project under consideration by the Early Implementation Projects (EIP) section of the Bangladesh Water Development Board (BWDB). The study was conducted in collaboration with EIP and FAP 19 (Geographic Information Systems—GIS) and is presented as an Environmental Impact Assessment Report (EIAR) in Part B of this document.

4. Evaluation of the EIA Case Study

As with the previous two EIA case studies the procedures and steps advocated in the EIA guidelines were found achievable and practical as a process. A number of technical and procedural problems and issues were encountered in the study and are elaborated below.

4.1 Land Type Classification in Coastal Areas

The definition of land types within a study area is a very important step in an EIA process for water and agricultural development projects in Bangladesh, since it forms the basis for estimating agricultural gains and for predicting post-project flooding conditions. As presently applied in most parts of the country, a land type is an area of land subjected to specific ranges of flooding depths at times when prevailing water levels are at a three-day maximum for a return period of 1 in 5 years. At the initiation of the study, some doubts were expressed as to the practicality of the concept in a coastal area subjected to tidal inundation where water levels fluctuate diurnally. A certain amount of trial and error was required to decide which water level was an appropriate definer of land types, and whether the resulting units had any real meaning in terms of land use definition (Sections 3.2.1 and 3.2.2 of EIAR).

The level chosen on the basis of normal probability and Gumbel analysis as a 1 in 5 maximum water level was 2.6m above local datum. GIS-based land type maps were produced for this water level by overlaying flood levels onto a digital terrain surface generated from a contour map (Section 3.2.1 of EIAR). Similar maps were produced for levels above (2.8m) and below (2.4m). The results are summarized in Table A. An average maximum flooding level of 2.8m was clearly too high, since this produced about 800 ha (18 percent of the project area) of F_2 land which, on the basis of field surveys and farmers' opinions, was known not to be abundant in the project area. A level of 2.4m appeared to be too low since it resulted in substantial areas of T. *aman* appearing in F_0 lands which, also on the basis of field surveys, was considered to be unlikely.

The chosen level of 2.6m produced land types within which crop types were mainly restricted to specific land types, although there was some overlap. Part of the overlap between land type and cropping pattern boundaries may be due to errors or changes in the elevational data on the base maps (made in 1964), field survey error in defining exact cropping pattern boundaries, and local variations in elevation and crops grown. There appears to be sufficient agreement between the land types designated by the 2.6m level (1 in 5 maximum daily water levels) and the cropping pattern boundaries to indicate that the standard approach of designating land types is valid for coastal areas subject to tidal conditions.

4.2 Hydrological Understanding of System

There was little hydrological information available for the study area, except that which was gleaned from field sources during fields surveys, through direct observations, and from standard water level readings from a limited number of gauging stations for a limited number of years. The area is hydrologically complex, with strong tidal inflows and outflows, and a network of interconnecting canals

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Table A Comparison of Land Cropping Patterns Within Land Types Delineated by Different Mean Maximum Flooding Levels

Cropping Pattern	F_0			F_1			F_2			Totals	
	ha	%	%	ha	%	%	ha	%	%	ha	%
Flooding Level 2.4m											
B.Aus-T.Aman-RC	1160	88	52	1073	34	48	0	0	0	2234	100
B.Aus-T.Aman-Fallow	14	1	17	70	2	83	0	0	0	84	100
T.Aman-Boro	37	3	8	441	14	92	0	0	0	478	100
T.Aman-RC	83	6	41	118	4	59	0	0	0	201	100
B.Aus-T.Aman-RC	12	1	1	1437	46	98	15	100	1	1464	100
T.Aus-T.Aman-Fallow	7	1	44	9	0	56	0	0	0	16	100
Totals	1313	100		3148	100		15	100		4477	
Flooding Level 2.6m											
B.Aus-T.Aman-RC	187	65	8	2036	50	91	10	8	0	2234	100
B.Aus-T.Aman-Fallow	12	4	14	72	2	86	0	0	0	84	100
T.Aman-Boro	23	8	5	456	11	95	0	0	0	478	100
T.Aman-RC	64	22	32	137	3	68	0	0	0	201	100
B.Aus-T.Aman-RC	1	0	0	1344	33	92	118	92	8	1464	100
T.Aus-T.Aman-Fallow	0	0	0	16	0	100	0	0	0	16	100
Totals	287	100		4061	100		129	100		4477	
Flooding Level 2.8m											
B.Aus-T.Aman-RC	37	69	2	2021	56	90	176	22	8	2234	100
B.Aus-T.Aman-Fallow	6	11	7	70	2	84	8	1	9	84	100
T.Aman-Boro	0	1	0	475	13	99	3	0	1	478	100
T.Aman-RC	11	20	5	190	5	95	0	0	0	201	100
B.Aus-T.Aman-RC	0	0	0	850	23	58	614	77	42	1464	100
T.Aus-T.Aman-Fallow	0	0	0	16	0	100	0	0	0	16	100
Totals	54	100		3622	100		800	100		4477	

Source: Field Survey, 1992

and creeks. Hydrological changes are the main theme of the EIA, and are the main objective of the project, i.e., reduction or elimination of storm surges and high tidal flooding. All future hydrological changes were based either on simple analyses of level frequencies or on professional judgements.

The aim of the EIA is to predict the future situation if protective embankments are constructed. It follows that any environmental predictions based on uncertain hydrological predictions are difficult to describe quantitatively or qualitatively, and are subject to considerable potential error. The future mean maximum water levels, which are important determinants of land types and future agricultural production, could be based on nothing more than educated guesses. This is unsatisfactory for water resources development in general, and for EIA in particular. Obvious solutions are more intensive water level monitoring in the project area prior to project study, field observations by experienced hydrologists, and the use of models (which require good data) for making hydrological estimations and predictions.

4.3 Level of Effort in EIA

The total level of effort (LOE) expended on the case study amounted to about 60 person-months. This included the field surveys, which required a number of enumerators to conduct the household surveys, the time spent by GIS staff in preparing and producing overlays and tabular output, and overall study planning, analysis, and reporting. Since this was a case study, there a great deal of time was spent in analytical discussions on the approach to be used in the EIA, problems in applying the guidelines, etc. The size of the study team (≈ 10 professionals plus a number of field surveyors) was larger than would normally be applied in practical cases because of the development and training nature of the case study.

It was generally felt that the LOE expended on a project as small as Bhelumia-Bheduria was excessive, and could be reduced considerably. Field effort was considered appropriate at about 7.5-10 person-months. Planning and liaison should take approximately 5 person-months, and data analysis and reporting about 15 person-months. Based on the experience in this case study, a reasonable LOE for a project of this size would be about 30 person-months for an experienced and competent multidisciplinary EIA team. This assumes that basic information on water levels, project design features, etc. are readily available. The LOE would have to be extended if project designs were changed during the course of the study, or if major deficiencies in data were detected.

4.4 Scope of EIA for Small Projects

Two common concerns of EIA were expressed at various times during the course of the case study:

- Is EIA required for small projects of the size and scope of Bhelumia-Bheduria?
- Could the scope of the EIA be reduced for a small project such as this?

Screening of projects for EIAs is commonly applied in many countries, and is a feature of many EIA guidelines. A reduced level EIA is undertaken in cases where the type of project is common, has been built and operated successfully in the past, the environmental impacts are well understood, and the environmental management and mitigation measures are well developed and known to be effective.

None of these requirements for reduced-level EIAs apply in Bangladesh at the present time, not even for projects of relatively limited size and scope such as Bhelumia-Bheduria. As noted above, a major problem with the project was the lack of clear understanding of the hydrological changes that would ensue if the area were to be embanked as proposed. The project was found to have potentially severe impacts for certain resources (fisheries) and certain social groups (fishermen), and suitable mitigation to address these had not been included in the project design. The potential impacts on the fishing community and the fisheries resource had not been taken into account in the economic evaluation of the project. From a general perspective, EIA is still in its infancy in Bangladesh, and the appropriate body of knowledge and experience in detecting environmental impacts and designing suitable mitigation has yet to be developed. From the project-specific point of view, it was readily apparent that even a small area such as Bhelumia-Bheduria can be hydrologically complex enough that specific studies and field surveys are necessary to describe the present situation and to adequately predict the future. It is concluded on the basis of this case study experience that partial EIAs cannot yet be applied in any practical sense in Bangladesh water resource development.

It would be possible to reduce the LOE and scope of work in the EIA by careful scoping during the study planning process so that the major impacts could be identified early in the process and most study effort devoted to quantifying them, with less effort spent on impacts of relatively minor concern. However, this too requires a body of experience and knowledge of environmental impacts and mitigation efficiency which is not yet available in the country. Note that this is not the same as a reduced-level EIA decided upon by pre-study screening described above; the major difference is that the scoping and determination of LOE are undertaken by the study team after thorough field reconnaissance, not as a desk-top exercise prior to project commencement.

4.5 Application of GIS

One of the objectives of the case study was to examine the role of GIS in EIA and to evaluate its use and efficiency in the process. GIS usage in this case study necessitated digitization of base maps, preparation of overlays, various associated analyses of data, and participation in team discussions and planning.

Several advantages of using GIS were readily apparent in the case study:

- It permitted the effective integration of digital terrain data and water level data to produce land type maps, which are key components of water resource planning in Bangladesh. These were produced at a level of precision and accuracy not attainable with manual analysis, and at a level of consistency not always achieved with manual mapping.
- It encouraged objectivity in the analysis of data, and discouraged manipulations and interpretations to suit preconceived impressions (which is frequently easily done with manual data analysis).
- It permitted the application of satellite image processing to examine river channel migration patterns.

The drawbacks to the GIS were also apparent:

- GIS and satellite imagery processing hardware and software are expensive to acquire, operate, and maintain.
- Time and labor required for basic data preparation are not always commensurate with the results achieved.
- Skilled and experienced GIS personnel are required.

The fundamental problem with the application of GIS to typical EIAs such as this case study is that it is underutilized to a considerable degree. The main advantage of a GIS is that it has the capability to overlay and merge spatially base data sets, to modify stored data according to some specified rules, and display the results in mapped format or as data summaries. For EIA this means that it could produce both analyses of existing situations as well as predictions of future conditions by overlaying, combining, and analyzing existing data. An example is the production of a present land type map by combining terrain elevational data with present flooding levels, and prediction of a future land type map by combining the same elevational data with some estimation of future water levels. For most environmental components, however, the conceptual models which direct how to overlay and modify present data to predict the future are not developed. Moreover, the basic data required to adequately make these predictions are either unavailable or are insufficiently precise and accurate to justify the use of sophisticated components to handle them. This is largely a question of experience and professional expertise in EIA and will hopefully develop in time as EIA matures into a scientific process in Bangladesh.

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Environmental Impact Assessment

BHELUMIA-BHEDURIA PROJECT

November 1994

PART B:
ENVIRONMENTAL IMPACT ASSESSMENT REPORT

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EXECUTIVE SUMMARY

This report presents an environmental impact assessment (EIA) of the proposed Bhelumia-Bheduria Project on Bhola Island in the Southwest Region of Bangladesh.

The project, as currently proposed would consist of embankments completely surrounding 5,306 ha of agricultural area between the Tetulia and Jangalia rivers. The embankment on the Tetulia (western) side of the project area would cut off all out- and inflow channels, including the large Bheduria Canal opening. Canal openings on the eastern (Jangalia) side would be left open. Other project components include drainage sluices, culverts, a cyclone shelter, and a footbridge. All internal canals would be reexcavated. The objectives of the project are to protect the area from the effects of severe tidal and storm surges and to improve drainage conditions.

The project area is a typical coastal agricultural area with a network of interconnecting canals. Erosion and accretion in the adjacent Tetulia River are very active, while the Jangalia River on the eastern side is relatively much more stable. The area population is estimated at about 42,644, consisting of 7,808 households. Professional fishermen make up more than 20 percent of the area population, while 60 percent depend on agriculture for their livelihood. Landless people and small farmers make up 90 percent of the population, but occupy less than 30 percent of the land; 70 percent of the land is owned by large farmers or absentee landlords, the latter extracting high rental fees for the use of their land. An estimated 2,400 boats, most of them manually operated, are kept in the area, and about 50 percent are devoted to fishing, the remainder are used to transport agricultural produce and other goods. Ninety percent of the available cropland is classed as medium highland (F_1). Cropping intensity in the area is high, with two paddy crops and a dry-season *(rabi)* crop obtained in most sections. Crop losses due to tidal flooding and poor drainage are estimated at about 5,646 tonnes annually (13 percent of total crop). Substantial crop losses also occur due to insect pests. Tree cover is limited to homestead areas and along high-elevation roads. More than 80 percent of the area homesteads are affected by flooding every year. Homestead horticulture is severely constrained by high water levels and repeated flooding. Professional fishermen fish inside the project area and outside in the Tetulia and Jangalia rivers. About 50 percent of the fish harvested come from the interior canals; 25 percent come from the rivers. River fish, because of their size and value, make up 80 percent of the gross fishery income in the area. Culture fisheries are extensive in the area, based on more than 1,600 ponds, but many are flooded every year.

The expected impacts of project development are summarized in Table 1. *Beneficial impacts* would include increases in agricultural and horticultural crops and income derived from these crops as well as from the labor activities associated with project construction. Secondary benefits would include improvements in the nutritional and health status of local communities, and a reduction in flooding risks to households. The most serious *negative impacts* would be the blockage of the western canal openings by the embankment, with consequent obstruction of boat passage and fish migrations. Other negative impacts would include the loss of land and displacement of some homesteads affected by the embankment, some loss in soil fertility, increased losses from wildlife and insect pests due to cropping intensification and embankment refuge areas, and possible declines in water quality and increases in the incidence of waterborne diseases.

Mitigation of most impacts is possible and would include the measures listed in Table 2.

Cumulative environmental impacts due to other proposed developments and environmental changes in the southwestern region are unlikely to significantly affect the Bhelumia-Bheduria project area, or vice-versa, due mainly to the prevailing hydrological conditions around the project area, which are strongly dependent on the Meghna River flows.

Recommendations for an Environmental Management Plan are given in the EIA report and include development of a code of good engineering practice, coordination of cooperating agencies, development of sound operating and maintenance procedures, environmental enhancement through embankment revegetation, social forestry programs and agricultural extension programs, effective people's participation, regular monitoring and inspection of the embankment, a reporting and accountability schedule, and a disaster management contingency plan.

Table 1 Summary of Environmental Impacts for an Unmitigated Bhelumia-Bheduria Project (negative impacts are shaded)

Important Environmental Component	Present Amount or Frequency	Project Impact*	Impact Type†	Impact Rating‡
Tidal flooding	Daily in monsoon season	Slower flood rise, rapid dissipation	EILM	+2
Storm surge	Annual, multiple in some years	Eliminate average surges	SIHM	+7
Land drainage	Extensive over project area	Reduce or eliminate over 80% congested area	SGHM	+5
Groundwater	Drinking purposes only	Negligible	-	0
River erosion and shifting	Extensive migration of river shorelines, possibly declining in rate	Negligible, shifting river channel may erode embankment	-**	0
Land types			Nil or SIHS	0 or +7
F_0	287 ha	Nil (Scenario 1) or +1,026 ha (Scenario 2)		
F_1	4,061 ha	Nil (Scenario 1) or -912 ha (Scenario 2)		
F_2	129 ha	Nil (Scenario 1) or -114 ha (Scenario 2)		
Soil quality	Moderately fertile, suitable for crop production	1. Reduction in nutrient sediment deposition	SGLR	-2
		2. Reduction in saline tidal flushing in SE	EGLS	+2
Agricultural production				
Irrigated area	≈13% cultivable area irrigated	≈5% increase in irrigated area	EGLM	+2
Crop damage	≈4,350 tonnes lost annually to floods & pests	65% reduction	SGHM	+5
Crop production	≈23,000 tonnes annually	≈17% (Scenario 1) or 19% (Scenario 2) increase	SGHM	+5
Homestead vegetation				
Homestead forests	≈400 ha	Improvements in cover and species diversity	SGLS	+4
Homestead gardens	≈50 ha	Improvements in species diversity and production	SGLS	+4
Biomass energy	≈16,000 tonnes available annually	Increase in fuel wood and crop residues	EGHS	+4
Homestead land	760 ha	Some loss to embankment possible	EGLV	-2

* Project impact is the difference between effects produced by the project and anticipated long-term changes in the absence of the project.

† Sensitive (S) or less sensitive (E) resource; immediate (I) or gradual (G) impact onset; high (H) or low (L) impact magnitude; beneficial impacts may be sustainable (S), sustainable with mitigation (M) or not sustainable (N); negative impacts may be irreversible (I), reversible with mitigation (V), or reversible (R).

‡ Impact ratings are given in Annex 2.

** No impact expected by project, but project itself may be impacted.

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Important Environmental Component	Present Amount or Frequency	Project Impact*	Impact Type†	Impact Rating‡
Wildlife				
Endangered species	5 species	Negligible	-	0
Threatened species	7 species	Negligible	-	0
Pest species	Abundant (rats, granivorous birds)	Increased populations and damage levels	SGHR	-3
Commercial species	Turtles: 4-5 tonnes annual production	Negligible	-	0
Pesticide contamination	No information	Likely to increase in food chain concentrations	SGHR	-2
Capture fisheries				
Fish habitats	Extensive	Decline in quality within project area	SGLR	-2
Fish diversity	61 species	Probably negligible	-	0
Annual harvests	≈2,600 tonnes	10-15% decline inside area 3-4% overall	SGHV	-3
Fishing costs and inputs	Nominal	Increase in costs, decrease in security	SIHV	-7
Pesticide contamination	No information	Likely increase in food chain concentrations	SGLV	-3
Water quality	Moderately good	Slight decline	EGLV	-2
Culture fisheries				
Ponds	1,654	Slight increase	EGLS	+2
Annual production	≈455 tonnes	Slight increase	EGLS	+2
Water quality	Moderately good	Slight decline	EGLV	-2
Local employment				
Agricultural	1,386,000 person-days annually	1-3% increase	EGLS	+2
Fishing	≈20% households reliant on fishing	Sharp decline if river access is blocked	SIHV	-7
Household income				
Large landowners	≈11% population own 70% land	Improved	EGHS	+4

* Project impact is the difference between effects produced by the project and anticipated long-term changes in the absence of the project.
† Sensitive (S) or less sensitive (E) resource; immediate (I) or gradual (G) impact onset; high (H) or low (L) impact magnitude; beneficial impacts may be sustainable (S), sustainable with mitigation (M) or not sustainable (N); negative impacts may be irreversible (I), reversible with mitigation (V), or reversible (R).
‡ Impact ratings are given in Annex 2.
‾ No impact expected by project, but project itself may be impacted.

Important Environmental Component	Present Amount or Frequency	Project Impact*	Impact Type†	Impact Rating‡
Small landowners	≈89% population own 30% land	Little change	EGLV	-2
Risks to life and property	Widespread from many causes	Reduction in flood and surge hazards	SILV	-4
Vector-borne diseases	Not common	Little change	?	0
Water-borne diseases	Widespread	Similar incidence in larger population	SGLV	-3
Nutritional status				
Total food intake	387 gm daily	Improved	SGLS	+4
Protein intake	10 gm fish daily intake	≈10-15% decline for poor and middle classes	SIHV	-7
Education and literacy	29% (M) and 19% (F) literacy rate	Small improvements	EGLS	+2
Women's status	Stable, conservative	Small improvements	EGLS	+2
Road transportation	Local paths and routes only	Embankment used as roadway	EIHS	+6
Navigation				
Number of boats	≈2,400	Slight decline	EGLV	-2
Paddy transportation	≈900 tonnes annually	≈50% boats blocked by closures	SIHV	-7
Fishing boats	≈1,200	≈50% boats blocked by closures	SIHV	-7
Boat security	Adequate	Outside boats exposed to storm damage and loss	SGHV	-5

* Project impact is the difference between effects produced by the project and anticipated long-term changes in the absence of the project.

† Sensitive (S) or less sensitive (E) resource; immediate (I) or gradual (G) impact onset; high (H) or low (L) impact magnitude; beneficial impacts may be sustainable (S), sustainable with mitigation (M) or not sustainable (N); negative impacts may be irreversible (I), reversible with mitigation (V), or reversible (R).

‡ Impact ratings are given in Annex 2.

** No impact expected by project, but project itself may be impacted.

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Table 2 Recommended Mitigation Measures for Bhelumia-Bheduria Project

Water Resources:

- Maintenance of canals through clearing and excavation to correct size and bed slope
- Appropriate O&M
- Monitoring

Land Resources:

- Embankment alignment to avoid homesteads as much as possible
- Relocation of any affected homesteads to new sites
- Good environmental engineering practice to minimize damage
- Increased use of organic fertilizers and mulches
- Judicious application of chemical/inorganic fertilizers and pesticides
- Practice of Integrated Pest Management

Water Quality:

- Extension programs to farmers to minimize agro-chemical contamination
- Health education programs to increase risk awareness

Fisheries:

- Navigation lock on Bheduria Canal
- Fish passes on all main canals on Tetulia River side
- Local stocking programs for canals
- Culture fisheries development at village and community levels

Socioeconomic:

- Careful alignment of embankment to avoid displacements
- Relocation of displaced households to new sites

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ABBREVIATIONS AND ACRONYMS

BBS	-	Bangladesh Bureau of Statistics
BRDB	-	Bangladesh Rural Development Board
BWDB	-	Bangladesh Water Development Board
cm	-	centimeters
DEM	-	Digital elevation model
DOF	-	Directorate of Fisheries
DPHE	-	Department of Public Health Engineering
DTW	-	Deep tubewell
EIA	-	Environmental Impact Assessment
EIP	-	Early Implementation Projects
EMP	-	Environmental management plan
ERDAS	-	Digital image processing software
FAP	-	Flood Action Plan
FCD/I	-	Flood Control Drainage and Irrigation
FCD	-	Flood Control Drainage
FPCO	-	Flood Plan Coordination Organization
g	-	gram(s)
GIS	-	Geographical Information System
GOB	-	Government of Bangladesh
GR	-	Gini ratio
h	-	hours
ha	-	hectares
HTW	-	Hand tubewell
HYV	-	High-yielding variety
IEC	-	Important Environmental Component
ISPAN	-	Irrigation Support Project for Asia and the Near East
kg	-	kilogram
km	-	kilometer(s)
LGED	-	Local Government Engineering Department
m	-	meter(s)
m^3/s	-	cubic meters per second
mg/l	-	milligrams per liter
mm	-	millimeter(s)
MP	-	muriate of potash
mt	-	metric tonne
NGO	-	Non-government Organization
O&M	-	Operation and Maintenance
pc ARC/INFO	-	GIS application software
ppm	-	parts per million
PRA	-	Participatory rural appraisal
PWD	-	Public Works Datum
ROL	-	Rate of literacy
RRA	-	Rapid rural appraisal
SCWC	-	Subcompartmental Water Committee
STW	-	Shallow tubewell
T. aman	-	Transplanted aman
TD aman	-	Transplanted deep water aman
Tk.	-	Taka
TSP	-	Triple Super Phosphate

GLOSSARY

Aman	-	Rice grown during *kharif-2* season with the exception of broadcast aman, which is sown in the *kharif-1* season and harvested in the *kharif-2* season
Aus	-	Rice grown during the *kharif-1* season
B. aman	-	Broadcast aman
Bandalling	-	Low-cost dredging method applied to small channels involving bamboo mat panels which create spiral currents
Beel	-	A natural depression, the bottom of which normally remains wet throughout the year
Boro	-	Rice grown during *rabi* season
Bandhak	-	Mortgage
Barga	-	Sharecropping
Barsha	-	Normal seasonal flooding
Biri	-	Local cigarette
Conch	-	A variety of shell
Dhenki	-	Traditional foot-operated paddy dehusking device
District	-	An administrative unit comprising a number of thanas under the charge of a Deputy Commissioner
Khal	-	Natural channel
Kharif-1	-	Early summer (March through June)
Kharif-2	-	Late summer and fall (July through October)
Khasland	-	State-owned land
Macha	-	A high platform, usually made of bamboo
Matabbar	-	Informal village leader
Maund	-	A local unit of measurement (1 maund=37.3 kg)
Monsoon	-	Rainy season starting in June and ending in September
Mouza	-	The smallest revenue unit
Nikari	-	Middlemen in fish trading
Pagar	-	A small water body adjacent to the homestead and under individual ownership
Palan	-	Extension of homestead land, used for vegetable gardening
Rabi	-	Winter cropping season (November through February)
Sairat mahal	-	Places of public use given on annual or short-term lease by the government
Salish	-	Village court
Taka	-	Name of Bangladesh currency
Thana	-	Administrative unit (division of a district)
Union	-	Smallest administrative unit of the local government (division of a thana)
Upazila	-	Term previously used for thana

Chapter 1

PROJECT SETTING

1.1 Background

The Bhelumia-Bheduria project is one of many projects being considered as Early Implementation Projects (EIP) by the Directorate of Planning Schemes IV, Bangladesh Water Development Board (BWDB). The EIP program, supported by the Government of the Netherlands, has the objective of rapid implementation of relatively small-scale FCD and FCD/I projects in Bangladesh. Following a BWDB request that ISPAN use one of the projects as a subject for an EIA case study, the Bhelumia-Bheduria project, a small coastal project in the final feasibility stages of investigation by EIP, was selected for study.

The Bhelumia-Bheduria project area is located on the northwestern tip of Bhola Island in the Meghna River estuary, 3km west of Bhola town (see frontispiece). The project area is bounded in the west and south by the Tetulia River, by the Jangalia River in the east, and by Darogar *khal* in the northwest (Maps 1 and 2). The gross area of the flood-prone area within which the project would be located is 5,306 ha. The general slope of the area is towards the south and southeast.

The project area is presently subject to tidal flooding which spills over the banks of both the Tetulia and Jangalia rivers and the various *khals* linked to these rivers. The depth of tidal flooding increases during the monsoon period (July-September) due to a combination of high river stages and heavy rainfall. Flood waters from the Tetulia River recede during low tide, but often not completely before another high tide floods the area. Flood waters due to overspill from the Jangalia River usually recede completely as the overland slope is predominantly toward the river. Project area farmers report that the most severe crop damage is due to tidal flooding from the Tetulia River.

In addition to periodic tidal flooding, surges may occur during cyclones and severe storms; these may occur at any time but are more prevalent in October and November. During surges water rises rapidly above normal high tide levels, causing widespread crop and property damage. The last major surge occurred in 1971 and caused extensive damage to crops, homesteads, infrastructure, and property, in addition to claiming lives.

Other flood-related problems in the area indicated during initial project reviews were riverbank erosion in some areas, and possible intrusion of saline water in March and April. Erosion was subsequently found to be a problem in some places, but saline intrusions were limited to sporadic cases in the southern portions of the project area in late March.

1.2 Project Objectives

The objective of the project (BWDB 1993) is to prevent severe monsoon tidal flooding from damaging *aus* crops in June-July, and transplanted *aman* (T. aman) crops in August and September. Prevention of property and crop damage due to severe tidal surges accompanying storms and cyclones is not an objective of the project.

1.3 Environmental Assessment Methodology

The approach ISPAN used for the Bhelumia-Bheduria Project EIA was that advocated in the FAP EIA Guidelines (FPCO 1992a) and the FAP draft final EIA Manual (ISPAN 1992a) for use in FAP projects (although the Bhelumia-Bheduria Project itself is not a FAP project, but a proposed Early Implementation Project of the BWDB). The approach consisted of deploying a multidisciplinary team to undertake the studies and assessments through a 10-step process of project design and description, environmental baseline description, scoping, bounding, major field investigations, impact assessment, impact evaluation, environmental management planning, feedback to improve project design, and reporting. Project descriptions were provided by EIP (BWDB 1993).

The EIA team reviewed available literature on the EIP project and related secondary data sources. This was followed by a reconnaissance survey which helped identify the important environmental components (IECs) and formed the basis for developing the subsequent data collection methods. Extensive discussions took place at different stages of the EIA work with the EIP team in Dhaka and BWDB engineers in Bhola.

1.3.1 Data Collection

The EIA team conducted a reconnaissance survey of the study area for four days in October 1992 making an extensive tour of the area and talking to local people, BWDB engineers, and NGOs. This was followed in November by detailed data collection using semi-detailed land use surveys, household questionnaire surveys, and rapid rural appraisal (RRA) and participatory rural appraisal (PRA) techniques. The PRA is a development of the RRA especially tailored to social and community appraisal; it is designed to involve the community in the identification and analysis of local needs, issues, problems, and solutions. The individual experts visited each of 13 *mouzas* (including one uninhabited *mouza*: Annex 1) and collected information and data related to their respective discipline through observation, discussion with key informants and local knowledgeable persons, elites, groups of ordinary people, households, and professional communities. The RRA, PRA, and semi-detailed land use survey was completed in 10 days. The household questionnaire survey (Annex 1) continued through the whole of November and early December.

During fieldwork, the team used 1990 color infrared (CIR) aerial photographs (1:30,000) for the semi-detailed land use survey, SPOT imagery (1:50,000), and a global positioning system (GPS) for updating the bankline and fixing coordinates for the Land Use Survey. BWDB and EIP maps and reports were extensively used.

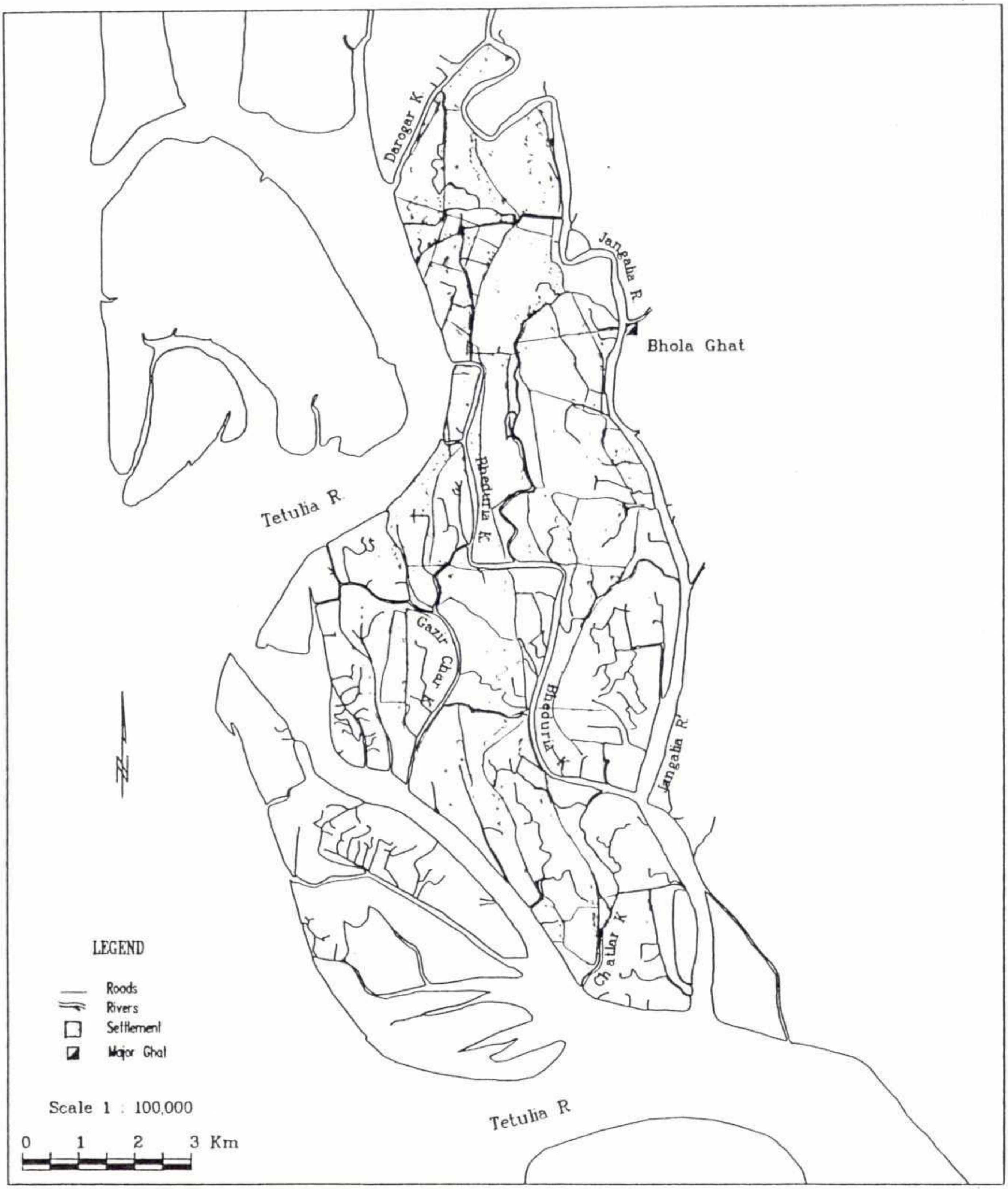
Water Resources

Hydrological information was collected through site-specific visits complemented by interpretation of aerial photographs and SPOT imagery. This information supplemented secondary data collected from the Bhola BWDB offices and the Hydrology Directorate, Dhaka.

Land Resources and Land Use

A semi-detailed land use survey using 1990 CIR aerial photographs was performed to map land use and cropping pattern. The cropping pattern units were identified from interviews with local farmers. The infrastructure, including roads, and the homesteads and other land uses were identified during the field survey. The cropping pattern units and the land uses were delineated on overlays. Crop areas, cropping patterns, crop damage, inundation levels, and modes of irrigation by season were noted on data sheets. Data on agricultural practices, crop yields, human and animal labor requirements, and crop damage were collected by interviewing knowledgeable farmers from different areas. Cross-checking was done to ensure the reliability of information. The whole study area was divided into sections and the land use survey team completed one section before moving on to the next.

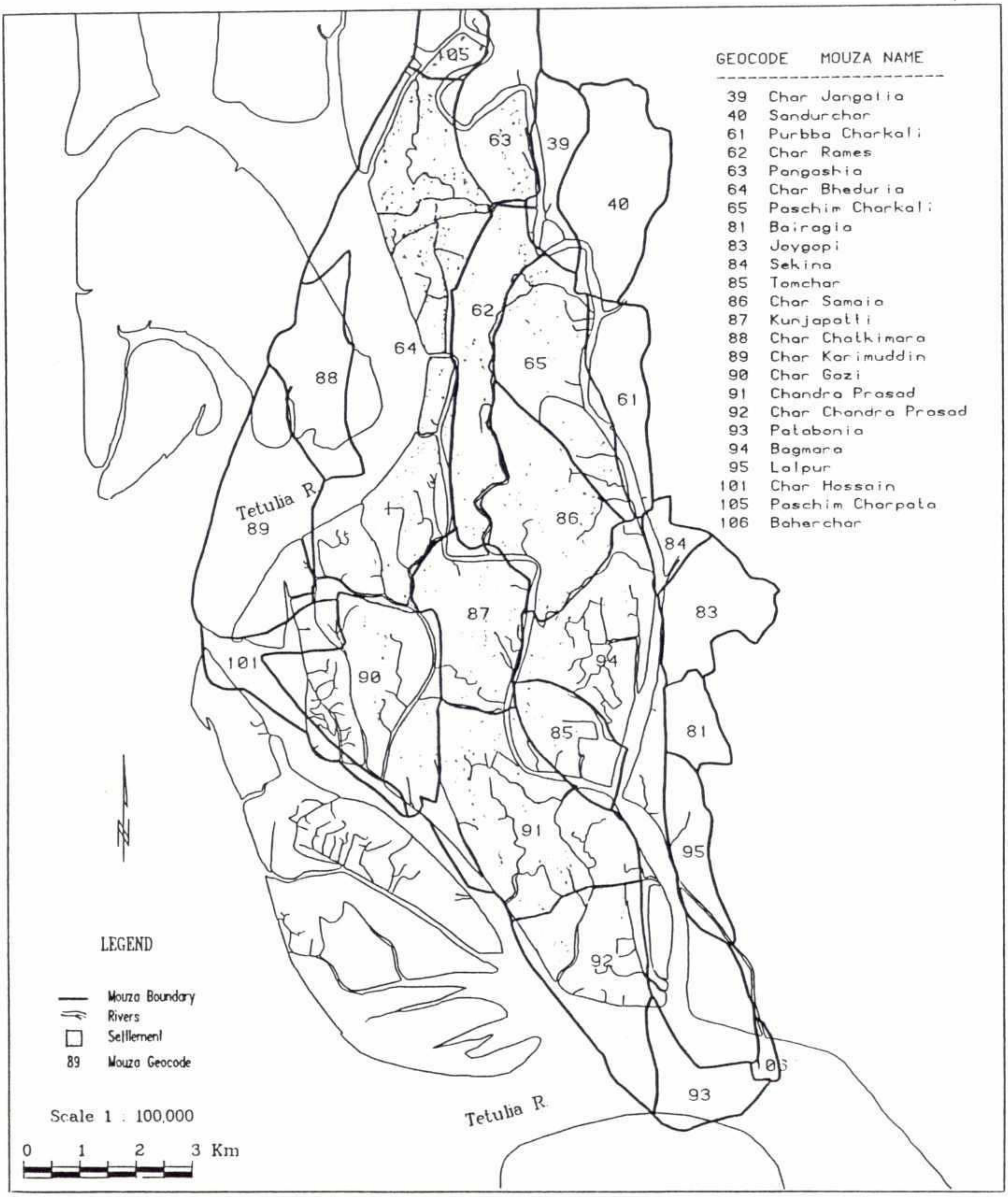
Map 1



ISPAN

Base Map

Map 2



ISPAN

Administrative Map

Forestry and Homestead Vegetation

Field data collection was based on both RRA and household surveys. Information was collected on:

- depth, duration, and frequency of inundation of homesteads at different levels;
- areas of housing, orchards, and vegetable gardens;
- abundance of species in homesteads, along roadsides, and along the verges of rivers and canals, including the nature of their consumption;
- production, consumption, and extent of damage of vegetables and other tree crops;
- biomass energy sources and their proportional and seasonal uses;
- programs and trends of alleviation for fuel crisis.

Terrestrial and Aquatic Habitats

Terrestrial habitats were surveyed during the RRA, household survey, and semi-detailed land use surveys. Aerial photographs were used to identify specific sites in each of the 13 *mouzas* for field visits. These sites included shoreline, agricultural land, homestead, and roadside sites. Habitat characteristics were noted with particular regard to species composition and growth.

Aquatic habitats were studied through RRA on a *mouza* basis. Aquatic habitats were classified into rivers/*khals*, intertidal mud flats, floodplain, and ponds. Limno-biological tests were conducted at 32 sites, 14 in rivers and *khals* and 18 in ponds. Ponds were classified as inundated or non-inundated, and sub-divided into large, medium, and small categories. The *khals* surveyed included Bheduria, Farazi, Majhirhat, Ujirer, Boalia, Napiter, Chatler, Goaliar, and Projar. The Tetulia and Jangalia rivers were also surveyed. Observation of rivers and major *khals* was done during both high and low tides at some designated points.

A Hach portable water testing kit was used to estimate levels of the following parameters: dissolved oxygen, carbon dioxide, alkalinity, hardness, chloride, ammonia, nitrite nitrogen, and pH. Surface water samples were taken from the central point of sampled canals. Plankton samples were collected by filtering 10 liters of water through a plankton net. Plankton samples were preserved in 5 percent formalin and later examined under a compound microscope using an identification key (Alfred, *et al.*, 1973). Benthos samples were collected from *khal* and pond bottoms from at least two sections for each of the selected points. Benthic invertebrates were identified alive. Aquatic macrophytes were identified by direct observation.

Channel Shifting, Erosion and Accretion

Changes in the banklines of the main rivers and chars in the study area were examined through the use of satellite imagery. Four digital Landsat images—1973 (the earliest available image), 1979, 1990 and 1993—were georeferenced to standard coordinates, overlaid using a digital image reader, and displayed by a Geographic Information System (GIS). Rates of change in bankline position from one image to the next were computed.

Wildlife

Information on wildlife was collected by visiting each category of terrestrial and aquatic habitat described in the habitat section above at different times of the day. Numbers of individuals per species per unit area within each habitat were estimated. Food habits for each species were observed. Particular attention was given to the identification and population estimation of endangered, threatened, and pest species. The critical habitat and causes of decline/degeneration, if any, of endangered and threatened species habitats were noted. Occurrence and use of commercially important wildlife were identified. Information on hunting/trapping/harvest techniques, amount of harvest, seasonality, and annual return for local consumption/export were collected from knowledgeable local persons including those who were involved in commercial exploitation. Ecological losses due to harvest were also noted.

Fisheries

Aerial photographs from 1990 were examined and representative types of aquatic areas identified and located. These were subsequently examined in the field. Wetlands were classified by type (e.g., *khals*) and location. Information on fish populations was obtained by observing fish markets, fish purchase centers, and fish catches *in situ* at various river, *khal*, and inundated rice field locations. Fish diversity and abundance were noted in catches, at markets, and in fish purchasing centers.

Information on fish migration routes, availability, and breeding was collected by interviewing knowledgeable professional fishermen, subsistence fisherman, and local villagers. Fish catch assessments were made by gear type. The cost of each type of gear, capacity of catch, and species caught were recorded from field observation and through interviews. Fish production was estimated on the basis of annual records of the fish purchasing centers. Information on marketing systems, leasing systems, and fisheries problems was collected from local knowledgeable persons, district fishery officers, thana fishery officers, Bangladesh Matshajibi Samabaya Samity (local office), fishermen, and local leaders. Information on inundated ponds, which were classified as open-water capture fisheries, were collected by visiting selected sites. Information on management aspects, including ownership patterns, stocking of ponds, and diseases and other problems was collected by interviewing fishermen and owners of inundated ponds. Information on fish consumption and other aspects related to capture fisheries was collected from the household surveys.

Information on culture ponds was collected by direct observation and by interviewing the owners of selected ponds. Information included cultured species, sources of fish seed, production management, annual fish production, marketing, and constraints to culture fisheries, including fish diseases. The number of ponds in the study area was determined from aerial photograph analysis and confirmed by field observation.

Socioeconomic

The socioeconomic data were collected through PRA, RRA, and household surveys. The social impact assessment (SIA) team visited each of the 12 inhabited *mouzas* and collected data/information from various socioeconomic groups, local elites, and households using an interview guide. The socioeconomic groups included:

- elected members of the local government, i.e., Members and Chairmen of Bhelumia and Bheduria unions;
- school/*madrasa* teachers, community leaders;
- doctors/*kabiraj*;
- large, medium, small, marginal, and tenant farmers;
- agricultural labors, including the landless;
- professional and subsistence fishermen and fish traders;
- shopkeepers and other petty traders;
- women from the households, particularly from the category of farmers, agricultural labors, and fishermen, including female-headed households;
- thana- and district-level officers in Bhola;
- NGO staff working in the study area.

Information/data were collected and people's views obtained on socioeconomic issues, including occupation/employment, income, subsistence patterns, migration, land tenure and tenancy relations, major development problems and perceived solutions, navigation, marketing and leasing (particularly fish), gender issues, education, water and sanitation, health and nutrition, and health service delivery system/outlets. These data were supplemented by BBS and other published sources wherever necessary.

Hazards and Risks

Information and data on environmental risks and hazards and perceived mitigation options were collected both through PRA/RRA and household surveys and included hazards such as flood, tidal surge, cyclone, saline intrusion, erosion, excessive rainfall, drainage congestion, waterlogging, and drought. The BWDB office files at Bhola were consulted for information on hazard events in the study area.

1.3.2 Application of GIS

A Geographic Information System (GIS) was used as a data platform for preparing base maps and for estimating land type distribution. Maps and tables were produced in pcARC/INFO on ERDAS software. Spatial data from field surveys were traced onto a stable film base at a scale of 1:50,000. Tracing was done on aerial photographs and satellite imagery overlays. *Mouza* boundaries were digitized from available police station maps. Digitizing was accurate to approximately 50m. Areas of roads were calculated by assuming a standard base width of approximately 10m including borrow pits. The distribution and areas of land types were computed by preparing a digital terrain model (DTM) based on digitization of BWDB contour maps for the area, and overlaying this with flood depth profiles based on assumed heights of flood waters above local datum.

1.4 Scoping, Bounding, and Selection of Important Environmental Components (IECs)

IECs were considered as ecological, social, and economic components worthy of sustaining at existing or enhanced levels under project conditions. Following the reconnaissance survey, the EIA team scoped the study components and bounded the *study area*. The latter was defined as the area that would be directly impacted by the proposed project, and was bounded by the Tetulia River to the west and south and the Jangalia River to the north and east. This included the *project area* enclosed by the proposed embankment, plus the *adjacent area* which comprised the southwestern char areas (Char Gazi and Char Hossain) between the Tetulia River and the embankment alignment and the small area north of Darogar Khal (Map 1). For consideration of socioeconomic impacts, the char land accreted to the west of the Tetulia River and sections of the Bhola mainland immediately east of the Bhelumia-Bheduria region were also included.

1.5 Impact Assessment and Analysis

The initially proposed approach to impact analysis was to develop two future scenarios for the project area—*future-without-project* and *future-with-project*—each considering a 20-year period into the future. Each would be predicted on the basis of available environmental baseline information and the information provided through GIS analysis of land resource data. The difference between the two scenarios for the various environmental components and resources would be considered the project impact. The purpose of considering a *future-without-project* scenario as a basis for comparison and assessment of impacts is to take account of future trends in many environmental components which are independent of any project actions, e.g., human population growth, changes in resource bases, etc.

Because of the high uncertainty associated with the hydrological changes which would take place under project conditions (see Chapter 4), it was deemed advisable to consider two possible scenarios for the *future-with-project*. One assumed no change in maximum three-day water levels in the monsoon season, and hence no change in land type distribution in the project area, the other assumed a small reduction in maximum water levels and a corresponding change in land type distribution.

Impacts were evaluated in economic terms through appropriate economic analyses. Changes in income and employment and the distribution of income were considered the major economic measures of the impacts of the project, and the underlying changes in cropping pattern and intensity, yields, labor requirements and other production inputs, and crop damages that determine farm income were computed. Similar computations were made for capture and culture fisheries production, fish trade, important waterway transportation routes, fish purchase centers, other markets, and origin and destination by type of goods. Non-economic evaluation was applied to impacts which could not be quantified in economic terms or for which suitable quantitative data were lacking.

1.6 Assessment and Scoring

Predicted impacts were scored using a 1 to 10 scale for beneficial impacts and a -1 to -10 scale for negative impacts. Scores were weighted according to the nature of the impacts, i.e.

- *sustainability* (applied to positive impacts only): sustainable (weighted 6x), sustainable with mitigation (weighted 3x), non-sustainable;
- *reversibility* (applied to negative impact only): irreversible (weighted -6x), reversible with mitigation (weighted -3x), reversible;
- *sensitivity:* sensitive (weighted 2x), less sensitive: sensitivity is defined as the readiness with which an IEC or set of IECs receive the impact.
- *magnitude:* high (weighted 3x), low: refers to the size of the impact. Can be negative or positive. Any quantifiable increase or decrease to an IEC as a result of the project action was converted to percentage values. Any direct threat to human life, internationally recognized endangered species, and environmentally sensitive areas was considered high magnitude.
- *rate*: immediate (weighted 2x), gradual: an immediate impact is effective within one year of project action, otherwise the impact was considered gradual.

The score scaling is given in Annex 2.

Impacts were not weighted by resource or by project component since alternative project options were not required to be compared. The EIA team's efforts were aimed at providing an unbiased assessment and scoring of specific IECs and presentation in the report for consideration by management and decision makers. It is believed that the decision and determination as what resource or resource use is more important than others is up to the decision makers and not individuals in the EIA team. By definition, all IECs are important, and components and resources with low weights are automatically excluded in the scoping process.

1.7 Study Team

EIA

Stan Hirst - team leader
Abu Md. Ibrahim - soils and agriculture
Dara Shamsuddin - impact assessment
Kazi Sadrul Hoque - social impacts and people's participation
Khurshida Khandakar - forests and homestead gardens
Mohiruddin Ahmed - hydrology and project liaison
Aminul Islam - climate and hazards
Afsana Wahab - social impacts and women's issues
Raguibuddin Ahmed - terrestrial and aquatic biology
Monowar Kamal - navigation and study mapping
Afroza Begum - fisheries
Carol Jones - report editing
Hena Rosline D'Rozario - word processing

GIS

Mike Pooley
Ahmadul Hasan
Md. Hasan Ali
Aneeqa Shireen Syed

1.8 EIA Level of Effort

The EIA team conducted the assessment, including the necessary field studies and household surveys from September 1992 through April 1993. Total level of effort expended for the entire team, including fieldwork, data analysis, and reporting, was estimated at 60 person-months.

1.9 Relationship of EIA to Project Feasibility

The EIA was conducted solely as a case study to develop experience in impact assessment under conditions pertaining to Bangladesh, especially in a fairly remote coastal area, and to examine the practicality of applying the EIA guidelines requirements. The study was conducted with the cooperation and assistance of the EIP group of the BWDB, but was conducted quite separately from the latter group's feasibility studies. A separate, more brief assessment of the agricultural, social, and environmental impacts of the project was conducted by EIP and incorporated in their feasibility report (BWDB 1993).

1.10 Acknowledgements

The assistance and helpful cooperation of the EIP group of the BWDB, especially Director Md. Lutfur Rahman, Executive Engineer K.T. Hussain, Socioeconomist A. Salahuddin, and Team Leader Paul A. Zijderveld, is gratefully acknowledged. The EIA team members acknowledge the cooperation and assistance of the Deputy Commissioner of Bhola, staff of the BWDB in Bhola, especially Executive Engineer Ali Akbar Hayder and Superintending Engineer Kayun Risvi, and the local chairmen, villagers, and elite of the Bhelumia-Bheduria Project area. Numerous government and nongovernmental agencies and individual officials provided information and assistance.

Chapter 2

PROJECT DESCRIPTION

A number of project concepts have been considered by EIP for effecting flood damage protection and improved drainage in the Bhelumia-Bheduria Project area. The one considered as a basis for this EIA is described in BWDB (1993). The pertinent features are as follows.

2.1 Project Plan

2.1.1 Embankment

The project area would be protected by an embankment (Map 3) with a total estimated length of 38km. From Bheduria Khal to Napter Khal the embankment would be exposed to wave action and would be constructed as a sea dyke with side slopes of 1:5 towards the river ("riverside" or "R/S" in standard BWDB terminology) and 1:3 towards the interior ("countryside" or "C/S"), a freeboard of 1.5m, and a crest width of 4.3m. Along the Tetulia River between Napter and Majhirhat *khals* the embankment would be built as an interior dyke with side slopes of 1:3 R/S and 1:2 C/S, a freeboard of 0.9m, and a crest width of 4.3m. Between Majhirhat and Bheduria *khals* along the Jangalia River the embankment would be a marginal dyke with a crest width of 2.4m, a freeboard of 0.9m, and R/S and C/S side slopes of 1:2. All crest levels were computed on a basis of a 1:20 probability water level on both the Tetulia and Jangalia rivers. A 50m minimum set-back distance would be maintained for both sea and interior dykes, and 10-15m for marginal dykes.

All *khals* originating from the Tetulia River on the western side of the project area, including Bheduria Khal, would be closed except where boat passage facilities are required. All *khals* along the Jangalia River would be left open.

2.1.2 Structures

One two-vent drainage and flushing sluice (1.5 x 1.8m) would be constructed at the outfall of Napter Khal, and two 0.9 x 0.9m sluices, one at the outfall of Munshir Khal and the other at the southern tip of the project area. These sluices would be intended to improve drainage during the pre-monsoon and monsoon seasons. Seven culverts for drainage improvement have been proposed (BWDB 1993) in the following locations:

- Char Samaiya near Natun Bazaar, south-west of Panditer Khal
- North side of Sharupkhar Hat
- Between Natun Bazaar and Bangla Bazaar
- Near Bangla Bazaar along Bheduria Khal
- From Bhelumia Bazaar to Napter Khal
- South side of Bhelumia Bazaar
- Between Natun Bazaar and Bhelumia Bazaar

These are not necessarily the same locations as identified for drainage improvement by local people (see Chapter 6).

A footbridge would be constructed over Bheduria Khal at Bangla Bazaar.

2.1.3 Excavation

All silted *khals* would be excavated during project construction.

2.2 Preconstruction Phase

Other than sporadic study team presence and activity in the project area from 1990 through 1992, preconstruction work has been confined to desk studies. These early activities have had no apparent or identifiable environmental impacts, apart from arousing people's expectations regarding the benefits of the project when implemented.

2.3 Construction Phase

Project construction is planned to commence in 1993 and could be completed by 1998/99, i.e., a five-year time span. All construction work undertaken by the BWDB would use local labor. The components of the project during the construction phase are listed in Table 2.1.

Supply of electricity during and after the installation of the 20 tubewells is recognized as an activity associated with tubewell development.

Table 2.1 Bhelumia-Bheduria Project Construction Components

1.	Land acquisition (125 ha)
2.	Embankment (including sea dike, interior dike, and marginal dike, total length: 38km)
3.	Drainage/flushing sluice gate (1 no.)
4.	RCB sluices (2 nos.)
5.	Closures (4 nos.)
6.	Reexcavation of *khals* (unspecified length)
7.	Culverts (7 nos.)
8.	Footbridge (1 no.)
9.	Tubewells (20 nos.)
10.	Cyclone shelter (1 no.)
11.	Maintenance during construction
12.	Borrow pit*
13.	Soil disposal during *khal* reexcavation*
14.	Labor mobilization and associated service requirements*

Source: BWDB (1993)

* Additional construction items identified according to the EIA Guidelines (FPCO 1992).

Embankments would be constructed from materials excavated from borrow pits immediately adjacent to the embankment alignment. For the most part the embankments would follow the course of present roads. Sea dykes would be reinforced with locally made bricks or with boulders barged in from the Sylhet area in northern Bangladesh.

2.4 Operation and Maintenance Phase

Present project plans call for a three-year operation and maintenance (O&M) phase following construction, to be undertaken by the BWDB. O&M beyond the initial three years has not been defined. The components to be considered during the O&M phase are listed in Table 2.2.

Table 2.2 Bhelumia-Bheduria Project O&M Components

1.	Embankment (Total 38 kms)
2.	Drainage/flushing sluice (1 no.)
3.	Sluice gates (2 nos.)
4.	Closures (4 nos.)
5.	Reexcavated *khals* (unspecified length)
6.	Culverts (7 nos.)
7.	Foot bridge (1 no.)
8.	Tubewells (20 nos.)
9.	Cyclone shelter (1 no.)
10.	Borrow pit

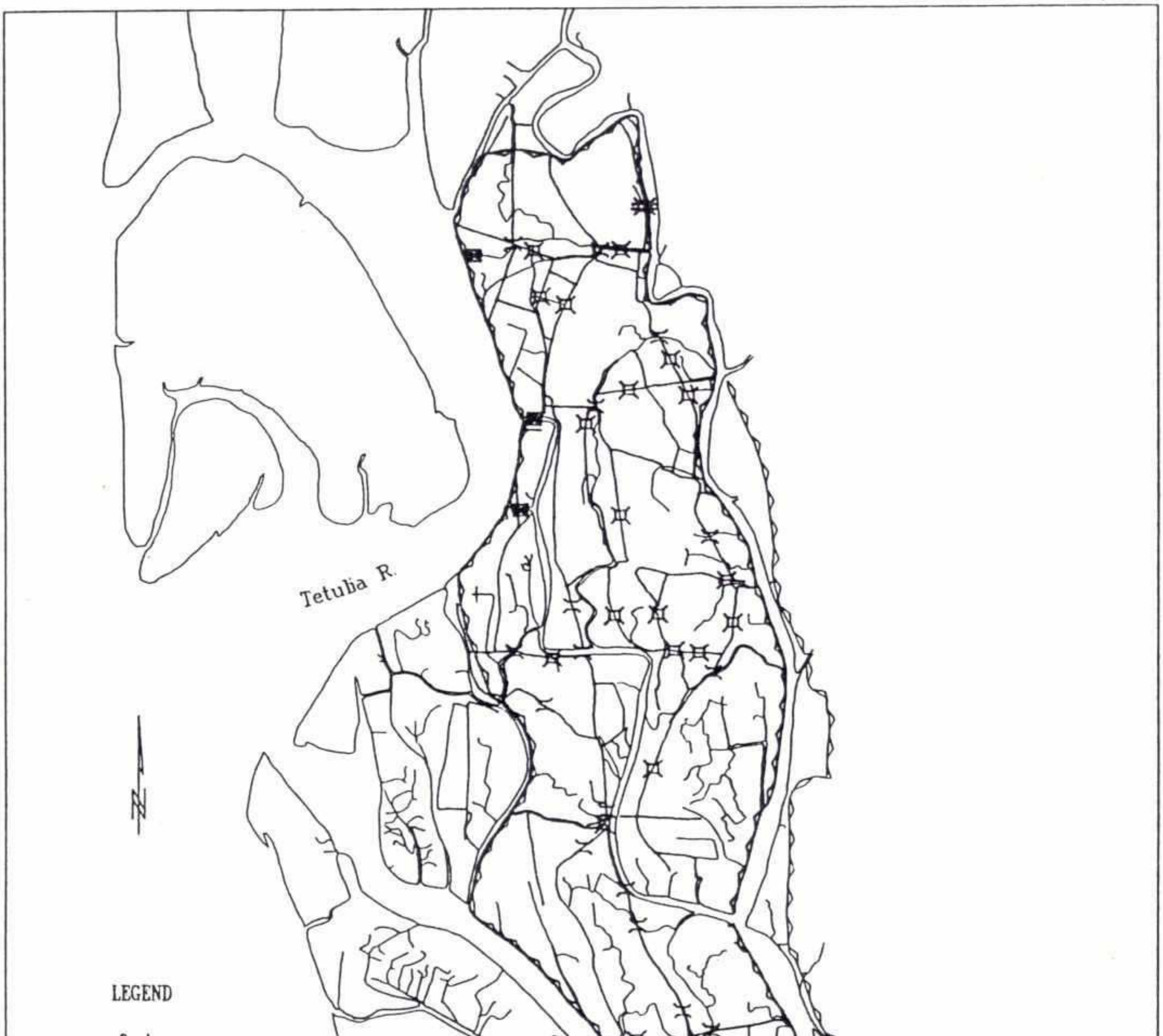
Source: BWDB (1993)

2.5 Project Alternatives

No alternatives to the project have been proposed. Project objectives (Section 2.2) are directed at reducing crop damage by floods, and this would be difficult to effect with any other project approach. Reduction of property damage and protection of human life have not been specified as project objectives.

Consideration of a no-project alternative is included in this impact assessment as a basis for compar-

Map 3



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ison and a basis for estimating project impacts in cases where present baseline conditions are not considered to be stable (e.g., human population growth).

Chapter 3

DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Physical Environment

3.1.1 Climate

The project area has a tropical monsoon climate and falls within a moderate rainfall zone of the country. Mean annual rainfall is about 2,301mm (compared to the national mean of 2,320mm), with 96 percent of the rain occurring between April and October. Temperature of the area begins rising in February/March, peaks in April/May, and remains fairly steady from June to October. The mean summer temperature is 25°C; the daily maximum may rise to 35°C, while the daily minimum is about 17°C. Relative humidity is high throughout the year with a maximum of 90-95 percent during the monsoon. The humidity drops gradually from October and reaches a minimum of 60-65 percent in February/March. Summary climatic data for the area are given in Table 3.1.

3.1.2 Water Resources

River System and Channel Network

The hydrology of the area is dominated by the Tetulia River, a perennial, tidal, and active river which forms the western and southern boundaries of the study area (Map 4). Darogar Khal, at the northwest tip of the project area, links with the lower Meghna and Jangalia rivers to form the eastern boundary. Many *khals* originating from the

Table 3.1 Climatological Data for the Bhelumia-Bheduria Study Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall monthly mean (mm)												
	7	21	50	110	218	438	458	419	302	191	42	10
Temperature mean daily maximum (°C)												
	26	28	32	34	33	32	31	31	31	31	29	26
Temperature mean daily (°C)												
	13	16	21	24	26	26	26	26	26	24	19	15
Relative humidity (%)												
9 a.m.	76	74	74	74	74	83	87	85	83	79	78	78
6 p.m.	60	56	56	66	74	82	83	83	82	77	69	64
Average wind speed (km/h)												
	3.5	4.3	6.5	8.4	9.1	8.9	9.1	7.6	6.0	3.0	2.3	1.9

Source: BWDB (1993)

Tetulia flow inside the project area, the most important of which is the perennial Bheduria Khal. During high tide, water flows northwest from Bheduria Khal, reversing to southeast during low tide; it divides the project into two segments. Other small *khals* and creeks in the area interlink with Bheduria Khal; among the most important is Majhirhat Khal, which connects the Tetulia and Jangalia rivers as well as connecting with small creeks in the northern region. During high tide water enters Majhirhat Khal from both the Tetulia and Jangalia rivers, spreads throughout the northern region, and then recedes back to the small creeks during low tide. An existing road from Majhirhat Khal to Bankerhat divides the area into northwest and northeast regions. The northwest region drains through existing creeks into Bheduria Khal and the Tetulia River, while the northeast region drains through Kheyaghater Khal into the Jangalia River. In the central part of the project area, Chatler, Panditer, and Bheduria *khals* link with the Jangalia, and Bheduria, Kulgazir, and Kamper *khals* link with the Tetulia.

Bharanir, Chatler, and Napter *khals* play important roles in the southern portion of the project area. Bharani Khal is well defined and openly connects with the Tetulia River from its depressed, northern portion. Water from its southern portion first flows through Bharani Khal before discharging into the Tetulia.

Surface Water and Floods

During the monsoon season from July to October, high tides cause flood waters to spill over the banks of the Tetulia and Jangalia rivers. Impacts of flooding include damage to crops (Section 3.2.2) and homesteads (Section 3.2.3). Rainfall aggravates the situation. During low tide, flood waters recede through *khals* and creeks either fully or partially. In some areas, however, high tide flows in again before the previous flood water has receded. Low-lift pumps supply surface water for any needed crop irrigation during the dry season.

Drainage

While drainage congestion is not a major problem in the area, some localized congestion occurs due to accumulated rainwater and tidal flood water. In these areas, drainage is hampered because of insufficient culverts, openings, and linking *khals*, and because of unplanned roads and other types of barricades that obstruct flow.

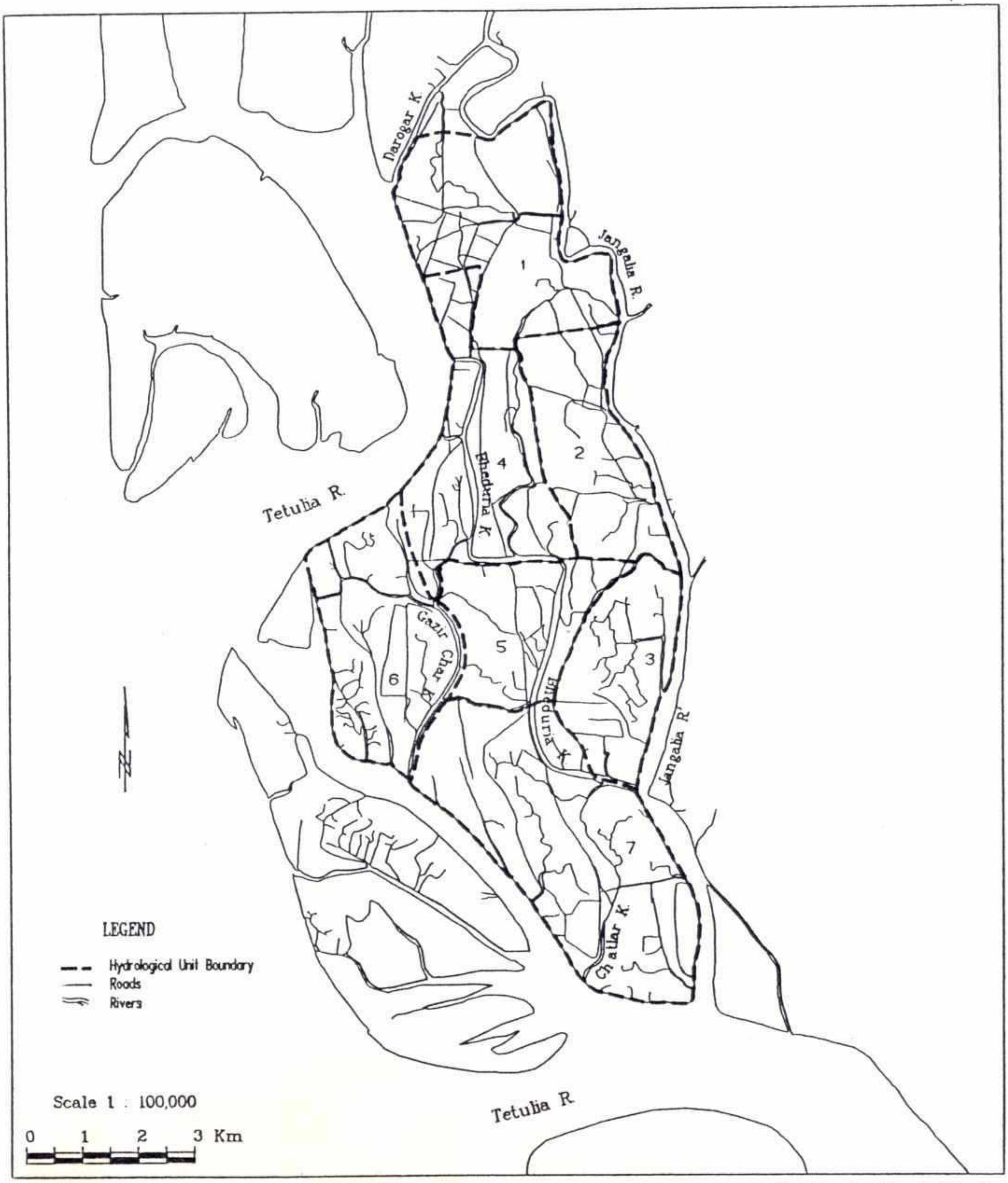
Groundwater

Groundwater is not used for irrigation because of its salinity and because of the abundance of surface water in the project area, but it is used for drinking purposes. Tubewells for drinking water vary from 275m to 370m in depth. There are 468 tubewells in Illisha, Char Samaiya, Bheduria, and Bhelumia unions to serve a population of 56,280, or 8,485 households (Public Health Engineering Bureau 1991).

3.1.3 Erosion and Channel Migration

The study area is located in a dynamic coastal area where erosion, accretion, and channel shifting have been active for millennia. The available Landsat imagery permits examination of such changes for the relatively very brief period of the preceding 20 years. Major erosional and accretional changes have taken place in this period (Maps 5 and 6), with the Tetulia River moving eastward at the rate of approximately 200m/year. The current focus of erosion is just below the mouth of Bheduria Khal where the bank migration rate is estimated to be about 30-40m/year. At the time of the study, the flow of the Tetulia is roughly split in half by the accretion of a large mid-channel char. Marked accretion on the left bank north of the study area is taking place, and the east channel, which borders the project area, could conceivably be shut off within a few years. Channel migrations are notoriously unpredictable in coastal areas, however.

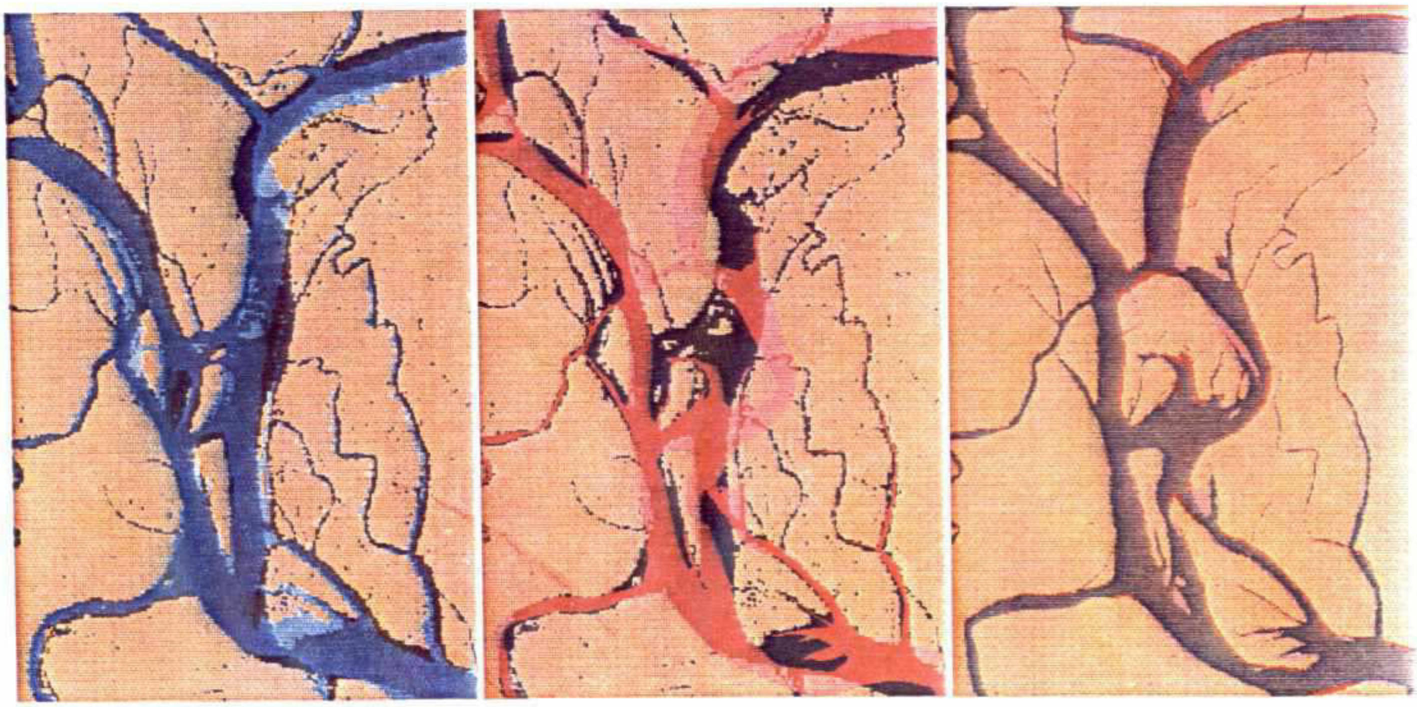
Map 4



ISPAN

Hydrological Units

Map 5



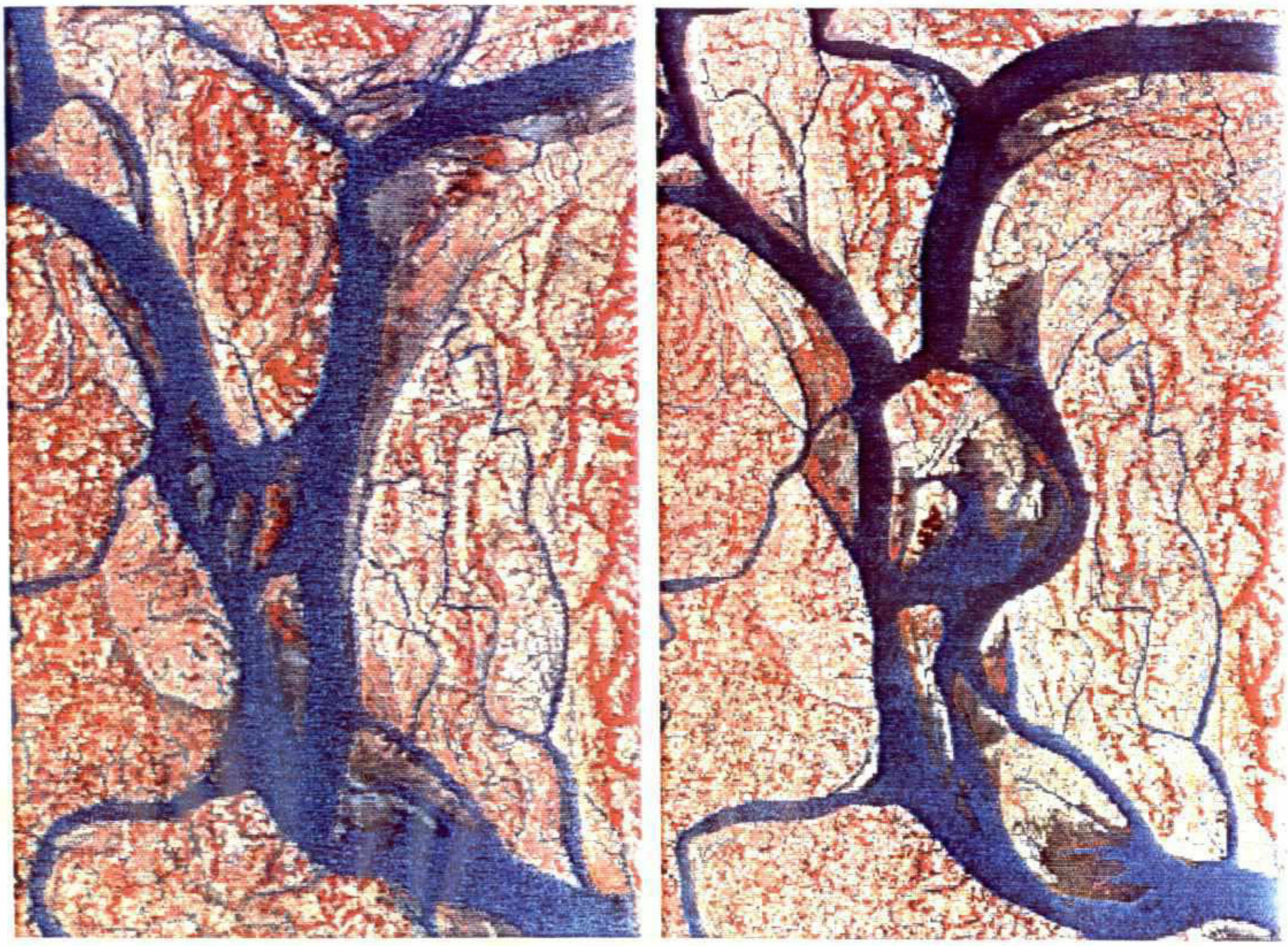
Water in 1973
Water in 1973 and 1979
Water in 1979

Water in 1979
Water in 1979 and 1990
Water in 1990

Water in 1990
Water in 1990 and 1993
Water in 1993

ISPAN Movement of Tetulia River in the Bhelumia Bheduria Area

Map 6



1973 1993

ISPAN Change in Bankline and Charland 1973–1993

88

By contrast to the dynamic Tetulia River, the Jangalia River and Bheduria Khal are stable in their locations, and have shown very little inclination to bank migration within the past 20 years.

3.2 Terrestrial Environment

3.2.1 Land Resources

Land Types

Land types are flood depth phases of floodplain soils. Common practice in Bangladesh is to designate land types according to the maximum flood depths prevailing for a minimum three-day period during the peak monsoon and occurring with an annual probability of about 1:5 (ISPAN 1992a based on MPO 1986). In the EIA case study undertaken for the Compartmentalization Pilot Project at Tangail (ISPAN 1992c) for which GIS was used, maximum water levels prevailing in an average year (i.e., about 1:2.3 frequency) were found to give more realistic results in terms of field verification of land type occurrence.

Application of land type designations and mapping to a coastal area subjected to tidal inundation presented some uncertainties, since maximum water levels during the monsoon season fluctuate diurnally according to the prevailing tides (Figures 3.1, 3.2). The maximum water levels (20-year return period) at the Meghna off-take, Bhola Kheyaghat, and Dhulia are calculated to be 3.80m, 3.79m, and 3.08m above PWD datum, respectively (BWDB 1993); these probably reflect water levels occurring during storm events. Maximum water levels prevailing during the period June through September on a five-year return basis were computed to be 2.63m (normal plot method)

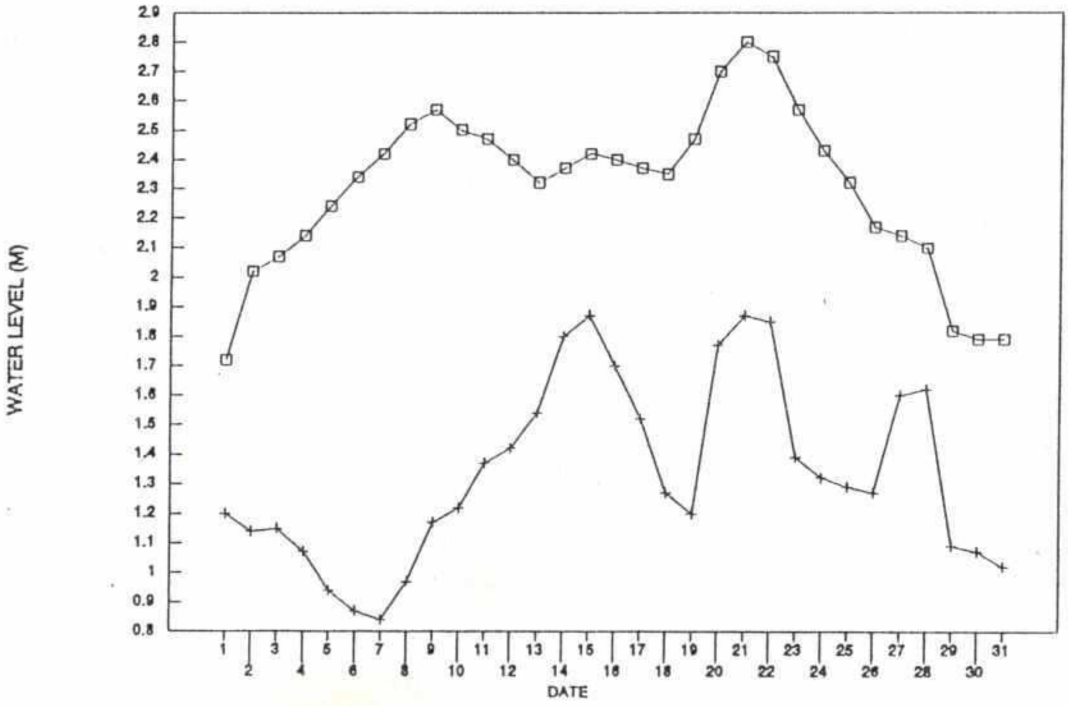


Figure 3.1 Daily highest and lowest water level fluctuations in study area (data from Bhola Kheyaghat gauging station, August, 1991)

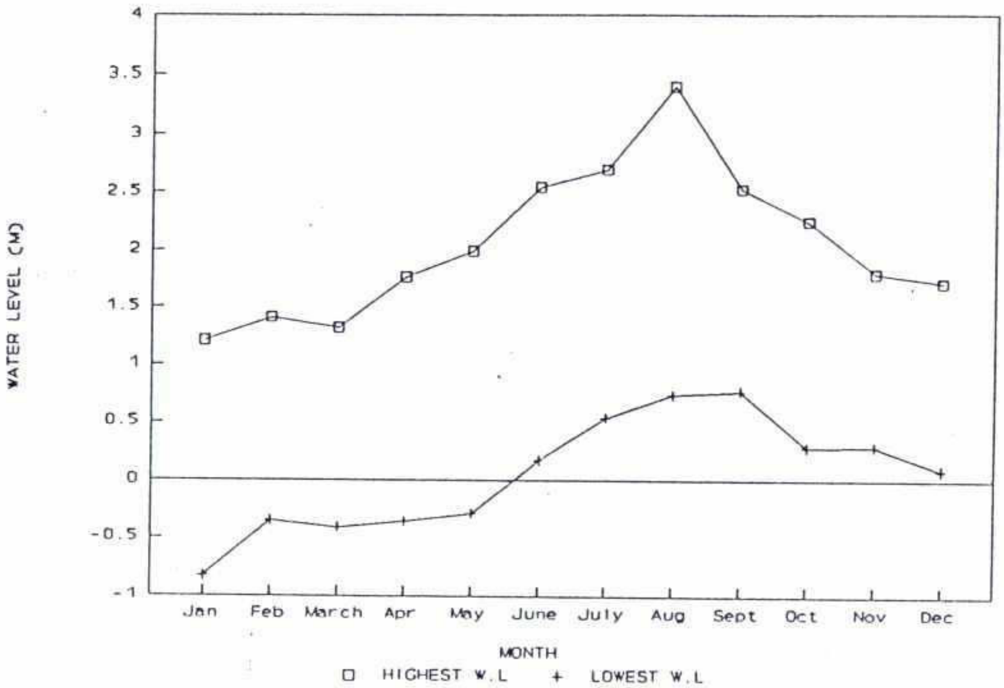


Figure 3.2 Monthly highest and lowest water level fluctuations in the study area (data from Bhola Kheyaghat gauging station, 1987)

and 2.64m (Gumbel probability method). A level of 2.6m was selected as an arbitrary level for the GIS to determine land types according to the presently accepted classification (Annex 3). The resulting land type distribution is shown as Map 7 and summarized in Table 3.2.

Soils

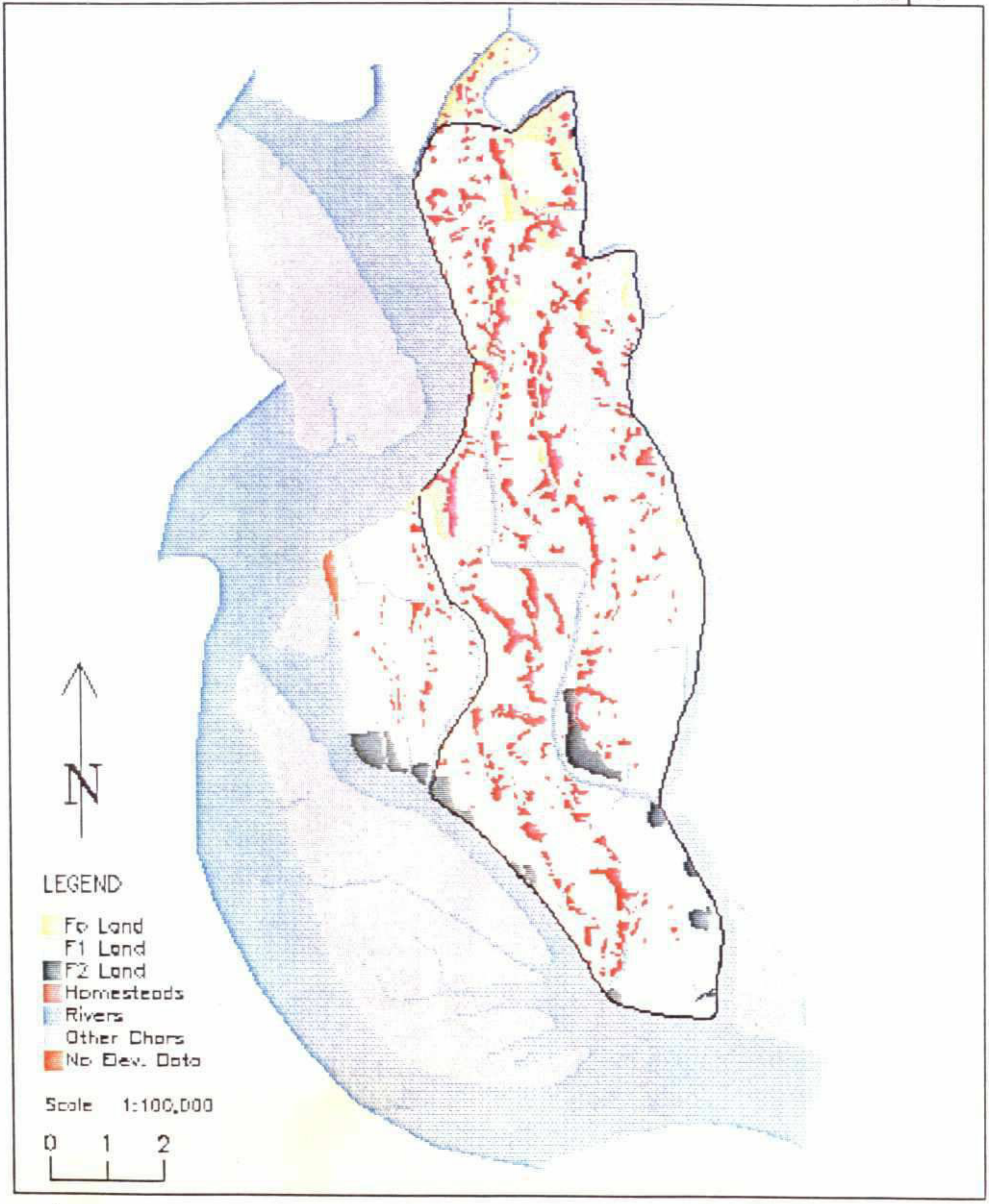
Soil surveys of the Bhelumia-Bheduria project area were carried out by the Soil Resources Development Institute (SRDI) in 1967. Soil association maps prepared for the area as a part of the reconnaissance soil survey of Barisal District shows that the area falls under the Ramgati-Nilkamal soil association. Soil series of the area are developed in alluvial sediments carried down by the Meghna and Tetulia rivers and deposited on the younger, lower Meghna estuarine tidal floodplain.

Table 3.2 Distribution of Land Types in the Project and Study Areas (ha)

Land Type	Project Area	Adjacent Area	Study Area
F_0	287	93	380
F_1	4,061	725	4,786
F_2	129	55	184
F_3	-	-	-
Sub-Totals	4,477	873	5,350
Settlements	686	71	757
Canals and Creeks	143	38	181
Miscellaneous	-	92	92
Totals	5,306	1,074	6,380

Source: FAP 19 GIS

Map 7



ISPAN

FLOOD EXTENT FOR WATER LEVEL OF 2.6m

The soils of the area occupy flat tidal landscapes, with general patterns of olive grey to grey, calcareous, loamy soils on the ridges, and grey to dark grey, calcareous, silty clay loam soils in the basins. Ramgati soils cover about 50 to 60 percent of the cultivable area and occupy the ridges of the project area. They are of a friable and weak prismatic structure and are stratified in places. Nilkamal soils, which occupy the basin sites, or about 30 to 40 percent of the area, are of a firm, blocky, and moderately strong prismatic structure. Most of the soils are poorly drained, moderately permeable, have high to moderate moisture holding capacity, and are low in nitrogen and potassium. There is moderate phosphorus and zinc content in Ramgati soils, but little in the Nilkamal series. All other essential nutrients occur in moderate to high levels (Annex 4). Such a nutrient makeup requires balanced fertilizers for a high production level as well as the use of modern soil and crop management techniques.

About 97 percent of the project area is good agricultural land and includes highlands of the Ramgati soil series and medium highlands of the Ramgati and Nilkamal series. Moderate agricultural land makes up about 3 percent of the area on medium lowlands of the Nilkamal series.

3.2.2 *Agriculture*

Crops

Agricultural production in the area is limited by sudden, high tidal water levels at full and new moon during the monsoon season. Moderately flooded Nilkamal soils often become congested and remain wet early in the dry season, preventing the growth of *rabi* crops. Due to unfavorable hydrological conditions, Nilkamal soils on medium highlands (F_1) are not suitable for growing HYV transplanted *aman*, and local transplanted *aman* is preferred. During the dry season, *rabi* crops grown in the area suffer drought that reduces the yield of crops, and soils along the southern coast become slightly saline late in the dry season; this reduces *rabi* crop yields.

The hydrologic regime dictates area cropping patterns (Table 3.3, Map 8). *Aus*, grown during

Table 3.3 Cropping Patterns per Land Type in the Bhelumia-Bheduria Project Area

	Area Under Cropping Patterns (ha)			
Cropping pattern	F_0	F_1	F_2	Total
T. Aman (H) - Rabi crop	250	-	-	250
T. Aman (L) - Rabi crop	20	-	-	20
B. Aus (L) - T. Aman (H) - Rabi crop	17	267	-	284
T. Aus (L) - T. Aman (L) - Rabi crop	-	181	-	181
T. Aus (H) - T. Aman (L) - Rabi crop	-	65	-	65
B. Aus (H) - T. Aman (L) - Rabi crop	-	194	-	194
B. Aus (L) - T. Aman (L) - Rabi crop	-	1,398	-	1,398
T. Aman (L) - Boro crop	-	555	-	555
B. Aus (L) - T. Aman (L)	-	908	115	1,023
T. Aman (L)	-	493	14	507
Totals	287	4,061	129	4,477

Source: Field Survey, 1992

8a

kharif 1, followed by transplanted *aman* during *kharif 2*, are the dominant crops on all land types. Non-rice crops dominate in the *rabi* season when only 13 percent of the cultivable land is planted in HYV *boro* crops. Low-lift pumps provide river water for irrigating *boro*. Local varieties of rice are commonly grown during the *kharif 1* and *kharif 2* seasons. Six percent of cultivable land is under HYV during the growing period of *aus* and 12 percent is under HYV during the *aman* growing period. Farmers generally grow HYV cultivars IR-8, BR-3, BR-10, BR-11, and BR-14. Unfavorable hydrological conditions prevent expanding HYV production during the monsoon season. Total crop production comprises yields from both normal and damaged crops (Annex 5). Current cereal production is 10,953 tonnes per year, including paddy and wheat. The cropping intensity of the net cultivable area is about 236 percent. Each year, about 2,783 tonnes of paddy are lost to tidal floods and 1,475 tonnes are damaged by pests and diseases. Cereal production adjacent to the project area has been estimated at about 2,173 tonnes per year, including wheat and paddy.

Tidal floods damage *aus* crops during harvesting in June and July, while T. *aman* is submerged soon after it is transplanted during July and August. Submergence generally is more acute during the full and new moon, especially when accompanied by heavy rainfall and wind. Localized drainage congestion aggravates crop loss during the monsoon season. Again, transplanted *aman* crops are damaged by storm surges during harvest in October and November. Early tidal flooding damages late *rabi* crops, mainly chili, along the Tetulia River and damages *boro* crops at the harvesting stage. Pests and diseases are widespread in the area, causing significant damage to major crops. About 28 percent of *aus* and 20 percent of *aman* are damaged by tidal floods, while insects and pests damage another 22 and 20 percent, respectively, inside the project area. Flood-related crop damage is slightly higher in the study area than outside the project (Annex 5, Maps 9-11).

Current input levels of human labor, animal power, seed, and fertilizers in the project area are generally low, particularly with crops that are vulnerable to flood and drainage damage. Inputs for different crops are presented in Annex 6.

Livestock

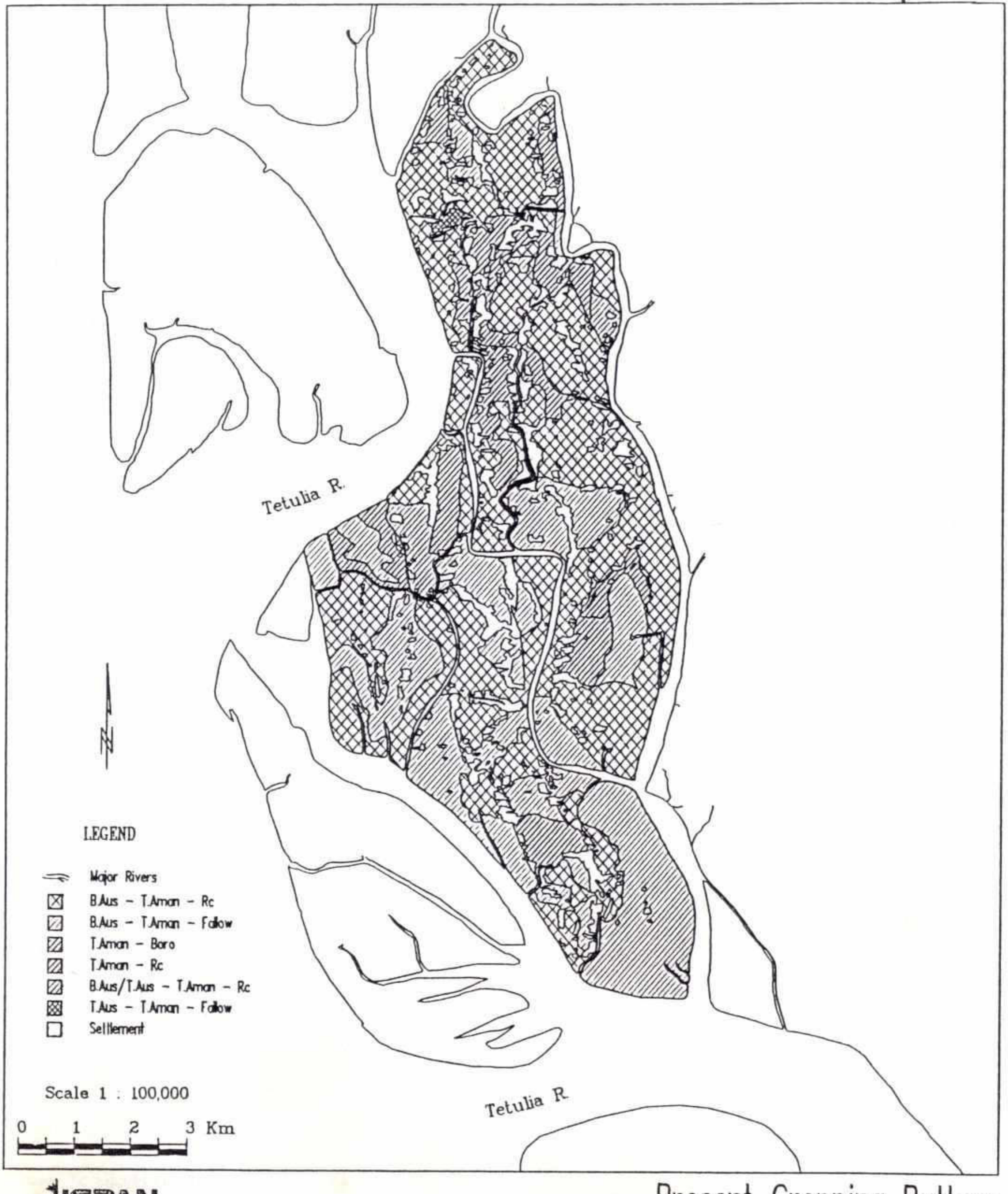
A few livestock are kept in most rural households (Table 3.4). Bullocks, buffaloes, and cows are kept primarily as draft animals; goats, chickens, ducks, sheep, and pigeons are kept for income and as a protein source. Livestock holdings per household range from 0.25-0.76 animal units, and chicken and duck holdings are 10.3 and 4.5 per household, respectively. Because there is a shortage of draft animals in the project area, farmers often use milk cows and calves to plough their land. Draft power availability in the project area is only 1.5 per ha compared to the national average of 2.6. Small farmers who cannot maintain draft animals hire them at Tk. 125/*kani* (0.65 ha). Power tillers are used by some farmers.

Table 3.4 Livestock Population in the Bhelumia-Bheduria Study Area

Species	Total No.	No. owning Households	Av. No./ owning Household
Buffalo	108	432	0.25
Bullock	204	425	0.48
Milk cow	161	424	0.38
Calf	152	422	0.36
Idle cow	54	415	0.13
Goat	166	426	0.39
Chicken	4349	424	10.26
Duck	1892	424	4.46
Sheep	7	350	0.02
Pigeon	318	424	0.75

Source: Household Baseline Survey, 1992

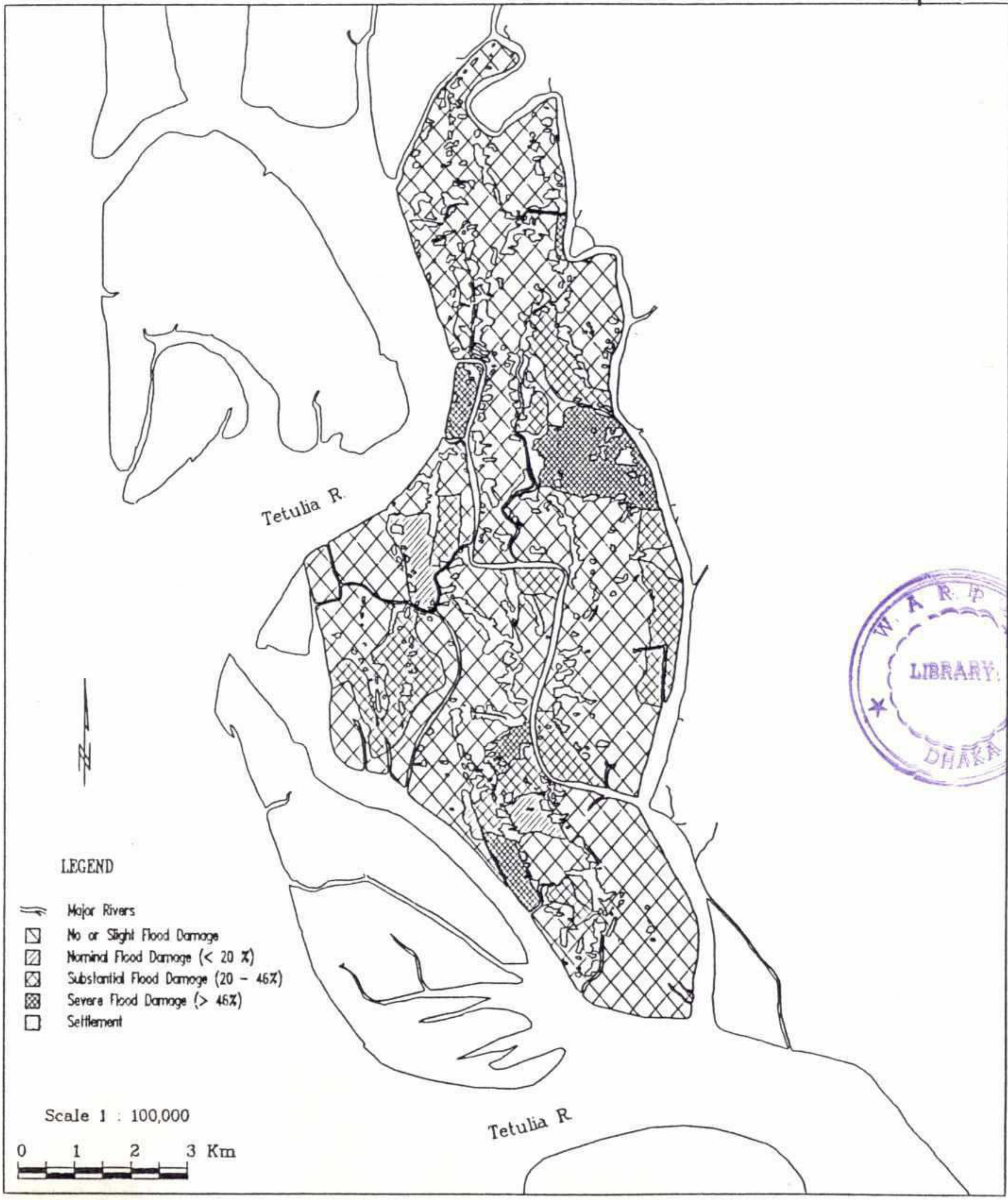
Map 8



ISPAN

Present Cropping Pattern

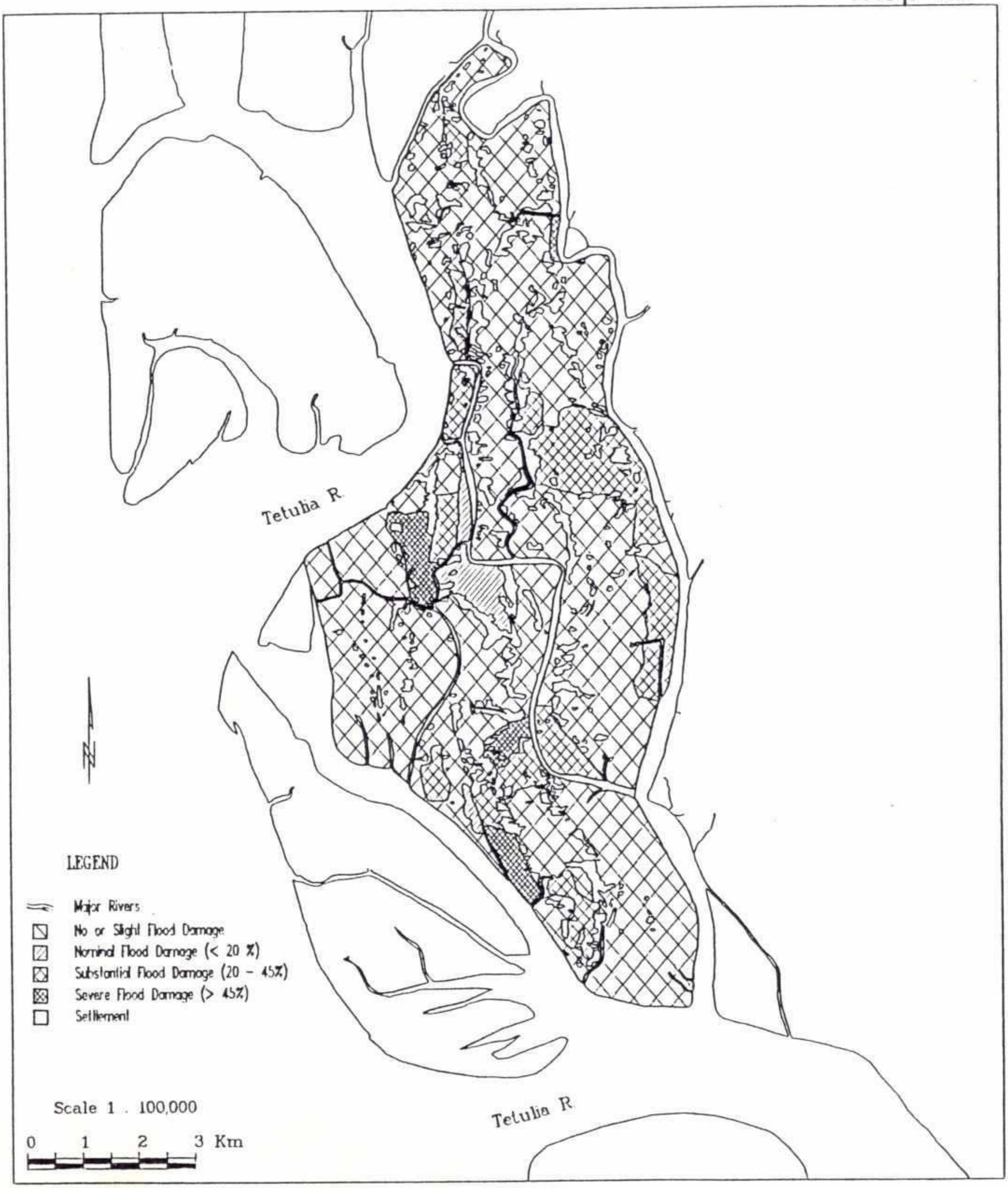
Map 9



ISPAN

Aus Crop Damage from Floods

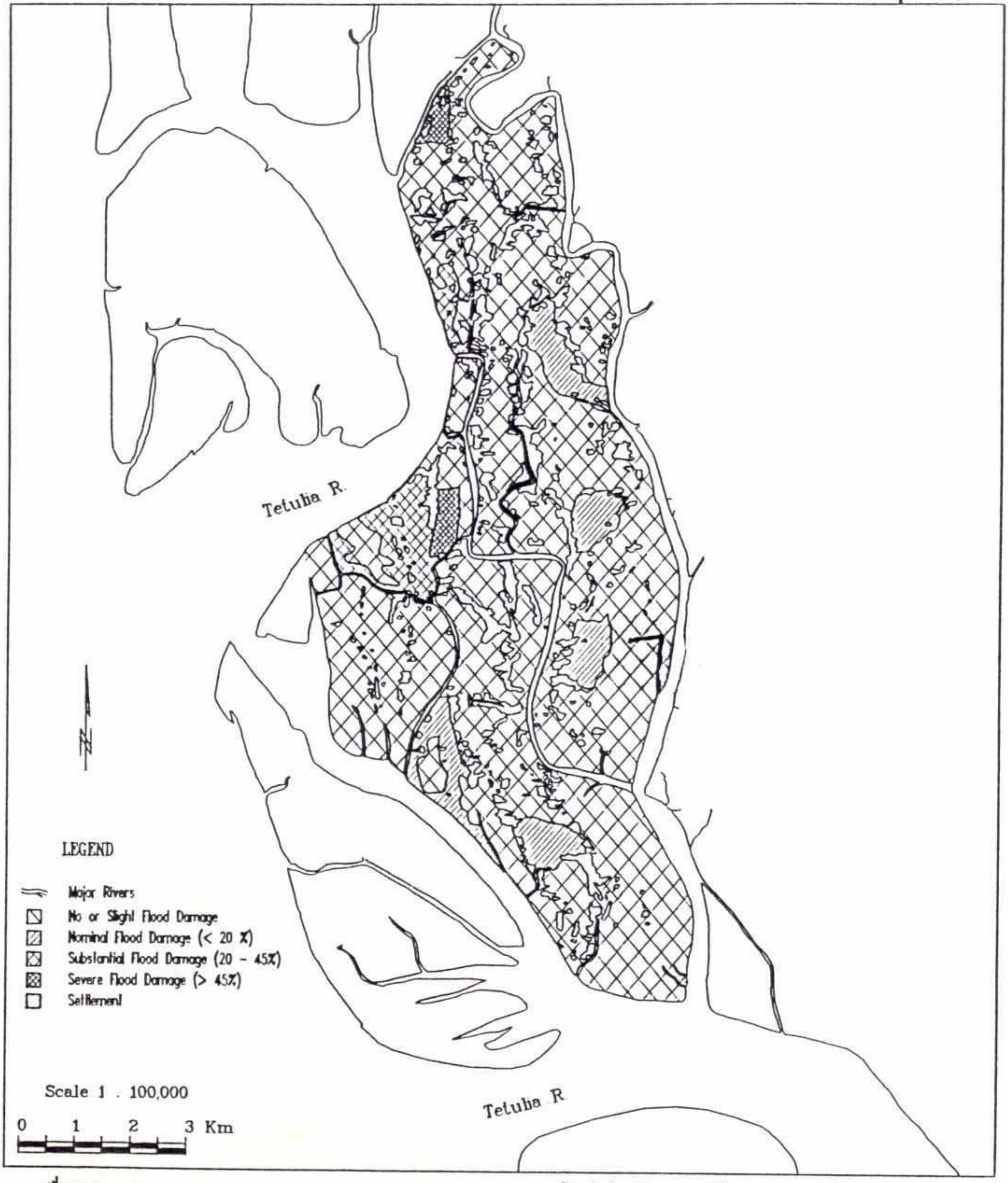
Map 10



ISPAN

Aman Crop Damage from Floods

Map 11



ISPAN

Rabi Crop Damage from Floods

Most livestock are inadequately fed due to a shortage of grazing land. The situation improves during the dry season when major crops are harvested and some of the pulse *(khesari)* crop becomes feed for grazing animals. In the rainy season, livestock are usually confined to the homestead and stall fed. Few cattle and bullocks graze year-round along roadsides and riverbanks.

Livestock disease and epidemics are common in the area. Bullocks and cows primarily suffer from diarrhoea and rheumatism. Farmers report that these diseases become epidemic when salinity levels rise in the rivers and *khals*. During the monsoon season, the soggy condition of homestead courtyards promotes foot and mouth disease in cattle. Farmers prefer roads over courtyards as animal shelter because they dry faster, therefore offering a more hygienic environment.

3.2.3 Forests and Homestead Vegetation

Forests and homestead vegetation play an important role in the environmental balance and economic life of the people in terms of food and nutrition, construction material, biomass fuel, fodder, shelter and shade, windbreaks, organic matter, erosion control, and the balance between flood and drought. This vegetation is vulnerable to damage by flooding. Flood is traditionally classified into *barsha*, normal inundation from June-October which does not overtop the homestead land or submerge *aman* crops, and *bonnya*, disastrous and damaging flood of long duration that overtops homestead land and damages *aus* and *aman* crops during the *kharif* season (Islam 1990), and results in physical and economic damage to the people and land (Zaman 1992).

Forests

The project area does not have any public forest land, limiting plant diversity to a few site-specific species. About 10 percent of the river, canal, and creek banks were found to be covered with tall reeds of *hogla (Typha* spp.) and *kash* (*Saccharum* spp.), two economically important coastal/swamp species. *Hogla* is used in the production of mats, roofing and fencing, as biomass, and provides mat-making employment for about 10 percent of the area's women. *Hogla* mats are used mainly for sleeping and sitting and for drying agricultural produce. Fish brokers also use the mats to pack iced fish. Fifty percent of households use *kash* as house construction material and as biomass fuel. An important medicinal herb, locally known as *bashok (Adhatoda vesica)*, was found growing under homestead groves, as live fencing material, and as roadside vegetation.

As the majority of the area is prone to high tides and tidal surges, tree plantations are restricted mainly to roadsides that usually rise about 120cm above the paddy fields. A tree planation project, begun in 1992 by a local NGO known as Jatyo Bandhujan Parishad, planted trees along 33km of roadside in Bhelumia, Bheduria, and Char Samaiya Unions. Two caretakers were employed to tend the 1,000 mahogany, *sisoo, chambol, koroi* (raintree), *akashmoni, arjun,* and jackfruit saplings. Each caretaker receives 4.5 kg of wheat daily for his/her work and is responsible for replacing any damaged seedlings. However, no benefit-sharing agreement has been developed between the NGO, local government, caretakers, and adjacent households. Villagers are aware that the plantation program will bring economic benefits, but they see negative impacts in losing the use of roadsides as livestock shelters during floods.

Homestead Vegetation

Homestead mounds in the area are not raised high enough to completely avoid flood inundation from the river and canal banks. Approximately 81 percent of homesteads are affected by high water about five times annually (Figure 3.3). About 51 percent are affected by seasonal floods, 15 percent by seasonal floods plus high tide floods, 13 percent by high tide floods only, and the remaining 2 percent by heavy rainfall, seasonal floods, and tidal floods. About 70 percent of the affected homesteads are inundated up to the courtyard level, including vegetable gardens, while 11 percent are inundated up to the plinth.

Forest and homestead vegetation includes natural vegetation, plantations, and homestead groves and vegetable gardens. Annex 7 lists the scientific names of economically important species of trees, shrubs, and herbs.

Homesteads are arranged in linear, clustered, and nuclear forms and each homestead ranges in size from 0.09 ha to 0.18 ha. The proportionate distribution of homestead land for housing, vegetable gardening, ponds, and orchards was noted to be 16, 7, 25, and 52 percent, respectively. Homesteads generally are bordered with live fences of *mandar, jhiga,* betelnut, and *bashok* species. About 50 percent of homesteads are more than 20 years old and have many tree species, of which betelnut is the dominant cash fruit crop, and raintree and *mandar* the dominant cash timber trees and biomass resources. The other 50 percent of homesteads range from one to 19 years old, are found in comparatively low-lying areas, and have little species diversity. Wild banana varieties and *mandar* are commonly planted when new homestead areas are established. Villagers reported that during the preceding 10 years more than 10 percent of the area's marginal crop land has been converted to homestead land.

Among the 57 economically important tree species listed in Annex 7 the most important are betelnut (occurring in 27 percent of homesteads), *bitchi kala* (23 percent), *mandar* (15 percent), and raintree (7 percent). The other 48 species occurred infrequently, these included trees resistant to normal inundation such as palm, date and coconut.

Betelnut is planted most often as it is the most important cash crop of all planation trees in the area. Since it is susceptible to waterlogging and drought, it is mainly planted in the high elevation areas of Pangasia, Char Samaiya, Char Bheduria,

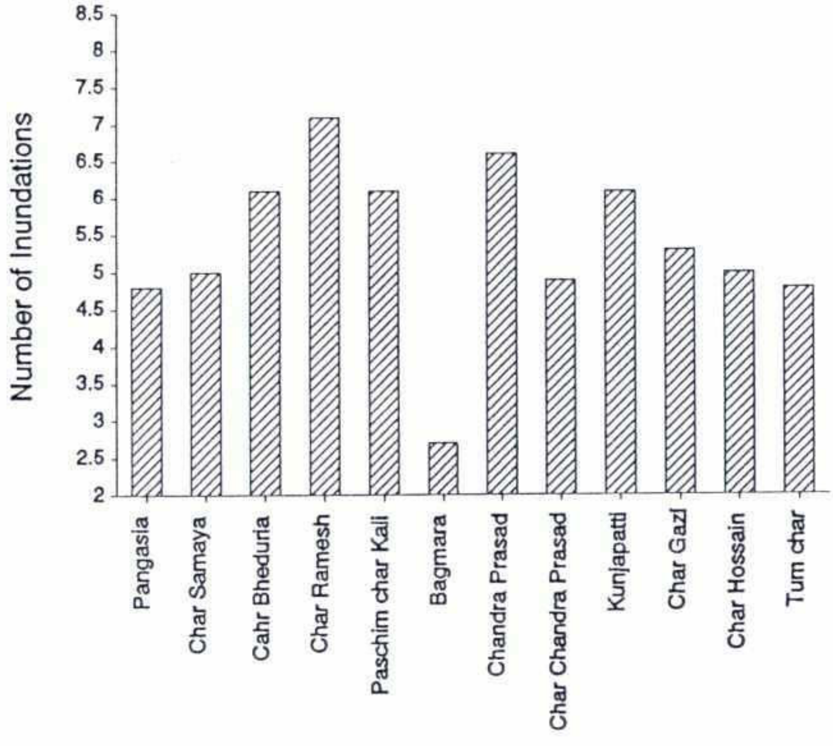


Figure 3.3 Average annual frequency of homestead flooding
(Source: Household Baseline Survey, 1992)

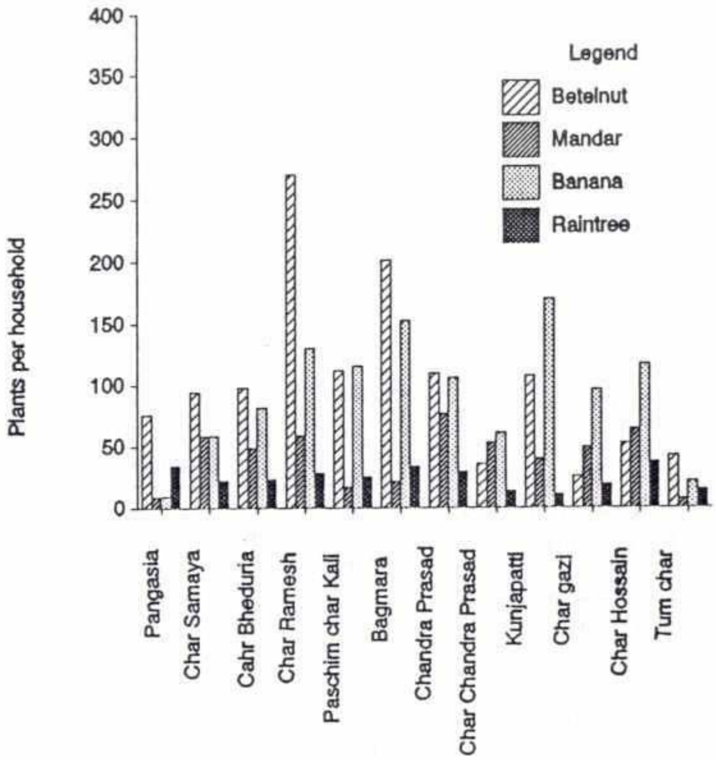


Figure 3.4 **Relative abundance of homestead vegetation species**
(Source: Household Baseline Survey, 1992)

Char Ramesh, and Bagmara (Figure 3.4). Indigenous varieties of banana are grown in the depressed and low elevation areas of Kunjaputti, Char Hossain, and Char Gazi. Bamboo, nationally the most important cash vegetation crop and an important source of construction material, is difficult to establish in the study area because frequent inundation and waterlogged soils damage its shoots and roots.

In 52 percent of orchards a combination of *mandar* and betelnut is grown for commercial use. *Mandar* is a leguminous species whose leaves are considered rich organic fertilizer for betelnut cultivation. Each betelnut tree can yield an income of Tk. 100 annually, and each *mandar* tree Tk. 50 annually. *Mandar* branches are often used to build fish shelters and sell for Tk. 5 each; a single *mandar* tree can produce at least 10 branches. The percent of households possessing different tree species is noted in Annex 7.

Only 7 percent of typical homesteads grow vegetables such as sweet potatoes, string beans, gourds, and spices. Important cash vegetables in other parts of Bangladesh such as cauliflower, cabbage, and *arum* (elephant's foot) are not grown in the area because of repeated inundation, while early *rabi* vegetables cannot grow in the saturated soils. In Char Samaiya, Char Bheduria, and Char Ramesh, villagers raise sweet potato seedlings and some winter vegetable such as spinach, amaranths, and radish on roadsides.

Because of the limited homestead vegetable production, about 75 percent of common fruits, vegetables, and spices in the area come from other parts of the country, mainly Dhaka, Noakhali, Barisal, and Khulna. The poor local economy, however, prevents about 60 percent of the villagers from buying imported vegetables; these people mostly depend on locally produced sweet potato and black gram that are neither nutritious nor tasty. Although the banana crop ranks second in planted numbers, and ideally could provide another food source for local people, it does not produce optimum yields because of frequent flooding and waterlogged soils.

Table 3.5 summarizes the production value of fruit, vegetables, timber, and fuel wood of the area, which totals about Tk. 29 million. Betelnut is a major contributor to the value of vegetables and fruit, while *mandar* and *koroi* (raintree) contribute to that of timber and fuel wood.

Table 3.5 Average Annual Production and Damage Loss of Vegetables and Trees

Production Sources	Value (Taka)
Total Actual Production	29,138,860 (100%)
Vegetables and Fruits	19,352,980 (66%)
Timber and Fuel Wood	9,785,880 (34%)
Average Damage Loss	2,254,660 (8%)
Potential Production	31,393,520

Source: Household Baseline Survey, 1992

Energy Use

Energy use differs between mouzas of the Bhelumia-Bheduria project area (Annex 8.1). Over 80 percent of fuel energy in the Bhelumia-Bheduria project area is provided by rice straw (43 percent) and firewood (38 percent). The remaining 19 percent comes from leaves and twigs (14 percent), *dhaincha* (*Sesbania canabina*; 3 percent), cow dung (0.6 percent), and rice husks (<0.5 percent). Fuel sources in the Bhelumia-Bheduria area differ considerably from the national pattern of cow dung (27 percent), jute stick (5.5 percent), *bagasse* (9.7 percent), twigs and leaves (10.1 percent), rice husks (19.3 percent), rice straw (14.7 percent), wood (3.8 percent), and other (10.1 percent) (BBS 1993). Information on indigenous fuel sources and their respective energy efficiency in terms of calorific value by weight are presented in Annex 8.2.

Based on a national minimum fuel requirement of 10 kg/day/household (Hossain and Mahfuzur 1993), the study area, with its current population of 48,196 (8,827 h/h) needs about 32,335 tones of biomass energy annually (Table 3.6). The current fuel shortage results in householders cooking one meal a day. As rice straw provides 43% of fuel energy, fuel shortage becomes severe when there is crop failure.

Table 3.6 Average Requirement, Production, and Shortages of Biomass Energy

Status	Quantity (tonnes/year)
Requirement	32,335 (100%)
Available	24,258 (75%)
Shortage	8,077 (25%)

Source: Household Baseline Survey, 1992

3.2.4 Wildlife

Of the 152 wildlife species observed in the area (Annex 9), most are wetland-dependent species such as shoreline birds and turtles. Turtles are abundant in the area and are commercially valuable on the international market. Other wildlife species, such as rodents and grain-eating birds, are considered pests. Seven threatened (monitor lizard, yellow lizard, white-backed vulture, bull frog, grey heron, little grebe, grey headed fishing eagle) and five endangered species (changeable hawk eagle, Pallas' hawk eagle, brown fish owl, large whistling teal, gangetic dolphin) occur in the area.

The area's wildlife can be grouped according to habitat distribution patterns:

- Shoreline species (concentrated in the mud flats of rivers, canals, and creeks).
- Woodland species (found throughout the area).
- Pest species (found on agricultural land).

- Predators (concentrated in the central part of the study area).
- Commercially important species (found in canals, creeks, and ponds).

Habitats

During the pre- and post-monsoon seasons, roughly 50 percent of the study area is available as terrestrial habitat in the form of homestead, roadside and shoreline vegetation, and agricultural land. The figure drops to 30 percent during high tide in the monsoon season. Within the terrestrial habitats there are 58 plant species that are considered economically, socially, and ecologically important.

Betelnut is the dominant tree in the study area. Of an estimated 50,000 betelnut trees established in the project area, 30 percent are full grown, 22 percent are of medium growth, and 48 percent are seedlings (proportions estimated from household questionnaires). Banana is the second most abundant species, followed by *mandar,* bamboo, raintree, mango, jackfruit, and coconut.

Betelnut is primarily found in the upper and central regions of the study area where it is grown on comparatively higher lands. Banana trees are found more often in the southwestern part of the study area, primarily in new settlements. *Mandar* in grown mostly in the southeast in low-elevation areas. Plant diversity is highest in the central part where about 42 species have been observed. In the west the number of plant species drops below 30, and in the east the number varies between 30 and 40 species.

Roadside vegetation comprises two broad categories: trees and vegetables (e.g., pulses planted by the NGO Jatyo Bandhujan Parishad). Trees planted along roadsides include mahogany, *sisoo, chambol, koroi* (raintree), *akashmoni, arjun,* and jackfruit saplings, and constitute good habitat for common village birds. The area's vast mud flats are used as breeding and feeding habitat by different shoreline birds. Shorelines of the rivers, canals, and creeks are partly covered with the reed *hogla (Typha* spp.), while various species of grass such as *kash (Saccharum* spp.) dominate the shorelines. Some of the shoreline is used as seed bed for *boro* rice. Agricultural land supports both granivorous and insectivorous wildlife, but cropping patterns and seasonal variations in crops influence the biological activities of the area's wildlife.

Shoreline Wildlife

Long shorelines along the rivers, canals, and creeks are home to resident and migratory birds such as herons, egrets, sandpipers, plovers, redshanks, greenshanks, and other common wading birds. Bitterns use the mud flat areas as feeding grounds and the adjacent reeds *(hogla)* as nesting places. Herons, cormorants, and egrets, which have established three colonies within the study area, nest in the tall trees of the homesteads. One of the three colonies is a combined colony of the three species, and includes the rare night heron.

Woodland Wildlife

Woodland wildlife are the common village wildlife that are found in or near homesteads, and include the endangered changeable hawk eagle and Pallas's fishing eagle. Some of these woodland species are beneficial to pest control. The drongo, myna, and warbler aid in agricultural insect pest control, while eagles, owls, kites, monitor lizards, foxes, mongooses, and snakes help control rodents and other vertebrate pests.

Pests

Four species of rats, of which the bandicoot rat is most common, are the primary agricultural pests in the study area; they damage an estimated 4.5 percent of paddy yield (Agricultural Officer, Bhola, pers. comm.). The rat breeding season follows the *aman* growth and cropping season. Another 2 percent of rice yield loss is attributed to birds such as parakeets, munias, weaver birds, and house sparrows.

Predators

Kites, eagles, and owls are the most common predators of the area, and they play an important role in keeping agricultural pests under control. Other important predators include lizards, snakes, frogs, and mongooses.

Commercial Important Wildlife

Turtles are the most commercially important wildlife of the study area; four species were identified during the case study. Most turtles breed in neighboring char areas during the dry season, then migrate to the study area via the southern canals during the monsoon. Turtles are caught with hooks from rivers and canals, and with harpoons from ponds. Although only a few people are involved in collecting turtles, four to five tonnes per year are collected from the study area, bringing Tk. 300-400/kg depending upon the size and variety. Most of these turtles are exported, both dead and alive. Other commercially important wildlife include frogs, monitor lizards, and snakes, but their collection is banned by government regulation.

3.3 Freshwater Environment

3.3.1 Habitats

Numerous major canals, branch canals, and creeks cross the study area. Major canals originate at the Tetulia and Jangalia rivers and divide into numerous branch canals and smaller creeks. Creeks provide the best shelter and rearing grounds for shrimp and other fish in their early growth stages. Low-elevation lands which retain water and are not cultivated due to large accumulations of water hyacinth or because they are not agriculturally productive are common in the area and constitute good fish habitat; fish are collected once a year from these areas.

Two types of tidal influences affect wetlands: normal tide and high tide during full or new moon. Water depth in the different water bodies fluctuates within 1 m four times a day due to normal tides. During high tides the water depth fluctuates 1-2 m every 4 or 5 days. The magnitude of these two tides differs between the monsoon and non-monsoon seasons, and can rise suddenly during a storm surge. Regardless of the season, the flow direction of water remains the same: south to north during high tide and the opposite during low tide. The extent of seasonal flooding in the study area is shown in Map 12.

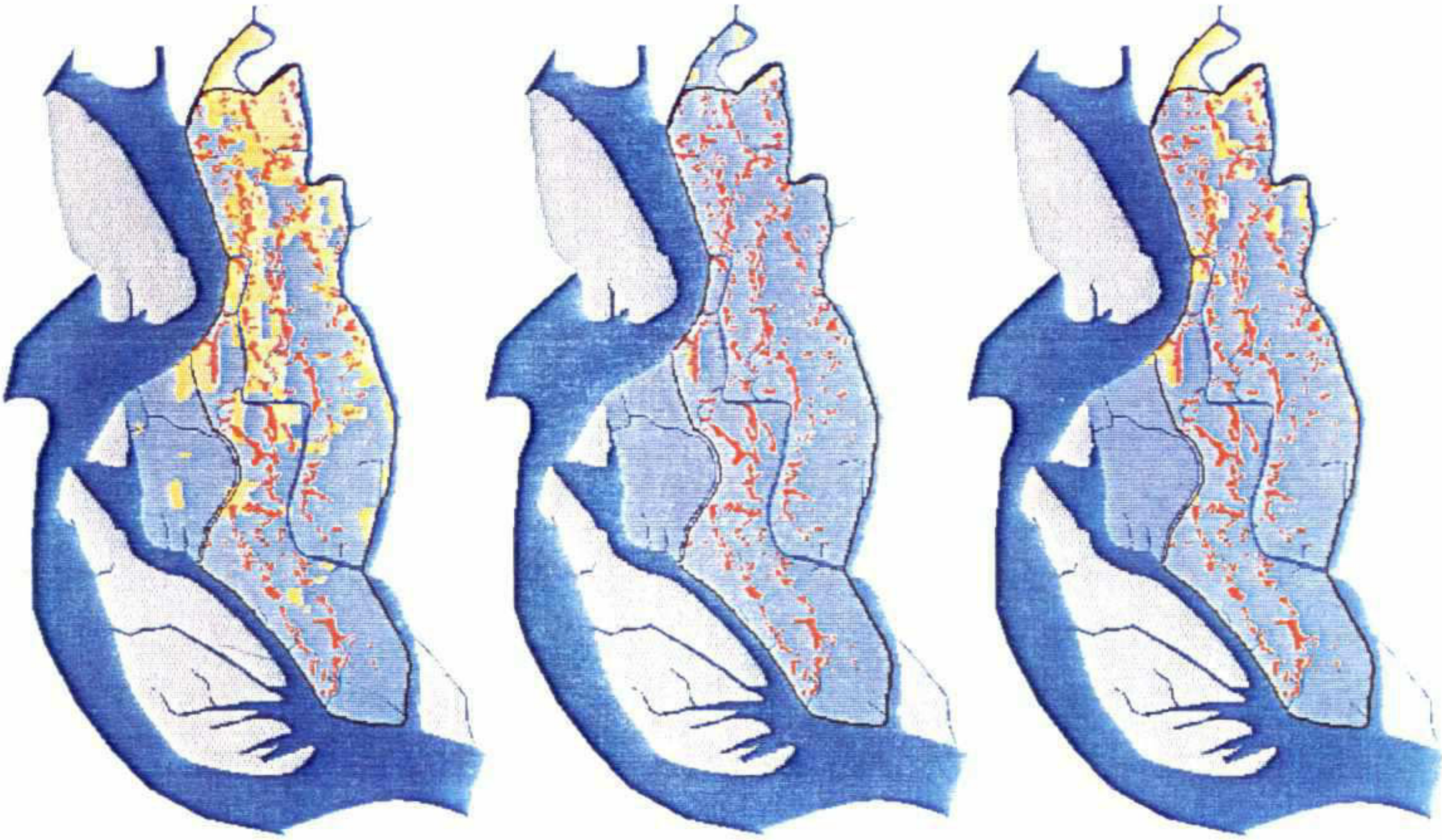
3.3.2 Plankton, Macroinvertebrates, and Macrophytes

A detailed species list of aquatic fauna and flora appears in Annex 10. Creeks were found to have the highest diversity and balanced distribution of plankton. Blooms of *Microcystis* are found in some ponds and stagnant waters of the floodplain areas, and great concentrations of these blooms negatively impact aquatic habitats, causing lower production. Algal blooms do not form in the creeks due to water flushing. Concentrations of most phytoplankton are low due to turbid water. Ponds are usually edged by trees that reduce the light reaching the water surface, creating favorable conditions for large populations of zooplankton. The area's macroinvertebrates include fresh water clams, snails, annelids, and a wide variety of insect larvae. Fresh water crabs are common along the shoreline of rivers and canals.

About 20 species of aquatic macrophytes were identified during the case study (Annex 10). *Typha* spp. (*hogla*) is the most common macrophyte found along the shoreline of rivers and canals; it also is observed along pond banks. As noted earlier, *hogla* is important in the rural economy in terms of mat-making; it also provides shelter for shoreline birds. Low *boro* area wetlands have the highest diversity of aquatic macrophytes, and are dominated by water hyacinth.

Map 12

PRE MONSOON | MONSOON | POST MONSOON



2.34 m | 2.8 m | 2.46 m

Area Submerged
> 20 cm depth

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AQUATIC HABITATS

3.3.3 *Water Quality*

The water quality parameters in canals, ponds, and rivers are similar, except that chloride concentrations are comparatively high in ponds. Although large quantities of pesticides and fertilizer are used during all cropping seasons, these pollutants are washed away by tides, effectively keeping water quality suitable for fish as well as human use. Some locations in the central part of the study area do not receive this flushing effect, except during the peak monsoon season. The long-term effect in all areas may involve an increasing concentration of agricultural pollutants and consequent problems for fish. Water quality parameters in the Bhelumia-Bheduria study area are shown in Annex 11.

3.3.4 *Open Water Capture Fishery*

About 63 species of fish have been observed in the area (Annex 12), including 25 species of small fish, 15 species of catfish, six of carp, six of predators, six of *hilsha,* three of eel, and two of shrimp. There are two exotic species and one species of tongue fish. *Hilsha* and one species of fresh water shrimp are the most common, commercially important fish. Other common fish, but not as commercially important, are predators *boal, aire, pangas,* and one small fish, *chewa.* About 50 percent of all fish are collected from canals, while 25.5 percent are caught in the Tetulia and Jangalia rivers (Figure 3.5).

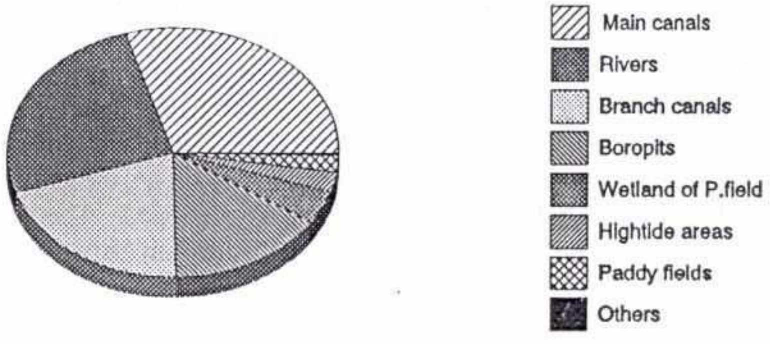


Figure 3.5 Distribution of fish sources in Bhelumia-Bheduria study area
(Source: Field Survey, 1992)

Twenty-one percent of the people of Bhelumia-Bheduria are full-time fishermen. There also are occasional and subsistence fishermen, and all divide the year into two fishing periods: *baissha,* the peak fishing period from mid-June through mid-December, and *dhuella,* the lean fishing period from mid-December through mid-June (Annex 13). The study area contains a high quality capture fishery due to:

- availability of commercially important fish such as *hilsha*, shrimp, *aire*, *boal*, and *pangas*;
- good fishing access which is free for subsistence fishermen;
- the proximity of the large Tetulia River
- good fishing boat harbor facilities exist for fishing activities both inside and outside the study area;
- fish are sold within, or close to, fishing areas; and
- a positive fisherman/fish purchaser relationship exists and all transactions are made in cash.

Fisheries are especially important since agriculture is difficult in the area.

Fishery problems in the area are not considered acute in comparison with other parts of the country. Problems most often cited by local people include:

- fish diseases;
- overfishing;
- no implementation of fishing laws;
- extensive use of prohibited drift nets;
- catching juvenile and immature fish; and
- poor or no fish processing facilities.

Although the area fishery is considered of good quality, some species are no longer found in the area, or are in danger of disappearing, due to some of the problems cited above. Those species include: *kayoon*, a brackish water catfish that disappeared from the area within the past 10 to 15 years, and *saur puti*, *chama chingree*, and *baush*, a ray fish, which are all declining in number.

The area provides an ample supply and wide variety of fish throughout the year for local consumption and for markets in Bhola, Barisal, and Dhaka, as well as for export to other countries (Annex 14). Study area residents capture about 2,576 tonnes of fish annually from open water sources both inside and outside the study area (Household Survey). This figure includes fish caught for consumption.

Fish in the study area depend upon the daily, monthly, and seasonal variation in tides for migration, spawning, nursery, rearing, and feeding. Strong upstream flows during early monsoon draw gravid shrimp, *aire*, *boal*, and *pangas* toward their spawning grounds. Similarly, late monsoon upstream flows help *hilsha* in their spawning migration against costal currents, while downstream tides aid spawning shrimp. Carp enter the area with upstream flows, but only during high flood years. Fishermen alter their fishing activities and gear according to tidal variation. Every six hours, at low tide, fishermen trap fish with sack nets *(bindijal)* that they have placed at the end of canals and along the Jangalia River. Long shoreline nets *(berjal)* also are used to catch fish depending on the tides.

Fishing Methods and Gear

While there are about 14 different fishing methods (Annex 15, and Figures 3.6 and 3.7) practiced in the study area, *katha*, a traditional Bangladesh method, is the most popular. Tree branches are placed in water between high tides to create fish shelters. As the tide water rises, fishermen encircle the *katha* with nets, catching the fish after removing the tree branches. Shrimp are the primary catch from the *katha* process. During the study period, 91 *kathas* were counted in Bheduria Canal, but local people claim the number increases to 300 beginning in December. *Khuchijal*, *jhakijal*, *moijal*, and hooks are low-cost fishing gear used mainly by the poor. Drift, or current, nets which often are used for catching *hilsha*, have been banned by the Bangladesh government on the grounds that they threaten fish conservation by allowing fishermen to catch fish in their early growth stages, but are in use in the study area. *Hilsha* also are caught with small and large *berjal*, a net made of natural thread rather than the synthetic material used in current nets.

Agricultural Influences

Extensive use of fertilizers and other agro-chemicals create water quality problems in the central part of the study area where drainage congestion exists. Aerial insecticide spraying in 1991 significantly affected the fish population. Local people reported that fish began dying a few hours after the spraying and continued to do so for four to five days. The fish were not safe for human consumption. In addition to these problems, complicated, deteriorating relationships between landowners and farmers drive more people out of farming and into fishing. The result may be overfishing problems in the near future.

Fishery Management

Of the area water bodies, only the Tetulia River is under lease by the Bangladesh Department of Revenue. The lease owner collects Tk. 300-500 every six months for each fishing boat that uses the river. More than 1,500 boats are involved in fishing according to Tetulia River lease owners. Boats are recorded by canal name and type of fishing gear used (Annex 15). Small boat owners have free access anywhere in or adjacent to the study area, including the Tetulia River. There are no access restrictions on fishermen using canals and creeks. Although Bangladesh law prohibits the use of drift nets, and the catching fish fry and undersized fish, these actions continue indiscriminately as there is little to no enforcement.

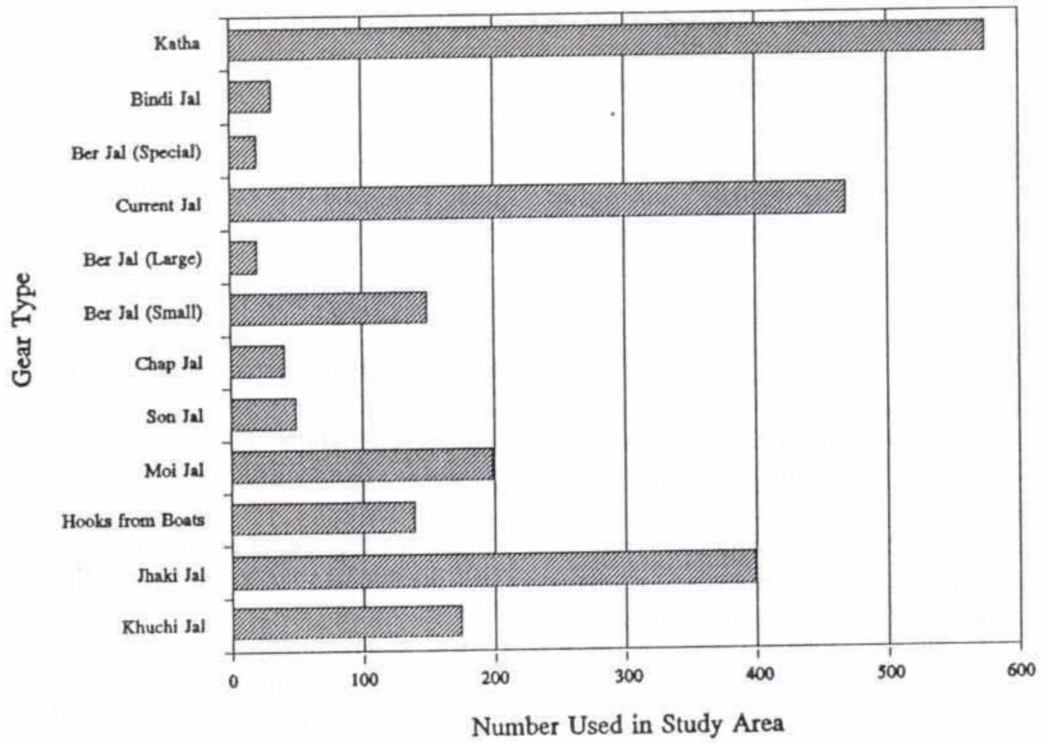


Figure 3.6 Numbers of fishing gear of various types used in study area
(Source: Field Survey, 1992)

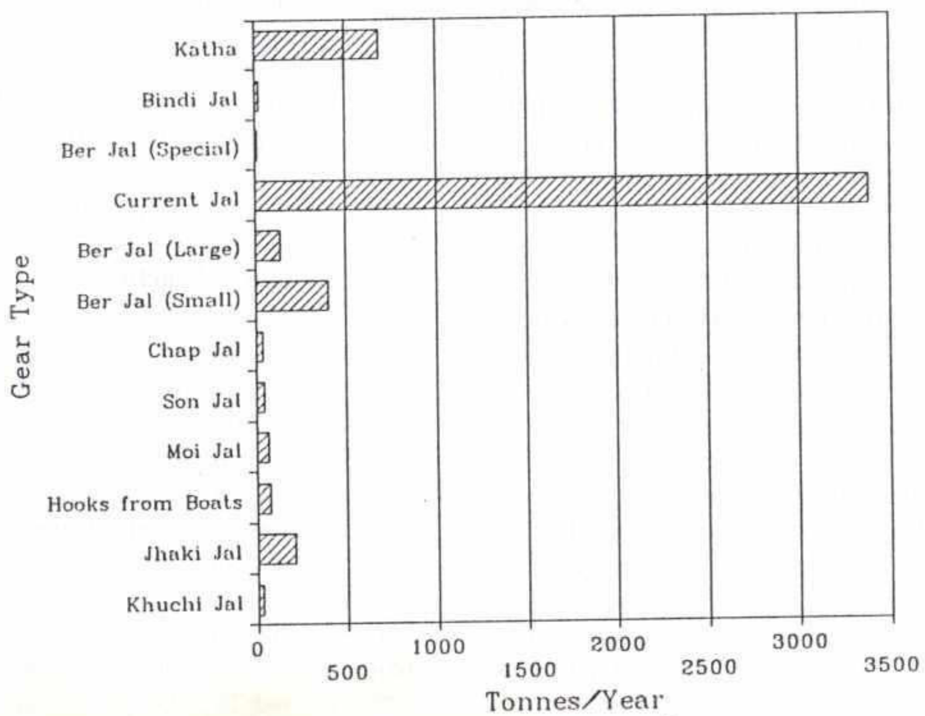


Figure 3.7 Annual fish catch in study area by gear type used
(Source: Field Survey, 1992)

3.3.5 *Closed Water Culture Fishery*

Fish culture has a long tradition in the study area. About 58 percent of all study area households have at least one pond to use in culture fisheries. Pond owners culture local carp, catfish, and other varieties. Some exotic species such as silver carp, common carp, and perch have been supplied from the Bhola and Barisal fish hatcheries.

Of the study area's 1,654 ponds, 59 percent are inundated during normal and/or monsoon tides, while 41 percent are not inundated except during storm surges (Annex 16). Of those that are flooded, inundation occurs between one and nine times per year, and about 50 percent of them remain flooded from June to mid-September. Study area ponds are broadly classified as inundated or non-inundated, and as large, medium, or small. Inundated ponds are those used only for extracting capture fish (Annex 16).

About 25 percent of pond owners maintain their fish culture by purchasing fish fry, feeding, fertilizing, liming, removing predators, re-excavating ponds, and building pond banks. About 80 percent spend more than Tk. 1,000 per pond per year, most of which goes to the purchase of fish fry. Fish feed is distributed in 63 percent of cultured ponds, fertilizer is applied in 12 percent, and liming and predator poisoning occurs only rarely.

Most ponds are within homesteads, but some are the property of markets or *masjids* (mosques). There are two government-owned ponds within the study area that are leased. In addition, two *khals* in the central part of the study area were modified 40 to 45 years ago into a series of ponds.

Almost all ponds are surrounded by dense homestead vegetation that limits the amount of sunlight reaching the water surface; the result is low phytoplankton production. *Helencha, dholkalmi, kalmi*, and duck weed are the main aquatic vegetation, and most ponds are free of water hyacinth, except in the central portion of the study area where 60 percent of the ponds are fully covered by water hyacinth. The average depth of these ponds is 2-3 m but some are as deep as 4 m. Pond bottom soil is generally favorable to mollusks and other benthos that are an important food source for pond fish. In a few cases, however, the deposition of dead leaves limits benthos survival.

Pond water quality is favorable for fish culture. The pH varies from 7.5 to 8, dissolved oxygen from 2 to 10 mg/l, and ammonia from 0.2 to 1.2 mg/l. Water quality differs little between inundated and non-inundated ponds, except that inundated ponds are more turbid.

There are few major problems related to cultured fish. Problems mentioned by local people include:

- many fish died during the aerial insecticide spraying in 1991;
- although there are fewer outbreaks of fish ulcerative disease, it is still a problem during the dry season;
- inadequate supply of fish fry;
- little to no contact between government fishery officials and ponds owners;
- overgrowth of surrounding vegetation inhibits phytoplankton production;
- multi-ownership of ponds often creates complication for culture practices; and
- availability of capture fish lowers the interest in culture fisheries.

Culture Practices

Of the fish species released into ponds, pond owners prefer local carp. *Rui (Labeo ruhita)* predominates, with *catla, mirka*, and *nilotica* following. *Catla* was reported to be the most productive. Three-inch fry grow to a weight of 750-1,000 gm over 10 months. About 89 percent of fish fry are supplied by fish hawkers, 8 percent come from private hatcheries, 1.5 percent from government hatcheries in Bhola and Barisal, and 1.5 percent from area fishermen. Fish eggs from the Bhola hatchery cost Tk. 300 per 1,000 eggs. If they are taken to the private nursery ponds near Bhelumia market, they are raised to a size of three or four inches before being sold for Tk. 1-2 per fry.

Few pond owners use chemical fertilizer or poison in their ponds, instead they fertilize them with cow dung, duck droppings, and oil cake. Fish food usually consists of rice or wheat bran.

Inundated ponds have low productivity and are not cultured, but fish enter these ponds through canals and creeks. These fish are consumed by the pond owner throughout the year, and during the dry season they are caught by net or by draining the pond. Small fish such as *puti*, catfish such as *magur*, and snakehead are the common species in inundated ponds. Carp rarely enter these ponds except during high floods when five to seven inch carp fry have been observed.

Production

The average annual production value of fish from culture sources is 456 tonnes per year, while from all sources it is 3,032 tonnes per year (Household Survey). Annual fish production in the study area is quantified by considering the value of pond owner-consumed fish, annual sales, and the value of remaining fish stock.

Annual fish production from non-inundated ponds is comparatively higher than that of inundated ponds: 317 tonnes per year from non-inundated ponds, 137 tonnes from inundated ones. Out of the total production from non-inundated ponds, 20 percent is consumed by the fisherman's family, 28 percent are sold, and 52 percent are kept for stock. In the case of the inundated ponds, 41 percent are consumed by the pond owner, 25 percent are sold, and 34 percent kept as stock.

Fish consumption

Fish consumption information collected over seven days for each sampled household revealed that the daily average expenditure on fish per household is Tk. 8.48, and that people consume about 34 grams of fish per person, per day, year-round. About 63 percent of consumed fish are bought from local markets, 20 percent are caught and 17 percent are from mixed sources.

3.4 Socioeconomic Environment

3.4.1 Population and Settlements

The total population of the study area is estimated to be 48,192, of which 42,644 live inside the project and 5,548 live outside (Annex 17). The estimation is based on the population census 1991 and the GIS (FAP 19) prepared maps showing settlements, the project boundary, and *mouza* boundaries. There are 25,123 males and 23,069 females in the study area, of which 22,164 males and 20,480 females live within the project area (Annex 17). There is a large variation in population density among *mouzas* (Map 13) primarily due to differences in the age of settlements, infrastructural development, resettlement caused by river erosion, and the influence of Bhola town. Population density also is affected by land elevation and land types. Population density in the study area is 777 persons/km², compared to the national average of 740 persons/km² (BBS 1992b).

The average household size of the 8,859 households in the study area is 5.5 (Annex 17) compared to 5.7 for Bhola *thana* and 5.4 for the nation (BBS 1992a, 1992b). Muslims constitute 98 percent of the total population, while Hindus, both caste and schedule caste, constitute only two percent; Hindus make up 12 percent of the population nationwide (BBS 1992c). Buddhists and Christians are insignificant in the total population, and there are virtually no tribal groups (BBS 1992a). Settlements mostly are concentrated along earthen roads, *khals*, and creeks in linear-linking patterns. In the central and northern part of the project area the settlements are dense, while in the southern part settlements are mostly clustered or linear. There are only a few settlements along the Tetulia and Jangalia rivers. Nearly 59 percent of the settlements are between one and 30 years of age, 18 percent between 31 and 50 years, and 23 percent above 51 years (Annex 19), indicating that the majority of the settlements are young.

Inheriting property and river erosion are the primary reasons for the establishment of many new settlements in the project and study areas. Annex 18 shows that 57 percent of the respondents had settled in their respective *mouzas* because they had inherited property, while nearly 25 percent had migrated from nearby villages or *mouzas* where they had lost agricultural and homestead lands to river erosion. Only 12 percent settled because they had purchased land, and three percent because of kinship and marriage connections.

The area inside and outside the project is connected to the town of Bhola by an extensive network of *khals*, rivers, and earthen roads that crisscross and intersect at many locations. Throughout the year, small and medium-size country boats are used extensively for internal movement of people and freight to local markets and elsewhere. Mechanized boats also are used for transportation and freight. Daily steamer and launch services between Dhaka-Bhola and Bhola-Barisal link the project area with the country's capital and the newly formed Barisal divisional headquarters.

There are 11 major and five minor markets in the area of which Bhelumia bazaar and Bankerhat are the largest. These markets are important meeting places and the link between villages and Bhola town.

3.4.2 *Livelihood and Subsistence*

Fifty-nine percent of the area's households earn their livelihood from agriculture (41 percent farmers, 18 percent agricultural laborers), while fishing is the primary occupation of 21 percent (Annex 20). Business, including petty trading and shopkeeping, employs only five percent of households, and there are no factories or industry in the project area.

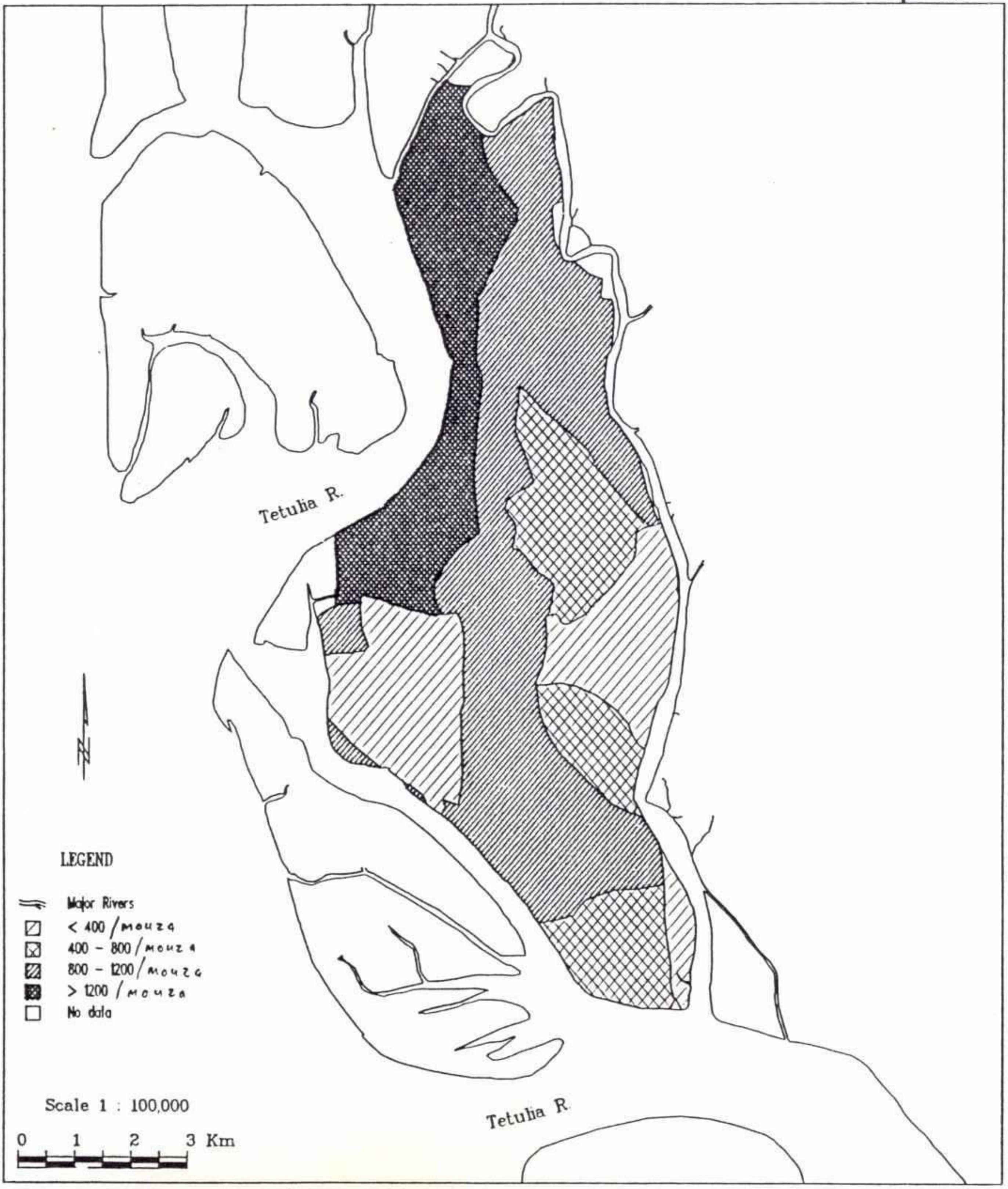
Rice is the main food crop and betelnut the main cash crop. Rice is grown on more than 90 percent of the total cultivated area. Other important crops are chili, mustard, pulses, sweet potato, watermelon, and wheat. *Dhaincha* (a legume) and *hogla* (a reed plant), two important cash crops, are grown mostly along the sides of *khals* and creeks, are used primarily for roofing or fencing material, mats, and as fuel for poor households.

Families usually work their own land and raise crops primarily for their own consumption. If used, hired and outside laborers work during peak agricultural seasons, particularly during sowing and harvesting. The daily wage rate for agricultural laborers varies between Tk. 25 and Tk. 30 (with two meals) during peak or *baishya* season and between Tk. 15 and Tk. 20 (with two meals) during lean or *dhuliya* season. In some places, day laborers take one *seer* (0.93 kg) of rice in lieu of food during the lean season. There is no advance sale of labor for cash, but sometimes contracts are made at the rate of Tk. 6,000-7,000 per year plus food and clothing. Most day laborers are from landless and poor households, and are dependent on the large, medium and absentee landowners for employment throughout the year.

Increasing population pressures prevent the agrarian sector from absorbing the area's growing labor force. This situation is further compounded by a lack of employment opportunities outside agriculture. There is little employment during the lean season, especially in September, October and February. Women do not work in the fields, and their nonagricultural income-generating activities also are limited.

Fishing-related activities employ a significant number of households in catching, selling, and trading. Annex 20 shows that while 21 percent of households depend entirely on fishing as their livelihood, nearly 35 percent are subsistence

Map 13



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Human Population Density

fishermen. Sometimes, however, this latter group sells their catch to supplement household income.

There are no perennial or seasonal beels in the study area, but closed water culture fishery is widely practiced. The Tetulia River and the Meghna estuary are the main fishing areas. Fishing occurs year-round, with April through September being the peak fishing period and late October through December, and March being the lean periods. Professional fishermen pay tolls to absentee lease holders to fish the rivers. Tolls are determined according to boat size, varying between Tk. 300 and Tk. 600 per boat per annum. Fishermen work in groups of five to 10 depending on the boat size and the fishing net to distribute financial obligations and labor requirements. The groups usually come from the same family lineage.

Most professional fishermen are poor and have insufficient equipment and no land. Rarely can they save money to invest in fishing implements. A medium-size fishing boat (9m by 2m) costs nearly Tk. 7,000 and a 700m by 6m *hilsha* fishing net *(chani jal)* costs about Tk. 18,000. Because most fishermen cannot bear such costs, they are forced to borrow money from local petty *mahajans* (moneylenders) who require that the fishermen sell them their entire catch at a rate that is usually 20 to 40 percent lower than market value. This system, known as *dadan* (meaning advance sale of fish), accounts for 80 percent of the total fish sales of the area. The petty *mahajans* are middlemen who borrow money from bigger *mahajans* living in Bhola and Barisal town. This dependency relationship, or bonded *mahajani* system, allows both the petty and big *mahajans* to prosper, while the fishermen live in chronic poverty.

Some area *jalmahals* are leased through auction for three years to local *matshajibi samity* (fishermen's cooperatives) at 10 percent increase of lease fee per year. These cooperatives, however, appear to exist in name only and are controlled by individuals outside the fishing community who dictate the terms of the leasing arrangements. These individuals control resources and marketing and are involved in wholesale fish trading. Most of the large rivers and *khals* are leased to large landowner/businessmen who do not live in the area. The most important fishing site, the Tetulia River, is leased directly by the Ministry of Land to an absentee landowner for three-year periods. The high cost of fishing equipment, the leasing system, and middleman control thus have changed the traditional ways in which fishermen used to freely fish the area's rivers, *khals,* and creeks. There also is competition with fishermen from areas adjacent to the Tetulia and Meghna rivers. In addition, fishermen are threatened by armed gangsters who rob them at night, taking everything in their boats including the fishing net.

3.4.3 Land Ownership

Sample surveys conducted by EIP in 10 villages (BWDB 1992) showed that landless, marginal, and small farm households constitute 89 percent of the population but own only 30 percent of the land, while medium and large farmers make up 11 percent of the population but own as much as 70 percent of the land. This indicates that the land ownership distribution in the study area is highly skewed. For example, the landless constitute 64 percent of the population, compared to the national average of 27 percent. Large farmers, on the other hand, make up only 3 percent of the population, but command 37 percent of the area's land. In terms of per capita owned land, the target group owns 0.03 ha compared to the nontarget group's 0.36 ha or 12 times less. The target group cultivates 63 percent of the total agricultural land while the nontarget group cultivates only 37 percent.

Much of the study area's land is controlled by absentee landowners. Although the exact percentage is not known, some villagers reported that 60 to 70 percent of the land in their areas is owned by absentee landowners who have cash rental contracts with tenants *(orkhait)*.

Each absentee landowner controls between 20 and 200 ha of land. Although it is not known exactly how these landowners acquired such quantities of

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land. The widely held view is that they established rights over newly created charlands. Moreover, since most of the study area is created by land accretion, it is likely that the people who foresaw the future value of accreted land (and who had some power), registered the land in their name or acquired leases from the government even before the lands were cultivable. Many of the first settlers of these new lands were poor people, often displaced by riverbank erosion, who preferred to work as tenants rather than laborers or fishermen.

Data from the Bhola thana land records office indicate that there are about 44 ha of cultivable *khas* land in the project area. Data from the Bhelumia-Bheduria union land office, however, show that there are 632 ha of *khas* land which includes land under *khals*, *khal* sides, village roads, and cultivable lands. Much of this *khas* land is under the control of absentee owners. The exact amount of *khas* land is uncertain because of the continuous erosion-accretion of charlands.

Land conflict is endemic, and there have been reports of violent conflicts over the forced occupancy of char and *khas* lands in the area. Common property resource use is limited, confined mostly to land under *khals*, village roads, and canal shores. Roadsides are used primarily by people whose lands and houses are adjacent to the road.

3.4.4 Tenancy Relations

An extensive, informal tenancy market exists in the study area. Cash rent tenancy *(logni* or *chukti barga)* accounts for nearly 70 percent of the total rented land. The rental rate varies between Tk. 7,000 and 9,000 per hectare depending on land type. The rent usually is fixed for one year and renewed in subsequent years if the landowner receives the cash in advance. In *kudi barga*, the other type of tenancy contract, the owner and tenant agree that the owner will receive 25 to 30 *maunds* (1,000-1,200 kg) of paddy per hectare after harvest. The contractual arrangement in both cases is verbal and, therefore, insecure.

Sharecropping *(shamun barga)* and mortgaging *(bandhak)* are less common. Sharecropping usually lasts for one cropping season, but may extend further if the parties agree that the landowner will receive 60 percent of the gross produce and the tenant only 40 percent. In most sharecropping contracts the tenant provides all inputs, but with HYV crops, the cost of seed and fertilizer sometimes is paid by the landowner.

Under the mortgaging scheme known as *kot kabola*, money is loaned against a piece of land which the loaner has the right to cultivate for three years. If the borrower fails to repay the money within the stipulated period, he permanently loses his land to the loaner. *Kot kabola* rates vary depending on land type, but the usual mortgage rate is Tk. 25,000 to 30,000 per ha. Many villagers reported that the existing mortgaging system is one of the primary reasons for landlessness and poverty in the area.

Villagers also say that the land available for sharecropping is decreasing, while cash rent tenancy is increasing. Obviously, a major reason for this is that it is less risky to obtain rent money in advance than to depend on a good crop under sharecropping. Moreover, landowners can invest their cash-in-hand in other economic activities and, thus, diversify their income. River erosion and population growth have forced more people into the landless and marginal farmer categories in the past 15 years, intensifying competition among farmers who have no other choice but to rent land under any condition in order to sustain their family without turning to full-time fishing.

3.4.5 Credit Relations

Although institutional lending sources charge as low as 16 percent interest, about 97 percent of those obtaining credit obtained it from noninstitutional sources that charge as much as 120 to 160 percent interest. For every Tk. 1,000 borrowed from these informal sources, the debtor must repay with 261 to 298.5 kg of paddy, or Tk. 1,600 to

1,800 after six months. Interest on a Tk. 100 loan is Tk. 15 to 20 per month.

Noninstitutional sources include private moneylenders, traders, shopkeepers, and large landowners, while institutional sources include commercial banks, the Bangladesh Rural Development Board (BRDB), and a few NGOs. Krishi, Agrani, and Sonali Banks offer credit delivery programs in the area, but their principal clients are those who have land for collateral. The landless and professional fishermen who do not own any land are, therefore, excluded from institutional credit facilities. However, most of the marginal, small, and medium farmers reported that in order to obtain credit from institutional sources, they had to pay 30 to 40 percent of their loan money to different agents or middlemen *(dalal)* through whom loan applications are first initiated and then processed.

In addition to such *baksheesh* requirements, farmers also have reported unusual delays in the disbursement of loans from institutional sources. These roadblocks explain why noninstitutional sources play such a crucial role and dominate the credit market. Private moneylenders are the primary sources of credit, followed closely by banks and a limited number of NGOs. Relatives, friends, and neighbors often help each other by providing *hawlat* (small loans, usually interest-free, under Tk. 100) with the understanding that the favor will be reciprocated in the future. For larger sums, relatives and friends usually ask for interest, but at a lower rate than that charged by private moneylenders.

Before-harvest crop sales are rare in the project area, but small and marginal farmers often sell their crops immediately after harvesting to meet debt liabilities and family expenditures. Debt repayment is the primary reason for land sale. Land is often sold by small and marginal farm households. The price of agricultural land varies from Tk. 80,000 to 100,000 per ha, while the price of homestead land varies between Tk. 125,000 and 150,000 per ha. Land prices have risen 20 percent in the past five years, due to increasing population pressure and social displacement by river erosion.

Grameen Bank, a community development bank, is not active in the area and, hence, income-generating activities for poorer households and women are limited. BRDB focuses its credit program on increasing income and employment of its cooperative members and for purchasing irrigation facilities like low-lift pumps. Its main beneficiaries, however, are the large and medium landowners who often default on their loans. A small number of credit-providing NGOs, such as *Proshika* and *Jatio Bandhujon Parishad*, are active in the area but based in Bhola town. Through their credit schemes they hope to expand into activities like low-cost housing, child health care, livestock vaccination, and roadside afforestation during fiscal year 1993-94.

3.4.6 Wealth and Equity

As stated earlier, absentee landowners own as much as 70 percent of the cultivable land in some areas. In addition, there are seven to eight large resident landowners in almost every village who own between 10 and 15 ha of land per family, or two percent of the total cultivable area. On the other hand, nearly 65 percent of the area's households are landless in both absolute and functional terms and there are also large number of households who own between 0.21 and 1.5 ha of land.

Although the absentee landowners already benefit from this lopsided distribution of wealth and equity, they also earn surplus income through a variety of tenancy arrangements. The dominant/ dependency relationship that exists between absentee landowners and poor households is a cycle seemingly impossible to break as the landless, marginal, and small landowners subsist at or close to destitution levels. Only 15 percent of households enjoy a surplus over their annual expenditures, 14 percent live on the margin, and 71 percent face acute deficits in their daily basic needs (EIP 1992).

In every village interviewed, the small and marginal farmers said that their economic condition had deteriorated during the previous five to six years due to crop damage caused by tidal flooding and agricultural pests. High cost of inputs, population pressure, and river erosion also contributed to their worsening economic situation. Furthermore, because there is no industry in the area, and little or no employment outside agriculture and fisheries, it is likely that more households are becoming poorer day by day.

3.4.7 Gender Issues

In Bhelumia-Bheduria, in spite of increasing landlessness, poverty and migrating males, the position of women remains relatively stable. Their status is characterized by conservative cultural and religious values, and a solid commitment to family and kinship ties. With a few exceptions, women carry out traditional roles as wives and mothers; they are not involved in any kind of income-generating activities.

Status of Women

The 1992 census shows that the male/female ratio in the project area is 106:100. The most likely reasons for the lower number of females are that many die during childbirth and infant daughters die from neglect. The average marrying age of girls is 12 to 15, while for men it is 18 to 20. As in other areas of the country, poor families struggle to pay high dowries that include household goods and furniture. In communities where marriage breakdown is common and females are considered a burden, the family can forgo the daughter's dowry if she is to become the second or third wife. Nonetheless, the labor of the second/third wife is undoubtedly of economic benefit to the husband's household.

Women in the study area hold a subordinate and insignificant position in family decision making. Most women said that they were consulted during discussions involving the family, but the final decision was always made by husbands or male relatives. As is the norm nationwide, women in the project area have no authority to spend money, even when they are the wage earner. Because there are no NGOs that work exclusively with women, there is no technical or financial support for women to initiate income-generating programs.

Women in the project area particularly suffer during floods. Due to their responsibilities and need for privacy they have difficulties in finding proper living and sleeping arrangements; they struggle to find water, food, fuel, and fodder. The lack of flood shelters and medical help, house damage, and the loss of livestock, trees, and vegetables also concerns them. During flood disasters, when food become scarce, they are the ones who go hungry first.

All but the poorest women send their children to school. Poverty, superstition, and religion are the main factors that families cite for removing puberty-age girls from school. Of the few professional women in the area, most are primary school teachers; 20 of the 40 primary school teachers in the area are local women.

Employment

Although there is a national trend of more women moving into the labor market, few of the sample area women participate in economic activities. Cultural prohibitions prevent most women from venturing outside their homes to seek employment. Their gardening and poultry raising activities are extremely poor, failing to even satisfy their family consumption needs.

Of the study area's 23,096 women, only 2,307, or 10 percent, are engaged in wage-earning employment. The NGO CARE employs 15 women in its road maintenance program in the Bhelumia area, and about 10 women are domestic workers for wealthy households. In Char Kali and Char Ramesh *mouzas* 25 women are employed as family planning workers and primary school teachers.

Approximately 2,266 women in Kunjaputti, Chandra Prashad, and Char Chandra Prashad *mouzas* of Bheduria Union are engaged in commercial *pati* (mat) making out of *hoglapata*, which is particularly susceptible to flood damage. It often must be bought in the market at a cost of Tk. 20 per bundle (enough for two 6 x 7.5 ft. mats). An increasing number of commercial rice mills have invaded the traditional women's job of rice husking. Only about 60 to 70 women are employed in post-harvest husking activities and they are paid in meals and, occasionally, given an old sari by the employer. In some predominantly fishing *mouzas* women are engaged in knitting and repairing fishing nets, but not on a commercial basis.

Literacy

People of all social categories said that they would like to send their children to school, but socioeconomic, sociocultural and institutional factors, and the reality that children make important economic contributions to poor households prompt many parents to keep their children home. Although primary education is free, the cost of school clothes may be too large a burden for poorer families. The literacy rate for both sexes in the study area is 25 percent (BBS 1992). In Bhola thana, 29 percent of males and only 19 percent of females are literate.

A shortage of high schools and poverty are the major obstacles to high school attendance. There are two high schools in the sample area: one in Bhelumia Bazaar and the other in Bankerhat. Most primary schools are inaccessible during the monsoons and, therefore, are closed for long periods. Only about 33 percent of primary students seek secondary education, and the high school dropout rate is 79 percent. The recent introduction of free schooling for girls class six to eight has had no impact on attendance in the over-14 age group because parents disapprove of the coeducation system. Informal adult education does not exist in the sample area and the quality of education for those who have received a minimum of formal education is very uneven.

3.4.8 Food and Nutrition

A seasonal pattern of nutritional deficiency occurs during the monsoon season when food grains and vegetables are less available. Nutrition deficiency heightens during the pre-harvest lean season in October or November and reoccurs from March to April. The landless and land poor suffer most at these times.

The most commonly consumed foods in the study area include rice, pulses, sweet potato, wheat, fish, poultry, and meat. Some of the more nutritious foods, such as vegetables, fruits, poultry, and livestock products can be produced in the homestead, but common consumption patterns reveal that these products may not be as available as expected. For example, only 25 percent of the vegetables consumed in the study area are locally produced, the remaining 75 percent are imported from outside the area. This is because vegetable cultivation is hampered by repeated flood damage. Moreover, few pulses, an important protein source, are cultivated locally. People primarily depend on rice, pulses, and fish for their nutritional needs; other foods make up a small proportion of the daily menu. Women, because of socioeconomic conditions and customs, consume almost 50 percent less food than male family members, and protein is often a negligible portion of their diet. The RRA showed that average food grain consumption is 387 gm/day/person (1,341 kcal) and fish protein is 10 gm/day/person (29 kcal). A woman's consumption of food grain is 194 gm/day/person (776 kcal) and fish protein is 5 gm/day/person (15 kcal).

The national figure for per capita daily calorie intake is 2,021 (WBR 1992), but BBS's recommended calorie intake for extreme poverty-stricken people is 1,805 cals/day/person (BBS Household Expenditure Survey 1985-86). The per capita household calorie intake in the study area is only 1,628 kcal, for women the figure is 814 kcal.

3.4.9 *Health and Family Planning*

The household survey found that people in the sample area conform to national seasonal trends for diarrhoeal and respiratory diseases. Typically, both are endemic throughout the year but are seasonally acute in early, late, and post-monsoon seasons. Diarrhoeal diseases, fever, and skin and eye infections were reportedly common during post-monsoon in virtually all the villages. Hookworm and roundworm, caused by lack of adequate sewage disposal, are common as is helminthiasis (parasitic worm infestation). These infections all contribute to the overall poor health and nutritional deficiency of the local population. More research is needed to determine the role of rainfall in the incidence of disease.

Public health facilities in the area are few for the population size. Family planning and maternal and child health care suffers due to lack of staff, infrastructure, and medical supplies. Although there are upazila health complexes, there are few union health centers for the outlying areas. Illisha, Bheduria, Bhelumia, and Char Samaiya unions have 26 family welfare assistants, but most health centers have no attending doctors or trained nurses for long periods of time. These health centers are run mostly by paramedics.

The existing medical service delivery centers for Bhola district (population 14,51,676) consist of two mother and child welfare centers, 31 union health and family welfare centers, two Public Works Department constructed union health and family welfare centers, one union family planning clinic, seven upazila health projects, three health-related NGOs, and seven health sub-centers.

It is unlikely that the 47 percent of families in the project area officially said to be using temporary or permanent contraception are actually using it. Some women said that they were aware of family planning but had no access to contraceptive supplies and services. Officially there are adequate numbers of union health and family welfare centers operating in the area but, in reality, they are hopelessly understaffed. The Department of Family Planning in Bhola said that poor roads in the area coupled with lack of transport facilities discouraged personnel from regularly attending their posts. Supervisors often made only one visit a month instead of one every week as required. Service users, especially those using contraceptives, said that field workers often did not come at all during the monsoons due to travel constraints. Family Planning Officers said that staff recruitment is problematic: women do not come forward because such employment is unacceptable in a conservative area like Bhola.

3.4.10 *Water and Sanitation*

There are 468 tubewells in Illisha, Char Samaiya, Bheduria, and Bhelumia unions to serve a population of 8,485 households (Public Health Engineering Bureau 1991). This 1:18 households to tubewells ratio apparently could supply enough safe water for the population. To avoid walking long distances to fetch clean water, however, women often use canal, pond, or river water for washing, bathing, and even cooking. In one village, residents said there was no pump for drinking water, in another it was reported that the pump was far away, and in a third, respondents said access to the pump was limited by the family who owned it. These responses imply that many families have either no access or limited access to safe drinking water. Moreover, households without boats or rafts often have no access to tubewells during floods.

Only 10 percent of the project area's population use proper sanitation facilities. Despite local efforts to promote low-cost water-sealed latrines, most are still built hanging over water surfaces, over pits, or in open fields. In addition, women commonly relieve themselves in vegetation growth around the homestead. The Tk. 200 charge for transporting a water-sealed latrine to a home convinces most villagers to use the polluting traditional-style latrines. But such open sanitation facilities, and animal wastes, totally contaminate the surface water. Women who use surface water understand the need to boil it before use, but they often cannot afford the fuel to do so. The household survey shows that 92 percent of the population drink tubewell water, but 93 percent use surface water for all other household purposes. As a result, the number of reported diarrhoeal diseases has increased from 36 cases in 1990 to 535 cases in 1992 (EPI, Bhola). The actual number of water-borne diseases in the sample area in 1992 is: diarrhoea, 512; dysentery, 529; cholera, 17; fever, 1,322; skin disease, 355; and others, 183 (FAP 16 Household Survey).

3.4.11 *Cultural Resources*

The area appears not to have any permanent structures of archaeological or cultural significance. No sites were identified to which people attach any specific cultural values.

3.4.12 *Navigation and Transportation*

Most of the many canals crisscrossing the Bhelumia-Bheduria study area are navigable year-round. The hydrological and physical characteristics of the area create a dependency on navigation for various household and business purposes. The total number of boats within the study area was estimated at about 2,400, based on extrapolation of numbers provided by a 5 percent sampling of households. Waterways are used for fishing from boats and most fishermen are concentrated year-round on the Tetulia River. About 50 percent of the boats in the area are estimated to make use of Bheduria Khal. Twenty-one percent of households are directly involved in fishing activities and most own boats. The trading system in the project area is highly dependent on navigation routes. Paddy and jute brokers usually travel by boats to conduct business with farmers.

The household survey (Annex 21) showed that of all study area boats, 89 percent are manually operated and 11 percent are mechanized. About 50 percent of boats are used for fishing activities, 17 percent for agricultural activities, nine percent for household use, and 34 percent for income-generating activities (some general-purpose boats used for fishing as well). Annex 21 shows boat use by *mouza* and reveals that 55 percent of the total fishing boats are used in Char Bheduria, 15 percent in Paschim Charkali, and the remaining are fairly distributed among the other *mouzas*.

Many people living inside the study area grow crops on the chars of the Tetulia River. Boats are used to carry the 922.5 tonnes of annually produced paddy to the mainland at a rate of 1,845 trips per year (Annex 21). The household survey showed that 50 percent of this annual crop transport occurred in Chandra Prashad. Only households on Char Chandra Prashad and Chandra Prashad reported using boats for household purposes.

Of the 1,238 fishing boats in the study area, 660 are small boats and 538 are large. Large boats, found primarily on the Tetulia and Jangalia rivers, are used by professionals, while small boats, found on canals and the Jangalia River, are used by poor farmers and subsistence fishermen.

3.4.13 *Natural Hazards*

The coastal physiography, the multiple river systems, and geophysical and man-made features have made the Bhelumia-Bheduria study area vulnerable to several environmental hazards. The area experiences natural and anthropogenic hazards such as seasonal floods, tidal floods, storm surges, cyclones, droughts, riverbank erosion, drainage congestion, exposure to pests and pesticides, saline intrusion, and health problems. At risk are people's lives, livelihood, and property.

Hazard Profile

Key problems in the study area are related to uncontrolled monsoon flooding during full and new moon, and by storm surges accompanying cyclones during pre- and post-monsoon periods.

Based on GIS and application of a digital elevation model, 64 percent of the study area is estimated to be flooded to a depth of 0.3-0.9 m during the monsoon, while another 14 percent is flooded between 0.9 and 1.8 m. Only 22 percent of the area is usually flood-free, but during storm surges even these areas may be affected.

Spatiotemporal aspects of flood characteristics in the study area differ by land type as does risk. Based on household survey data, relative risks can be quantified and their impacts on the area and land use predicted. Annex 22-1 shows the extent, depth, and duration of floods over the past 5 years on study area homesteads and crop land. Flood depth and duration was highest in 1988, 1989, and 1991. In 1989 and 1991 storm surges affected the study area, while in 1988 flood water from the north and the high tide from the south coincided, consequently increasing flood depth and duration.

Cyclones affect the study area almost every year (Annex 22-2). Monsoon flooding usually occurs once in 1.25 years, saline intrusion once every two years, drought every other year, and storm surges once every five years. Fifty-four percent of households are affected by drought, 42 percent by storm surges, 38 percent by cyclones, 28 percent by flood, and 22 percent by erosion.

Flooding Patterns

Of all study households, Char Samaiya and Char Gazi households are the most frequently affected by monsoon floods, particularly during high tide. Char Gazi is a relatively low-lying area with a network of channels directly linked with the Tetulia River. Char Samaiya, in the eastern portion of the study area along the Jangalia River, is a depressed area with a dense internal channel network. Areas that also are likely to flood include Char Bheduria, Pangasia, Char Chandra Prashad, and Kunjaputti. Developed rural roads impede flood flow in these low-lying areas.

Storm Surges

Large storm surges, such as the one in 1970, sweep over the entire study area. Even low surges, such as those of 1989 and 1991, typically flood Patabunia, Char Chandra Prashad, Bagmara, Tum Char, Char Bheduria, and Kunjaputti *mouzas*. Because the study area is in the northern part of the Bhola island, fierce storm surges are rare since cyclones usually track in a southwesterly direction, and cross more than 100 km of land and forested area before reaching the project area. Severe surges, which affect all the area homesteads, appear to have an occurrence probability of about 1:20 years, while moderate surges have an occurrence rate of about 1:10 years and affect approximately 40 percent of area homesteads.

River Bank Erosion

Char Bheduria is the only *mouza* subject to continuous bank erosion by the Tetulia River. Char Chatkimari, adjacent to Char Bheduria, has totally eroded during the past two decades. Char Ramesh, Paschim Charkali, and Pangasia *mouzas* experience minor erosion problems.

Saline Intrusion

Saline water regularly intrudes on Samaiya, Bheduria, and Gazi chars. Other study area *mouzas* are rarely affected by salinity. When it does occur, saline water usually intrudes during the dry season when sea water enter the rivers and cyclonic winds create high waves that fall on *rabi* fields.

Drainage Congestion

Drainage congestion is a continual problem in Pangasia, Char Ramesh, Char Bheduria, Char Chandra Prashad, and Kunjaputti. Most drainage congestion occurs when canals are closed by siltation or during unplanned road construction.

Drought

Drought is a common problem all over the study area, usually occurring every other year. Adequate water supplies for crop production are not available except during the monsoon period. Water conservation and management is needed for growing crops at other times of the year.

Cyclones

Cyclones are common in the study area and occur almost every year. Char Gazi, Pangasia, and Char Ramesh are the most frequently affected *mouzas*. Poorer households are the most affected by cyclones, mainly because their homes are built of weak materials.

Flood and Surge Damage Patterns

Standing crops suffered more damage than other property or assets in 1987, 1990, and 1991. Pond fish were the next most affected in those years. Livestock suffered most in 1988 and 1989, followed by standing crops. Annex 22-3 summarizes the estimated monetary values of flood and storm surge damage in the past five years.

Distribution patterns of average flood damage in 1991 show that landowners in Char Samaiya, Char Bheduria, and Char Ramesh were the most affected. In Paschim Charkali, Bagmara, Char Hossain, and Char Gazi sharecroppers were the most affected group, while in Char Chandra Prashad and Kunjaputti service holders were the primary victims. Fishermen were damaged most in Char Chandra Prashad. Annex 22-4 details household damage by *mouza* and occupation, and Annex 22-5 summarizes household resources damaged by flood in 1991.

In the study area 54.6 percent of households perceive flood to be their greatest risk, followed by cyclone and drought (Annex 22-6).

Chapter 4

IMPACT ASSESSMENT

The impact assessment of the proposed Bhelumia-Bheduria Project is based on the development of three scenarios.

- *Future Without Project*: this considers physical, biological, and socioeconomic changes likely to occur within the next 20 years due to prevailing environmental and social trends.
- *Future With Project*, assuming no change in land types. This considers the total changes likely to occur over the next 20 years with the project in place, and attempts to separate the impacts of the project from underlying natural trends in the baseline environment.
- *Future With Project*, assuming a change in land types due to a 20 cm reduction in maximum 1:5 frequency monsoon water levels. The rationale for this assumption is given below.

4.1. Physical Environment

4.1.1 Water Resources

Future Without Project

The primary hydrological problems in the Bhelumia-Bheduria project area are tidal flooding, tidal surges, and drainage congestion. During high tide, flood water spills over the river banks and through *khals* originating from the Tetulia and Jangalia rivers. Rainwater aggravates the flooding during the monsoon. During low tide, flood water usually recedes to the rivers. Storm surges, which can occur at any time of the year, also are a major hazard to the area. All these events are likely to continue. Storm surges may change in frequency due to regional and global climatic changes, but such changes are difficult to predict with any level of certainty.

Drainage congestion is caused by unplanned road construction and ill-maintained and insufficient small canal culverts, openings, and interlinks with the rivers. An insufficient number of culverts and openings also prevents flood water from receding during low tide. As a result, flooding lasts longer, is deeper than usual, and does not drain completely before high tide occurs again, resulting in waterlogging and reduced crop production. This situation is expected to continue. Other than the currently proposed Bhelumia-Bheduria Project, no major drainage improvement project is under consideration for the area.

Bheduria Khal is the area's most important *khal* for navigation and fishing. During low tide, water recedes mainly through this *khal* and other small *khals* and creeks that interlink with the Bheduria. When flood water recession is prevented, the discharge and velocity into Bheduria Khal is reduced, accelerating siltation that eventually will raise the canal bed and hamper navigation and fishing. In this area, low-lift pumps bring the Bheduria Khal surface water to irrigate fields. If the current siltation situation continues, the flow of water through Bheduria Khal and others may be reduced enough to hinder irrigation and consequently reduce crop production. In the absence of any sustained excavation, Bheduria Khal could silt up completely over the next 20 years.

In general, if flood control and drainage measures are not taken in the future then flooding, drainage congestion, and insufficient irrigation will continue to reduce crop production as well as negatively effect navigation and fishing.

Future With Project

There is likely to be little or no hydrological impact during the construction phase of the project, provided precautionary measures are taken against erosion of the new embankments. Following completion, the embankments along the Tetulia and Jangalia rivers and the proposed structures would prevent overspilling of the river bank during high tide, especially during the monsoon season. Extreme high floods of low probability (<1:20 years) would not be prevented, but the embankments would substantially reduce the potential destruction. Since the canals originating on the Tetulia River would be completely closed, the only route for entering flood waters in most years would be the canals connecting the Jangalia River. This flood water could sometimes overspill canal banks and inundate the agricultural lands on either sides of the canal. The general slope of the area is towards the south and southeast, and during low tide complete recession of flooding would take place, resulting in shorter durations of inundation and reduced crop damage. Reexcavation of canals would prevent overtopping in many cases.

The net impact of the project on tidal flooding damage would be positive and beneficial.

Drainage congestion in the area is due to unplanned construction of roads and a lack of sufficient culverts and sluices in proper positions. Seven culverts, one footbridge, and two sluices are proposed for construction: one sluice at the offtake of Munshir Khal will prevent over-drainage, thus facilitating low-lift pump (LLP) irrigation when necessary. This sluice would improve drainage in the northern region of the project area during the monsoon and pre-monsoon periods. The other sluice, at the southern tip of the project, would improve drainage in the southern region. Culverts plus *khal* reexcavation would improve the interlinkage of the canals as well as facilitating drainage. The proposed 2-vent (1.5 m x 1.83 m) drainage+flushing sluice at Napter Khal would improve drainage in the southern part of the project area during monsoon and facilitate LLP irrigation during the dry season. In the central part of the project area, especially in Char Ramesh, drainage congestion would be aggravated for want of a canal linking this low-lying area to other nearby canals. If all the proposed sluices and culverts are maintained properly, approximately 80 percent of the drainage congestion would be removed. Embankments, culverts, and bridges would have positive impacts on communication.

In summary, the net impact of the project on alleviation of drainage congestion would be positive and beneficial.

Canals originating on the Tetulia River would be closed, thereby restricting flows and associated fish migrations and fishing boat passage along the canals inside the project area. These impacts are described further in Section 4.3.2. In addition, the maximum water levels attained during periodic inundation may or may not be reduced; these are described further in Section 4.2.1.

4.1.2 Bank Erosion and Channel Shifting

Future Without Project

Satellite imagery analysis indicates that the Tetulia River is highly changeable and unpredictable. From 1973 to 1990 it underwent major changes as convolution of the channel adjoining the study area increased. Since 1990 the rates of erosion and accretion appear to have declined. The 1993 Landsat image suggests that accretion could close the east channel, thereby making the western boundary of the project area relatively more stable. Any prediction of river behavior remains uncertain, however, and the only reliable statement that can be made is that it will probably remain highly dynamic during the life of the project. The

Jangalia River and Bheduria Khal have changed little over the past 20 years and are likely to remain stable through the life of the project.

Future With Project

The project would have little effect on the powerful geomorphological forces causing river erosion and accretion, although the presence of a strong embankment on the Tetulia River side could be a stabilizing force in specific locations, especially where it has been strengthened to sea-dike standards. The main concern would the impact of future Tetulia River channel shifts on the integrity of the embankment itself—this would have to be taken into consideration in the final design. The Jangalia River channel is likely to remain stable, with or without the project in place.

The project would have little effect on overall erosion and accretion patterns as presently apparent in the general study area.

4.2 Terrestrial Environment

4.2.1 Land Types and Soils

Future Without Project

Current land types are not expected to change, and prevailing cropping practices are expected to continue if no project is built. Each year, fresh sediments are deposited within the project area, primarily near the river and canal sites. These sediments may add nutrients to the soils and help raise land levels. Local farmers believe annual sedimentation increases crop production.

Future With Project

Since the Tetulia River canal openings would be closed by the proposed embankment, the only water entering the project area during the monsoon period would normally come through the canals originating at the Jangalia River. This inflow could be significantly less than at present due to the limited periods available for rising tidal inflows to enter through the canal openings. Inflow current velocities would be increased, however, which would compensate to some extent for the limitations on inflow access and time available for flows to enter. The detailed hydrology of the study area has been superficially studied and documented, and no modelling has been undertaken, consequently there is no adequate basis for predicting the extent to which mean maximum water levels (in the monsoon period) would be reduced. To deal with the resulting uncertainty in hydrological predictions, two scenarios have been considered for mean maximum water levels and the associated distribution of land type phases:

Scenario 1:

No change of land type; the post-project mean maximum water level would be the same as under present conditions: 2.6 m (1-in-5-year mean maximum level for the months June, July, August, and September). Land types are shown in Map 7.

Scenario 2:

Change of land type due to a reduction in mean maximum water levels to 2.4 m. The reduction has been estimated on the basis of judgement—taking into consideration the topography of the area and its drainage pattern—and is subject to confirmation at a later stage when more information is available. The associated change in land types is shown in Table 4.1 and depicted in Map 14.

The 125 ha of land acquired for embankment construction would come partly from existing agricultural land. Following project completion, the soils of the project would be largely free from drainage congestion and protected from seasonal tidal surges and therefore more intensively used for agricultural production. As described above, the depth of surface inundation of soils might not be significantly changed in the monsoon season (*Scenario 1*) in which case there would be no change of soil phases and land capability of the areas. Alternatively, maximum monsoon water

Table 4.1 Distribution of Land Types Under Two Post-Project Scenarios

Land Type	Scenario 1		Scenario 2	
	ha	%	ha	%
F_0	287	5.4	1,313	24.7
F_1	4,061	76.5	3,149	59.4
F_2	129	2.4	15	0.3
Homestead	686	12.9	686	12.9
Rivers	143	2.7	143	2.7
Total	5,306	100.0	5,306	100.0

Source: FAP 19 GIS

levels might be reduced (*Scenario 2*), in which event the areas covered by the highland phase would increase and the medium highland and medium lowland phases would be reduced proportionately. Parts of the medium highland phase of Ramgati soils would become a highland phase while the medium lowlands of Nilkamal soils may be changed to a medium highland phase of the same soil series. The change would increase areas considered good agricultural land.

The project would control tidal flooding, which may in turn reduce fresh sediment deposition inside the project areas. The land accretion process, which is continuing within the project area, would be stopped. This may result in land subsidence in the future. Addition of essential nutrients to the soils from fresh sediments would no longer continue. This would probably be compensated by farmers using more fertilizers and manures. Increased use of chemical fertilizers may degrade the natural fertility of soils.

The proposed embankment is likely to prevent saline tidal flooding during storm surges, and this would enhance soil quality in the southeastern part of the project area.

The cyclone shelter would be used to store crop produce and seed, and protect livestock during cyclones. It would contribute to agricultural rehabilitation after the cyclone and therefore would play an important role in maintaining crop production the following season.

Overall, the project would have some negative impacts on area soil fertility, but would have small beneficial effects in reducing soil salinity in specific locations. The land types may or may not be changed by the project—present hydrological information is inadequate to predict this.

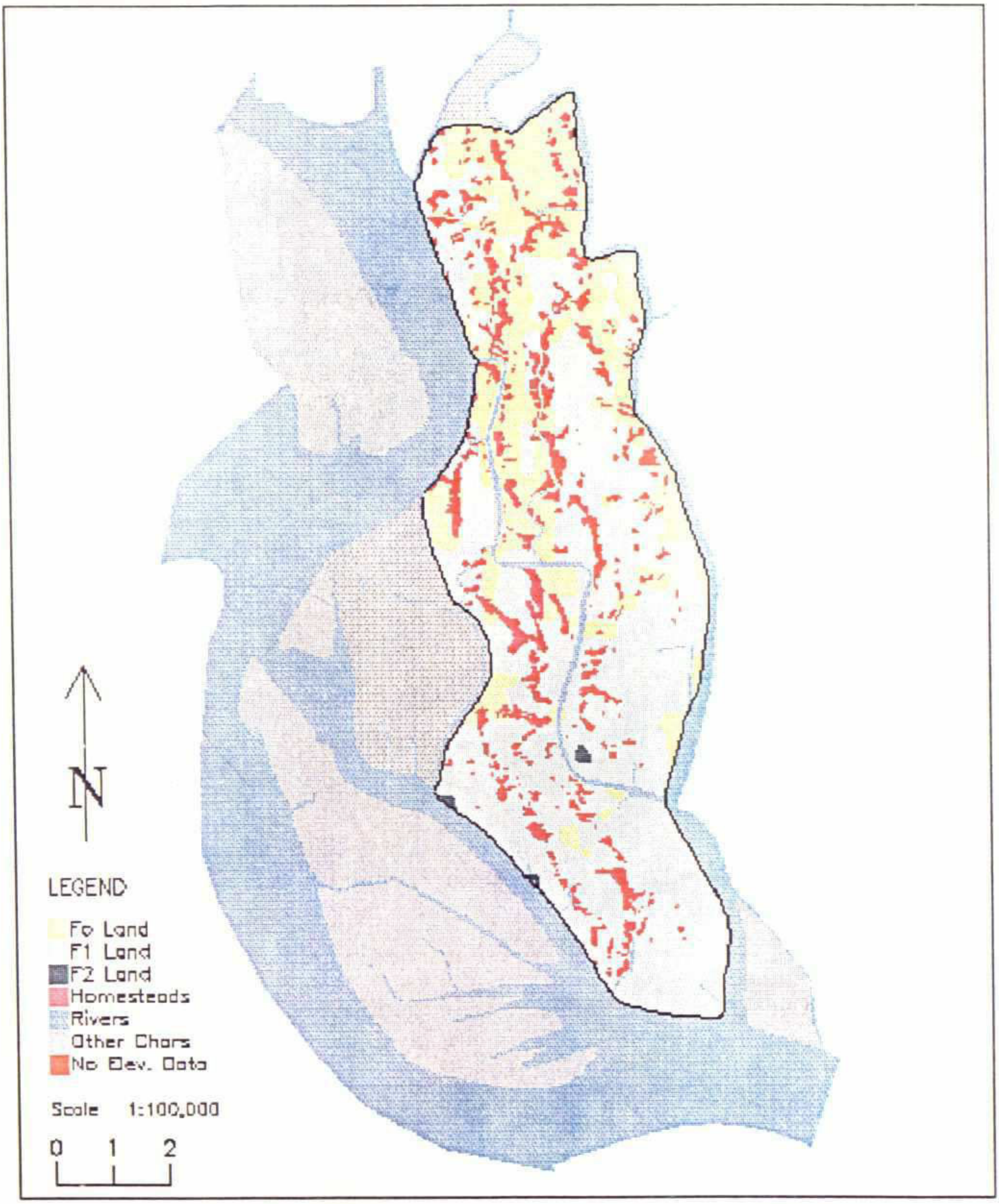
4.2.2 Agricultural Crops

Future Without Project

Tidal floods would continue to damage *aus* crops during harvesting in June and July and early growth stages of T. *aman* during July and August. Drainage congestion may increase and damage HYV *boro* crops during the pre-monsoon season, especially when heavy rain and winds occur. It is estimated that areas subjected to crop damage would increase from the current 1,726 ha to 1,855 ha, while flood- and drainage congestion-related crop losses would increase from the current 2,500 tonnes/year to 3,000 tonnes/year (Table 4.2). Crop estimates for future conditions have assumed that present agricultural land areas would not be substantially impacted by increased homestead areas necessary to accommodate the increases expected in human populations (see Sections 4.2.3 and 4.4.1), although some loss seems inevitable.

To compensate for crop losses due to damage and any losses in agricultural land areas, farmers are likely to increase *boro* cultivation by installing more low-lift pumps, increasing the area of irrigated land from 12 percent to 20 percent. These additional irrigated areas probably would involve F_1 and F_2 land types, replacing the B. *aus*/T. *aman*/*rabi* season cropping pattern with T. *aman* and HYV *boro* season. This replacement would be at the expense of pulse crops and local rice varieties. Pests and diseases would continue to damage crops unless farmers adopt effective controlling measures. Despite these changes, future cropping intensity is expected to remain the same, but food

Map 14



ISPAN FLOOD EXTENT FOR WATER LEVEL OF 2.4m

Table 4.2 Expected Cropping Patterns in the Absence of Project Development

Cropping pattern	Area under cropping patterns (ha)			
	F_0	F_1	F_2	Total
T. Aman (H) - Rabi crop	250	-	-	250
B. Aus (L) - T. Aman (L) - Rabi crop	-	1,319	-	1,319
T. Aus (L) - T. Aman (L) - Rabi crop	-	181	-	181
T. Aus (H) - T. Aman (L) - Rabi crop	-	75	-	75
B. Aus (H) - T. Aman (L) - Rabi crop	-	210	-	210
B. Aus (L) - T. Aman (H) - Rabi crop	37	300	-	337
T. Aman (L) - Boro (H)	-	925	-	925
B. Aus (L) - T. Aman (L)	-	608	115	723
T. Aman (L)	-	443	14	457
Totals	287	4,061	129	4,477

Source: FAP 19 GIS and Field Survey, 1992

grain production would increase by an estimated 570 tonnes (Annex 23-1). An estimated 1,418,000 person-days per year would be required for agricultural activities under the "without project" scenario (Annex 23-2), a figure slightly higher than the baseline estimate of 1,387,000 person-days.

Currently, about 1,200 tonnes of chemical fertilizers are being applied annually in the area. An increase of 100 tonnes/year is expected for the increased production of HYV *boro* and T. *aman* crops. The increase in cultivated HYV crops also is expected to increase pesticide use from the current 5.9 tonnes/year to 6.2 tonnes/year.

Future With Project

With the implementation of the project, agricultural crops would be protected from the high tidal flooding during the monsoon season and average storm surges in the months of October and November. Improved drainage conditions would reduce damage to *boro* crops at the harvesting stage, which in turn would encourage farmers to increase the cultivation of this crops by installing more low-lift pumps. At present, 12 percent of the cultivated land is irrigated. This is judged likely to increase to about 25 percent.

If the distribution of land types is unchanged (*Scenario 1*), the hydrological situation would remain unfavorable for the introduction of HYV paddy during the monsoon season, and agricultural gains would come from reduced crop damage. Paddy production could increase up to 18,646 tonnes annually (Table 4.3). Benefits of production would come from HYV *boro* only in the dry season. If the proposed embankments reduce maximum water levels during the monsoon season (*Scenario 2*), the land types of the project area would be changed and the cultivation of HYV paddy would increase significantly as a result of the increase in the highland (F_0) (Table 4.4). Paddy production, mainly composed of HYV *boro* and HYV *aman* crops, is projected to increase from 14,000 tonnes to 19,000 tonnes annually.

Increased crop production would increase the agricultural labor requirements, which may lead to a more active economic environment in the project area. About 2,783 tonnes of crop damage could be

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Table 4.3 Expected Cropping Patterns Under Scenario 1 (no change in land types)

Cropping pattern	Area under cropping patterns (ha)			
	F_0	F_1	F_2	Total
T. Aman (H) - Rabi crop	250	-	-	250
B. Aus (L) - T. Aman (L) - Rabi crop	-	1,195	-	1,195
T. Aus (L) - T. Aman (L) - Rabi crop	-	231	-	231
T. Aus (H) - T. Aman (L) - Rabi crop	-	125	-	125
B. Aus (H) - T. Aman (L) - Rabi crop	-	210	-	210
B. Aus (L) - T. Aman (H) - Rabi crop	37	300	-	337
T. Aman (L) - Boro (H)	-	1,119	-	1,119
B. Aus (L) - T. Aman (L)	-	508	115	623
T. Aman (L)	-	373	14	387
Totals	287	4,061	129	4,477

Source: FAP 19 GIS and Field Survey, 1992

Table 4.4 Expected Cropping Patterns Under Scenario 2 (change in land types)

Cropping pattern	Area under cropping patterns (ha)			
	F_0	F_1	F_2	Total
T. Aman (H) - Rabi crop	250	-	-	250
B. Aus (L) - T. Aman (L) - Rabi crop	-	803	-	803
T. Aus (L) - T. Aman (L) - Rabi crop	-	231	-	231
T. Aus (H) - T. Aman (L) - Rabi crop	125	-	-	125
B. Aus (H) - T. Aman (H) - Rabi crop	210	-	-	210
B. Aus (L) - T. Aman (H) - Rabi crop	728	-	-	728
T. Aman (L) - Boro (H)	-	1,119	-	1,119
B. Aus (L) - T. Aman (L)	-	623	-	623
T. Aman (L)	-	373	15	388
Totals	1,313	3,149	15	4,477

Source: FAP 19 GIS and Field Survey, 1992 prevented annually. However, annual losses caused by pests and diseases would likely increase from 1,475 to 1,630 tonnes annually, unless farmers adopt effective controlling measures, which would include the introduction of Integrated Pest Management (IPM) programs in the area. Farmers would use more chemical fertilizers and pesticides to raise their agricultural production. In *Scenario 1* about 170 additional tonnes of fertilizers may be used annually in the project area. At present, about 1,200 tonnes of fertilizers are applied annually. In *Scenario 2* about 200 additional tonnes of chemical fertilizers would be used.

Overall, project development would have positive and beneficial impacts on agricultural production, especially if maximum monsoon water levels are reduced and highland land types are increased in the area. Potential crop gains would be reduced by pest damage. Increased use of agricultural chemicals would potentially lead to negative impacts on water and soil quality, and on human health.

4.2.3 Livestock

Future Without Project

A continued high frequency of flooding, especially during high lunar tides, will probably continue to keep homestead courtyards wet and muddy, creating unhygienic conditions for livestock, especially cattle. Expansion of irrigated land in the dry season may further constrain the already limited grazing areas. Replacement of pulse crops such as *khesari* by irrigated *boro* would further reduce the supply of livestock fodder.

Future With Project

Reduced flooding levels in the monsoon season (*Scenario 2*) may permit slightly drier courtyard conditions for livestock, although heavy rainfall would continue to create generally wet and muddy conditions. An increase in paddy production associated with the project may increase the amounts of straw available as stall feed, but the quality of such feed would be low due to the shortage of pulse production in the area. Increased economic gains to farmers may encourage them to purchase feed. Draft power would likely continue to be limited in the area.

4.2.4 Forests and Homestead Vegetation

Future Without Project

Tidal inundation and drainage congestion would continue to limit the establishment of economically important forest and homestead vegetation species in the area if no flood control project is built. Local people would increasingly have to depend on imported fruits and vegetables. The expected 36 percent increase in population size (over 20 years) would lead to heavy utilization of trees for food, fuel, fodder, and cash. Unless actively managed and replanted, vegetative cover would gradually decrease, leading to deficiencies of nutritious food, fodder, durable building materials, and energy efficient fuel wood. Rice straw and *mandar* would increasingly be used as energy sources for cooking. When burned, rice straw and *mandar* wood leave soot that is hazardous to human health. Using these energy sources would be particularly detrimental for women as they do the cooking. Moreover, because women primarily are responsible for forestry products and homestead gardens, they would feel the economic stress caused by a reduction in economic tree species. The expected 36 percent increase in population and associated expansion of homestead areas could take some cropland out of production. About 50 percent of the total homestead area within the project has been developed in the past 20 years, but this trend of homestead expansion is unlikely to continue at the same rate as it would rapidly engulf the already limited amount of highlands, which are key areas for *rabi* and cash crops. At present rates of population increase, shortfalls of vegetables, fruits, spices, and fuel would occur over 20 years and create serious nutritional deficiencies and fuel shortages. Women would continue to meet the fuel shortage by cooking only one meal per day and serving deteriorated food, locally known as *bashi panta*.

Future With Project

Land used for construction of the embankment would affect some homestead land, particularly along the Tetulia River, causing a reduction in the homestead land in those areas. In addition, there would be a loss of natural vegetation, including *hogla*, which is a source of household income. Disposal of soil along reexcavated *khals* would bury *hogla* shoots that grow along the *khals*. Loss of other natural vegetation would adversely affect the availability of biomass energy. The amounts of homestead land lost would depend on the alignment of the embankment.

Some excavated soils would be disposed of on existing homestead mounds, raising them and making them drier and more suitable for homestead vegetable cultivation. This would also reduce damage to homestead trees and other vegetation from tidal and rainwater flooding.

Under post-project conditions, flooding from sporadic tidal surges would be reduced. Mean maximum water levels might remain the same as at present (*Scenario 1*), or might be reduced slightly (*Scenario 2*). Inundation losses of homestead plantations and vegetables would be reduced, including those along canal banks. Because of embankment construction, displaced households in the Char Hossain and Char Gazi areas may be resettled within the project area, resulting in a loss of homesteads and cropland production both outside and inside the project area.

The project would have direct positive impacts on the establishment of economically important vegetation species such as mango, jackfruit, cultivable varieties of banana, bamboo, and common summer and winter vegetables, resulting in higher production of food, fodder, construction material, and firewood, improved protection from wind through provision of shelter and shade, and reduced topsoil erosion. Betelnut cultivation on highlands and medium highlands would be more successful due to reduced levels of sporadic inundation. Any changes in land types (*Scenario 2*) would increase field crop production and thus reduce the stress demand on trees and non-crop vegetation. As over 40 percent of traditional resources of household energy is related to field crops in the form of straw and husks, reduction in crop losses would also improve the availability of household fuel.

The drainage condition of low-lying homestead areas towards the Tetulia River would be improved during the early *rabi* season, and various cash vegetables such as chili, sweet gourd, brinjal, cauliflower, and cabbage, could be grown, harvested, and marketed in time. Drainage/flushing sluices and sluice gates would reduce drainage congestion and increase irrigation facilities inside the project area. Reduced drainage congestion during the rainy season would help summer vegetables grow better. Irrigation facilities would help grow more winter vegetables.

The reexcavated *khals* would hold more water for dry season irrigation of homestead vegetables, leading to an increase in homestead vegetable production. In addition, tubewells sunk for drinking purposes would provide irrigation water for homestead vegetable production. The cyclone shelter would likely be used to protect vegetable seeds during cyclones, and the seeds thus saved would be used in post-cyclone rehabilitation of homestead vegetable production.

The indirect positive impact of the project would improve the nutrition level from fresh fruits and vegetables. Women should have a better opportunity for income generation and biomass production from homestead plantations and vegetable cultivation. Denser vegetative cover would lessen the local negative effects of floods, droughts, cyclones, and other environmental disasters. *Bandhujan* or some other local NGO may take up an embankment plantation program, therefore increasing vegetation and biomass production and contributing towards alleviating the fuel shortage.

Overall, construction of the project would have some negative impacts on natural vegetation, and some homestead land would be lost near embankment alignments. Most post-project changes would be beneficial in terms of homestead vegetation production, diversity, and biomass. An expected increase in land requirements for homesteads would lead to a small decrease in available cropland.

4.2.5 Wildlife

Future Without Project

Terrestrial habitat area has increased in size and quality in the project area over the past few years and is likely to continue doing so during the next 20 years through increases in homestead vegetation tree cover and diversity. The age distribution of some dominant plant species, such as betelnut, banana, and *mander* suggests that these species are self-sustaining. This qualitative improvement of economically important plants would likely expand from the central part of the study area toward the east and west. *Mander* and betelnut, as natural climax species, would succeed banana, and species diversity would likely increase as local NGOs introduce new species.

Wildlife populations in the area are decreasing. Whether they are decreasing at rates similar to those in other parts of Bangladesh is not certain. Land is being lost to erosion in Char Bheduria, reducing the area's quality wildlife habitat. The population of shoreline birds, however, is expected to remain unchanged because their shoreline habitat always would be available in some form or another and they are not routinely hunted. Freshwater turtles probably would decline because they are over-hunted and because a large proportion of juveniles are harvested. One positive note for wildlife is that plantation production and management may improve some terrestrial habitats.

Pest control by the thana agricultural officers has reduced rat populations in the area in the past, and this would likely occur in the future.

Future With Project

The embankment along the Tetulia River would stop immigration of such economically important species as turtles, affecting both their exploitation and production. They would, however, continue to gain access to the project area via the open canals along the Jangalia River. Harvestable numbers of turtles might decline because of the restricted access, the exact amount of such decline is difficult to predict without detailed studies of migration and harvesting patterns.

Pest wildlife species such as rats would become common along the embankment, as this would represent a valuable flood refuge for them. Extensive rat damage to the embankment is likely to ensue, unless active control measures are taken. Biological control, e.g., propagation and protection of rat snakes, would be the preferred method of rat control.

Habitat and land use changes are unlikely to significantly affect the habitats or populations of threatened and endangered wildlife species, although they are likely to decline further, possibly to the point of local extinction, due to continuing human population increase and resulting pressure on habitats and land and water resources.

4.3 Freshwater Environment

4.3.1 Habitats and Water Quality

Future Without Project

The area, flooding magnitude, and inundation duration of the area's perennial water bodies should remain close to what it is now during the next 20 years. Bheduria Khal probably would continue to silt up as far as the Bhelumia market area, increasing the water's salinity during the dry season. Water quality would be affected by an increased use of pesticides, and water quality would degrade in the north and central part of the study area due to canal blockages.

Future With Project

If maximum monsoon water levels are unchanged by the project (*Scenario 1*) then post-project aquatic habitat conditions would not differ greatly from those prevailing at present. About 70 percent of the area is inundated to a depth of 20 cm or more during the monsoon at present (Map 12) and this might continue to be the case. Under present conditions, post-monsoon maximum water levels decline slightly ($\approx$0.3-0.4 m) and the amount of area under inundation drops slightly to about 66 percent. Similar conditions are likely to prevail during the monsoon season if water levels are slightly reduced by the project (*Scenario 2*) since the assumed water levels are approximately the same ($\approx$2.4 m above local datum). Thus, under either scenario, the quantitative change in aquatic habitats would not be great.

The increased use of agro-chemicals, chiefly fertilizers, pesticides, and herbicides, would increase the run-off of these substances into existing habitats, diminishing the habitats' value to the aquatic biota using them.

4.3.2 Open Water Capture Fishery

Future Without Project

National statistics indicate that freshwater fish production declined between 1974 and 1989. Use of restricted nets, harvesting of juvenile fish, and poor to no fishery management are the main reasons for the decline. If capture fish production in the study area follows the national trend, it would decline during the next 20 years from the current 2,576 tonnes/year (1992) to 2,194 tonnes/year by the year 2012. Commercially important species such as the catfishes *aire*, *boal*, and *pangas*, as well as *hilsha* are often harvested too early in their life cycles, reducing the number that reach breeding maturity. Another problem adding to the expected decline in fisheries is the anticipated increase in the number of professional fisherman from the current 21 percent of the area's population to 25 percent. Despite declining fish stocks, the numbers of fishermen are likely to increase in proportion to the total population increase, since fishermen have little opportunity to change their vocation under socioeconomic conditions prevailing in the study area, and some poor farmers might even be forced to adopt fishing as a lifestyle if forced from the land by existing tenancy conditions.

Future With Project

During the construction phase, closures of the canals along the Tetulia River would preclude fish migrations. These migrations could continue to a reduced extent through the canals on the Jangalia River side. Reexcavation of *khals* would disturb fish populations and fishing activities in the *khals* and, hence, capture fisheries production would be reduced. The reexcavation work would have a temporary negative impact on capture fisheries production.

The embankment would stop fish migration from the Tetulia side altogether and reduce it substantially from the Jangalia side by blocking innumerable small creeks which at present overflow during high tide. The embankment would also stop fish migration during tidal floods. Furthermore, water quality inside the project would decline because of the reduced flushing effect and increased use of agro-chemicals due to the increased HYV cropped areas. This would adversely affect fish habitat. The combined effect of the two would greatly reduce capture fisheries production inside the project. The sluice gates, although allowing water in and out, would affect fish entry/migration into the project area from the rivers to a large degree.

The reexcavated *khals* would have more water holding capacity, and would therefore provide improved aquatic habitat for capture fisheries. Borrow pits would also provide suitable habitat for capture fisheries. Based on the information available for fish species present in the area (Annex 12) and their spawning and rearing sites (Annex 13), it is apparent that habitat declines and corresponding declines in production would affect mainly *pangas* and some portions of the carp and catfish populations. Many of the main commercial and food species, including *hilsha*, carps, catfish, and shrimp, breed outside of the project area and utilize it in part for rearing and migration.

Consideration of the fish production and purchasing information (Annex 14), and the distribution and types of fishing gear and boats (Annex 15), many of which are specifically for river use, it is apparent that the bulk of the fish produced and harvested comes from populations in the Tetulia and Jangalia rivers. Computing proportional production on the basis of the distribution of fishing gear (Figures 3.6, 3.7) suggests that about 78 percent of total fish harvests come from the main rivers or elsewhere outside the project area. The remaining 22 percent is derived from the canals inside the project area and represents an annual value of approximately 7 million taka.

The fish harvested in the Tetulia River are captured by boats operating from within the project area. Fishermen traditionally live in separate fishing communities within the project area and move once or twice daily from their home villages to the fishing grounds and back. These movements in and out of the canals on the Tetulia River side would be blocked by the proposed embankment.

In summary, the embankment would reduce fish harvests in the project area by a moderate amount, judged subjectively to be about 10-15 percent because of blockages to fish movements through the Tetulia River channels, and reductions in fish populations inside the project area. Fish populations in the Tetulia and Jangalia rivers would be substantially unaffected by the project, but fishermen's access to their traditional fishing areas would be blocked.

4.3.3 Closed Water Culture Fishery

Future Without Project

Culture fishery production in the study area is currently 455 tonnes/years and is expected to increased to about 597 tonnes/year by the year 2012 if the trend in the area is similar to the national trend. Tidal flooding would continue to be a constraint on culture fish production.

Future With Project

The embankment would protect ponds in the project area from sudden storm surges, but overall inundation from monsoon tidal flooding levels would not be affected. Most culture fish ponds have their own protective dikes that isolate them to some extent from surrounding flooding conditions. The reduction in storm surge damage might encourage local farmers to invest more in culture fisheries.

The project would have a slightly beneficial impact on culture fisheries in the area due to a slight increase in the amount of flood protection offered.

4.4 Socioeconomic Environment

4.4.1 Population and Settlements

Future Without Project

Without intervention, the population of the project area would continue to increase at an assumed rate of about 1.5 percent per year (Annex 26) between 1991 and 2011; the population of the project area would thus increase by 36 percent by the year 2011 to just over 58,000. This increasing population would put tremendous pressure on the existing land and water resources, further reducing the land/person ratio and per capita agricultural land availability. With an increase in farm households and farm population, the average farm size would decrease (Annex 26) and land would be further subdivided into smaller plots. This would reduce the productive efficiency of the farmers and land productivity probably would decrease.

Localized drainage congestion would be further aggravated, especially during heavy rainfall and high tidal flood, putting more agricultural lands under water for prolonged periods and causing increased damage to crops. Farmers would feel forced to make more cuts across village roads to drain stagnant water from croplands. Erosion would continue to displace more households along the riverbanks, exacerbate landlessness, reduce the amount of productive agricultural land, and promote internal as well as external migration. Facing such difficulties, farmers would feel discouraged to cultivate the land as intensively as in the past.

Bank overspill would continue to make living difficult for those along the *khals* and riverbanks, while those outside the proposed embankment would be more affected during high flood years. High tidal floods may lead to the break up of linear settlements along the *khals* and creeks, and increase the number and density of clustered settlements on medium and highlands. Moreover, tidal flooding makes it necessary to raise homestead mounds every year, creating extra financial burdens for many poor households. Consequently, these households may move from low-lying areas to medium highlands that currently are under cultivation.

Future With Project

With the implementation of the project, particularly with increased income from agricultural and homestead production and improved infrastructure, there may be a positive impact on the rate of literacy which, in turn, may have an indirect impact on the growth rate of population in the area. This would, by implication, reduce the anticipated increase in total population and therefore bring down the population pressure on the existing land and water resources.

The reduction in population growth rate would have a positive impact on the existing land-person ratio and per capita agricultural land availability, leading to decreased land fragmentation. This would improve the productivity of the farm holdings and as a consequence, farmers would cultivate the land more intensively. Areas under HYVs would increase and farmers would use more chemical fertilizers and pesticides to augment agricultural production.

Families living outside the project area, but inside the impact area, (especially parts of Char Bheduria, and Char Hossain and Char Gazi), would be more vulnerable to changes induced by the construction of embankments. These families may have to migrate to the project area and to Bhola town in large numbers, causing tremendous pressure on the already tight employment market.

Furthermore, families displaced by embankment construction and its setback requirement would permanently lose ancestral homes, homesteads, and agricultural land. This may cause considerable stress, particularly to the poor who would become refugees.

Given the limited availability of *khas* land in the area, those displaced families would face severe difficulties in finding a suitable place to build new homesteads and begin a new settlement with their meager sources of income. The compensation claim for those people has to be made in full and as quickly as possible.

In summary, the project would benefit farmers and landowners through increased agricultural production, but is likely to have negative impacts on people in the adjacent areas and on poorer people displaced by the embankment.

4.4.2 Livelihood and Subsistence

Future Without Project

Without project intervention, the expected increase in agricultural production by only 715 tonnes by the year 2011 would not keep pace with the growth of population and high input cost. As a result, per capita gross availability of major cereal grains would be reduced from the current 934 grams to 718 grams per day by the year 2011. Total gross food availability per capita/day would also be reduced from the current 1102 grams to 841 grams (Annex 25).

The growing imbalance between land availability and population increases, and the lack of employment outside peak agricultural seasons, would lead to progressive deterioration in the quality of people's lives. This deterioration would force many landless and land-poor households to migrate to Bhola, Barisal, and other urban centers in search of employment.

There is an existing rural-to-urban migration trend, and if this continues the 1981-1991 urban population growth rate of 7.15 percent for Bhola town (BBS 1992a) would be sustained. As a consequence, the population of Bhola town would be nearly 144,000 by the year 2011, which is four times more than its existing population. This would create tremendous pressure on the overcrowded urban center, aggravate resource overconsumption, and increase pollution. Increased migration also would negatively impact already over-crowded Barisal town and its environment. The net effect of continuing the current livelihood and subsistence patterns would be increasing poverty, inequality, and unemployment.

The project area is highly dependent on its fishery resources. If species extinction, loss of fish diversity, over-fishing, and prevalence of fish diseases due to water pollution continue, the animal protein intake of area households would be dangerously reduced. In addition, deteriorating water resources and declining capture fisheries production would negatively impact professional fishermen.

Future With Project

Construction of embankments, sluices, closures, culverts, footbridges, a cyclone shelter, excavation of borrow pits, and reexcavation of *khals* would all generate additional employment, provide incoming and food security. The additional employment would attract skilled labor and professionals from outside the project area. The increased population and the money supply would increase demand on the existing market outlet. New shops and expanded markets would meet the increased demand of essential items. However, there is likely to be extortion from the contractors, so that there would pressure on security forces. To serve the increased labor requirements and in response to labor mobilization drives by the contractors and others connected with project implementation, Landless Contracting Societies (LCS) may be formed. There will be an increase in the movement of labor both within the project area as well between the project area and outside. This would increase demand on the existing transport facilities and other services.

With the project, crop production would increase, and this would increase agricultural labor requirements from the existing 1,386,000 person/days to 1,464,000 person/days for a one-year cropping activity. Year-round agricultural production activities would be facilitated and would widen the opportunities for agricultural employment. Opportunities for non-agricultural employment and small-scale industries and marketing would also expand.

Intensification of agricultural activities would generate employment and may increase wage rates. Such impacts would increase the income of the landless and land-poor households and help absorb the expanding labor force in agriculture. With an increased income, households may have the capacity to improve their present nutritional deficiency and enhance their standards of living. Flood protection measures may alleviate the existing inequality in the distribution of capital resources in the sense that it potentially can increase the income of landless and land-poor households from various project-generated sources and project spinoff activities. Small and marginal farmers may also gain as their land would be protected from flooding. More opportunities would be available for gainful employment, and landless laborers may have more cash in hand to improve their living standards.

On the negative side, the project would have impacts on fishing in the *khals* and creeks as well as employment in the fish subsector. Fish consumption by communities dependent on capture fisheries may decrease due to reduced fishing areas. Navigation would also be affected by the closure of important *khals* on the Tetulia side. Although some structural measures are being considered to allow fish migration and reduce project impact on capture fisheries production in general and fish stocks in particular, the project would have residual impacts on fish catch, fish consumption, and nutrition, especially among fish-dependent communities.

Professional fishermen may abandon fishing and seek agricultural or other occupations, pressing the already tight employment situation. It is likely that some of the narrow streams and lowlands that are currently being used as fishing areas would be converted to agricultural land. This trend would have residual impact on the ecological, biological, and navigational aspects of fisheries. Increased use of chemical fertilizers and pesticides would have residual impact on surface and groundwater quality, thus increasing the risks of human health and fish diseases.

The project would improve the livelihoods of farmers and landowners on a long-term basis, and would provide short-term benefits to local labor forces during the construction period. The project in its unmitigated form would have major negative impacts on fishing communities by preventing their traditional access to their fishing grounds. Long-term project benefits would accrue mainly to landowners, with other groups receiving a much lower share, if any.

4.4.3 Land Ownership Distribution Pattern

Future Without Project

As resource productivity and income decreases in the project area, many small and marginal farmers would be forced to sell their land, probably for less than value, to feed their families. Leasing and mortgaging would increase and, in many cases, land would be permanently transferred to the lender because the farmer would not be able to pay his debt. This trend would further concentrate land and income into the hands of large absentee landowners and the area's few large landowners. If such trends continue and if the population increases as expected between 1991 and 2011, almost 76 percent of households could become landless by the year 2011 (Annex 25).

Future With Project

With the implementation of the project, more land would be brought under HYV crops which would increase crop production. The benefits of increased production would not be shared equally by all categories of households as land and other capital resources are highly unevenly distributed. Since the distribution of capital resources varies greatly among household categories, those with access to more resources would be more likely to take advantage of and benefit from the opportunities created by the project. The embankment would provide protection against tidal flooding, giving an increased sense of security to those living inside the embankment. This increased sense of security against flood loss would improve the investment climate and likely encourage increased investments in various income-generating activities, including agriculture, culture fisheries, livestock, business, and commerce.

Land prices for F_1 land would increase and some of the F_2 land that became flood-free would be sold at higher prices. This may allow some economic benefits to small and marginal farmers who must sell or mortgage land in distress situations. The small and marginal farmers would probably sell less, however, as the risk of crop damage due to flooding would be greatly reduced. Distress sales and mortgages of land would also be reduced for the same reason.

In general, the project would reinforce existing land ownership patterns.

4.4.4 Tenancy Relations

Future Without Project

As more land is acquired by large and absentee landowners, the tenancy market would expand and work exclusively in their favor. Population pressures and limited available land would reduce opportunities for tenancy contracts, because too many people would run for too few lands. In addition, the lack of employment opportunities outside agriculture would, inevitably, increase competition among the landless and land-poor for tenancy contracts. Such competition and growing land shortages would allow large landowners to impose stiffer tenancy terms and conditions and to dominate the tenancy market. Cash rent tenancy probably would increase and sharecropping may disappear due to the fact that landowners find the former more profitable and risk-free than the latter.

Future With Project

The existing tenancy market would further expand and as more land becomes flood-free, the rental rate for *logni* and *kudi barga* would increase. Given the growing imbalance between land availability and population growth, not enough land would be available for all possible tenants. Land shortages would enable large and absentee landowners to dictate the terms and conditions of tenancy in their favor. In other words, competition for land would cause severe downward pressure on tenure terms to the full advantage of large and absentee landowners. In a situation where all tenancy contracts are mainly verbal and insecure, it is likely that tenant farmers would work the land under more inequitable terms and conditions. As the costs of irrigation and other HYV inputs increase, landowners may not share the cost of production in the same proportion as is currently being shared. Traditional sharecropping (*barga*) systems may disappear and give way to various forms of annual cash leases with higher rates and terms imposed by the landowners.

The project would reinforce existing land tenancy and probably further aggravate the present inequitable land-sharing system.

4.4.5 Credit Relations

Future Without Project

Non-institutional credit sources with usurious interest rates would continue to dominate the credit market unless institutional credit facilities are enhanced or expanded. If the existing difficulties in obtaining credit from institutional sources are not removed, more households would seek loans from informal credit sources at even higher interest rates. This, in turn, would enhance transfer of resources from poor to wealthy households, exacerbating the landlessness process. The advance sale of crops before harvesting (*dadon*) may occur more often and distress land sales may increase due to continued tidal flood-related crop losses.

Future With Project

The average credit obtained by farm households from informal sources is significantly higher than from formal sources. With the project, it could be expected that institutional credit facilities would improve and more marginal and small farmers would gain access to formal credit sources to meet their financial needs. As long as the existing bottlenecks pertaining to collateral and terms are not removed, the informal credit sources would continue to operate with high interest rates. Prevalence of high interest rates would facilitate transfer of resources from poorer to richer households and exacerbate the inequality in the distribution of land in the long run. The credit delivery schemes of some of NGOs, when expanded as planned, could ease the credit constraints of the small producers. In addition, Grameen Bank activities, when introduced, could help alleviate credit constraints on many landless and poor women in the locality.

In summary, the project would have minor effects on existing credit institutions.

4.4.6 Wealth and Equity Situation

Future Without Project

Over time a large number of households would face increasing poverty, inequality, and landlessness. On the other hand, a few large absentee landowners who already own a highly disproportionate share of land would continue to benefit disproportionately, enabling them to extract surpluses from the area without any effective contribution to the improvement of agricultural production. The "patron-client" relationship would persist and possibly turn into other forms of impersonal relationships of domination and dependence, giving way to an increasing marginalization and polarization process. The implication of such a situation for the overall distribution of wealth and equity is that the rich would get richer and the poor poorer.

Future With Project

The loss of agricultural land from embankment construction would lead to financial loss and emotional/psychological stress. The financial loss would arise from the fact that compensation is fixed at the level of a three-year average price prior to the serving of the acquisition notice, but since the price of land goes up whenever a project is implemented, the compensation money cannot buy the amount of land lost. There is an invariable delay in the payment which causes additional hardship. Land loss may be accompanied by displacement, either because the agricultural land that has been acquired makes it unprofitable for the family in question to remain there, or the homestead land itself has been acquired. Some of the displaced households would belong to the fishing community, particularly along the Tetulia River.

Given the existing land ownership distribution, it is unlikely that increased production from HYVs would benefit all categories of households equally. Large and absentee landowners who already stand to benefit disproportionately would benefit more and they would also be able to diversify their income from many non-agricultural sources, further improving their socioeconomic status.

Unless boat passage facilities are provided for fishing boats, the fishing community would suffer major declines in their economic situation, with increased costs of travel, fish trans-shipments and transport, and higher damage and loss risks to any fishing boats moored outside the project area.

Overall, the project would improve the economic situation for landowners and most farmers. It would have minor if any benefits for landless and displaced people, and it would create major negative impacts on the economic status of the Tetulia River fishing communities. The project would have major negative impacts on displaced households unless adequate mitigative measures are taken.

4.4.7 Gender Issues

Future Without Project

The status of women in the Bhelumia-Bheduria area would probably deteriorate over time. Limited employment opportunities, continued inundation and drainage congestion, and damage to homestead production have specific negative impacts for women. For example, with continuing population increases and declines in traditional rural-based activities such as paddy husking by *dheki,* work opportunities for women would be reduced. With no skill or training women are limited in what they can do, and with little or no income-making activities, their position becomes weaker. Women in remote areas do not have access to development organizations (NGOs) whose activities focus on women. Women's mobility would continue to be hindered by a lack of adequate transportation modes and routes. Often they are unable to travel even in health-emergency situations.

Future With Project

Increased family income arising from improved agricultural and other sources probably would not have a significant and immediate positive impact on the women in the project area. Such increases, however, would have an indirect impact on women through an overall improvement in the quality of life of the people. Most of the income-generating activities involving women are in traditional and manual tasks, e.g., *pati* weaving and paddy boiling and husking. Very few NGOs are working in the project area because of bad communication. Road improvement work planned under the project would improve road communications and may extend GOB and NGO services, including basic technical and skill development training to the more remote areas. This may provide more diversified work opportunities.

Furthermore, with the project, increased labor requirements in the agricultural sector would increase the opportunities for women to engage in paid work to supplement their family income. Employment in the *pati* weaving sector would probably remain static. An increase in family income and purchasing capacity and availability of food grain may increase grain consumption by women. Since more land would come under agriculture it is expected that homestead vegetation would increase, thus contributing to improvement in their calorie intake. The potential negative impact on capture fisheries, however, would have a significant residual impact on the nutrition of women in poor fishermen's families and in subsistence fishing households.

In general, the impacts of the project on women would be beneficial due to improvements in food availability from agricultural crops and homestead gardens, and reductions in flood stress.

4.4.8 Health

Future Without Project

Baseline data indicate that 92 percent of the people in the project area have access to safe drinking water. In spite of the statistics, incidence of water-borne diseases like diarrhoea, cholera, and typhoid are high. The use of *khal*, river, and pond water for bathing (people and animals) and washing appears to be the prime contributing factor. The current number of tubewells, although apparently adequate for the sample area population, would not function properly without maintenance. People would continue to use other water sources for domestic purposes, proliferating water-borne diseases. In addition, if people continue to build and use unhygienic latrines, surface water would continue being contaminated.

Women are frequently in contact with contaminated water during their household chores and with patients suffering from those diseases. This, coupled with the women's already weaker physical condition, make them more prone to diseases. Although MCHFP services are being provided through the GOB, women normally have less access to those services.

Without project intervention and with increases in population, the per capita food intake is expected to decline. Because disparity in the eating/feeding patterns of females and males is poverty related, the nutritional status of females is expected to drop lower. This situation would be aggravated by expected declines in capture fisheries that, in turn, would reduce animal protein intake.

The existing health delivery system is inadequate to cope with increasing health concerns. Poor sanitary conditions are a primary health hazard in the project area, especially for women. Based on existing data and past trends, it is predicted that water-borne diseases such as dysentery, and scabies and acute respiratory diseases would increase considerably. However, increased efforts by NGOs probably could slow the incidence of diarrheal diseases and malaria.

Future With Project

Increased levels of production of agricultural and homestead crops under project conditions would lead to enhanced nutrition and improved health for most communities, although poorer and landless communities would share disproportionately in these benefits. Improved road communication as a result of the project would help access to existing facilities. Improved drainage in the project area may also have an impact on health since stagnant and contaminated water that is used for all domestic and personal purposes facilitate the incidence of scabies, skin, and parasitic infections. Increased levels of agro-chemicals in standing water may pose a new and increased health threat.

Tubewells, although part of the project, are not part of the FCD component and are intended for drinking purposes, although some irrigation of homestead vegetation may be expected. Provision of safe drinking water will greatly contribute towards improving the water-borne disease situation in the project area.

The cyclone shelter will to some extent mitigate losses due to tidal surges against which the embankment will not provide any security. The shelter would also provide positive benefits in terms of security of life and property.

The project would do little to improve existing poor health facilities, and hence would not alleviate some of the major causes of disease and poor health care in the project area.

The project would mainly have beneficial impacts on community health and nutrition, with potential negative impacts if high levels of agro-chemicals are employed. Poorer and landless groups are less likely to share in health benefits.

4.4.9 Education

Future Without Project

The Bhola District population census shows that the literacy rate for the total population was 22 percent in 1981 and 25 percent in 1991. The rate for females only was 21 percent and 19 percent, respectively. In comparison, the Household Survey found that the overall literacy rate in the sample area was 26 percent for males and 13 percent for females. Between 1981 and 1991 the literacy rate for females decreased by 6 percent. Assuming that there would be no external intervention and all other factors remain the same, the literacy rate for the total population is expected to rise by 3 percent, while for females it should fall by 6 percent.

One of the reasons given by parents for withdrawing their female children from schools at puberty is the poor quality or lack of roads to distant schools. During the rainy season, these schools become totally inaccessible to girls, and those who do go must make long detours to reach the schools. Improvement in the road network would encourage parents to send their daughters to schools more regularly and for longer periods. Thus, this would indirectly help in delaying the marriage of these girls.

Future With Project

Access to existing schools would be improved by the construction of embankments and improvements to road communications, culverts, and bridges. This would have some, probably only marginal, beneficial impact on educational levels. The cyclone shelter would likely provide permanent infrastructural facilities for schools as is the normal practice in the coastal areas. Other educational factors would probably not be affected.

The project would have minor beneficial impacts on educational levels in the project area.

4.4.10 Navigation

Future Without Project

A gradual increase in the number of boats used in the study area could be anticipated to match the rise in human population levels, and the associated increased flow of goods back and forth. The proportions of mechanized and manually operated boats is not expected to change significantly in the absence of any specific programs to encourage mechanization. Boats would remain the chief mode of transportation in the area due to the poor road network and abundance of easily navigated channels. The continual silting of the Bheduria Canal and other major waterways may lead to temporary closures, but due to the importance of this waterway, it is likely that excavations would be undertaken to maintain free passage.

Future With Project

The Tetulia River embankment would seal off all western navigable canals from boat access. Project options (BWDB 1992) do not specify any particular considerations for navigational activities in the project area, but provision of boat passage facilities would be made if required. Due to the very high importance of boat transportation to the area's economy, it is almost certain that such boat passage facilities would be demanded by local inhabitants and would have to be built into the project.

Most professional fisherman presently use waterways for fishing in the Tetulia River, usually making two trips per day in and out of the western canal openings. This would be stopped by the unmitigated project. Fishermen using the Tetulia River would be unable to effectively access their normal fishing grounds through the eastern canals because of the long distances involved. There would be no impact on navigational activities in the eastern side of the project. Even after closure of the canals, boats could still move freely inside the project area, and internal passage would be facilitated by the proposed reexcavation of *khals*.

Fishing boats maintained outside the embankment on a permanent basis would be highly susceptible to damage from tidal surges and storms, unless adequate protective harbor facilities were made available.

Paddy harvested and transported by boat through the western side of the project area would have to be transhipped over the embankment. This could be achieved at an additional cost to the farmers.

In summary, unless boat passage facilities are provided, the project would have major negative impacts on navigation, both for fishermen and for the transportation of commercial and agricultural goods.

4.4.11 Hazards and Risks

Future Without Project

Providing the frequency and intensity of large-scale seasonal and tidal floods remains the same (see Chapter 3), the flooding hazards and risks would essentially remain the same in the foreseeable future. With increases in population (see Section 4.4.1), however, more people would be exposed to them. Sedimentation in the internal canals would increase, creating drainage congestion and flooding problems. It is likely that the duration of floods due to rain water would increase in low-lying areas due to the deterioration of drainage conditions (see Section 4.1.1). The outlet of the Bheduria Canal in the west may eventually close off due to siltation, consequently affecting navigation and fisheries.

Natural hazards such as drought, tidal surges, cyclones, hailstorms, and pests would continue at sporadic intervals, although the frequency may change if global weather patterns are altered as sometimes expected (see Chapter 5).

There is a possibility of geomorphological changes in terms of land raising and stabilization, particularly in the southern part of the study area and on the floodplains subject to regular tidal inundation.

Future With Project

The probability of damage by seasonal floods and the flood associated with high tide is expected to be sharply reduced by the project embankment. The risk of frequent crop and property loss would be diminished, but there would be an increased risk of severe losses due to embankment failure. Due to increases in the growth of populations and settlements, flood risk may disproportionately affect poor and landless people encroaching on low-lying areas.

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The proposed project would have major positive impacts in terms of protecting against the damaging effects of storm surges. It would be markedly beneficial in terms of reducing crop, property, homestead resource, and infrastructure damages. It is estimated that damages would be reduced (in monetary value) by about 60 percent per household (estimate based on current losses reported in household surveys).

Improved drainage would reduce the risks of crop and homestead damage, but these could be offset by an increased risk of drainage congestion due to poorly planned rural roads creating water stagnation in low-lying pockets. Many canals and canal mouths may gradually silt up, causing water stagnation in low-lying areas.

The prevalence of drought conditions in the post-project situation is expected to increase only slightly within the project area. Due to reduced flooding, soil moisture content may be reduced, but this would largely be offset by normal rain water flooding.

At present, about 5 percent of the study area households are subject to erosion. This could increase under project conditions due to the confinement of in- and outflows though canal openings, both inside and outside the project area. Due to population growth, a larger number of landless people are likely to seek shelter in and around erosion-prone areas.

The likelihood of pest attacks on crops would be more severe within the project area, since there would be less flood flushing to destroy insect pests, and the drier conditions would be favorable for pest activity.

Post-project changes in the hydrological regime may transform the geomorphological characteristics inside and outside the project area. The area under regular tidal effects is increasing in elevation due to silt deposition. With the project intervention such deposition would be reduced. Outside the project area, however, the rate of deposition would be higher than inside the project area, creating a long-term differential change in elevation between the inside and outside areas. This would create drainage congestion problems in the newly formed low-lying southern areas in future.

Embankments tend to generate a false sense of security against any kind of flood. Ordinary villagers do not understand the implications of a designed flood, particularly in the absence of sustained information programs. Therefore they may well gain a false sense of security against massive tidal surges, for against which the embankment is not designed to protect. People may invest in developments they would not have otherwise made had they understood the embankment's limitations.

In summary, the project would have beneficial effects by reducing the risk levels of many natural hazards, especially tidal surge damages of average magnitude. Potential negative impacts include higher risk of pest attacks on agricultural crops. The potential hazard of severe tidal surges would not be fully overcome by the project.

4.5 Environmental Impact Summary

Table 4.5 summarizes the anticipated project environmental component impacts. The scale used is explained in Annex 2 and encompasses impact magnitude, duration and reversibility, and environmental component sensitivity to the impacts. Negative impacts are indicated in shaded cells.

Table 4.5 **Environmental Impact Matrix (project components/IECs) for the Proposed Bhelumia-Bheduria Project (unmitigated)**

	Tidal flooding	Drainage	Irrigation	Agricultural land	Agricultural production	Homestead land	Homestead production	Natural vegetation	Biomass energy	Capture fisheries production	Culture fisheries production	Economic wildlife species	Financial security	Emotional stability	Household income	Local economy	Local security	Existing transport	Security of life & property	Risk to life & property	Employment & income	Navigation	General health	Education & literacy
CONSTRUCTION																								
Land acquisition													-5											
Embankment				-2	-2	-2	-2	-2	-2					0	+6	-2								
Drainage sluices															+2	-1								
RCB sluices															+2	-1								
Closures										-7					+2	-1								
Khal excavation										-2					+2	-1								
Culverts															+2	-1								
Footbridge															+2	-1								
Tubewells															+2	-1								
Cyclone shelter															+2	-1								
Maintenance															+2	-1								
Borrow pit															+2	-1								
Soil disposal					-1		+2							-1			-2							
Labor mobilization																		-2						
OPERATION AND MAINTENANCE																								
Embankment	+6				+7		+3		+4	-7	+4	-6		+3				+4	+7	-5				
Drainage sluices		+6	+6		+7		+3			-7	+4										+3			
RCB sluices		+6			+7		+3			-7	+4										+3			
Closures	+6				+7		+3			-7	+4	-6										-7		
Reexcavated khals		+6	+3		+7		+2			+3												+5		
Culverts		+6			+7													+3						
Footbridge		+3																+3						
Tubewells							+2																+4	
Cyclone shelter					+3		+2													+7				+2
Borrow pit										+3														

Chapter 5

CUMULATIVE IMPACTS

Two sets of environmental impacts may interact with those produced by the project: those produced by regional and coastal developments and those stemming from continental and global environmental changes.

5.1 Regional Developments Within Bangladesh

The Bhelumia-Bheduria project area lies within the Southwest Water Resource Management Region which is currently under study by the FAP (FAP 4). It has been identified as an eventual long-term project for further consideration in terms of the Southwest regional plan (FPCO 1993b). Further development of the Bhola Irrigation Project, which is adjacent to the Bhelumia-Bheduria Project, is also proposed to take place between 1993 and 2000. There are no impacts within the Bhola Irrigation Project that presently affect the Bhelumia-Bheduria Project and extension of the project is unlikely to produce any significant effects.

The major regional developments in the southwest are expected to be development of a Ganges barrage, augmentation of the Gorai River flows, and construction of coastal cyclone shelters and coastal polders and irrigation schemes. The northern end of Bhola Island, the location of the Bhelumia-Bheduria Project, is remote from the direct influence of the Ganges and its distributaries, and any changes in the lower Meghna induced by flow changes in the Ganges (e.g., by water retention behind a future barrage) would be reduced by large-scale variability in the flows of the Meghna itself and in other component discharges, e.g., those of the Padma and Jamuna. A major cyclone shelter development program (apart from the one shelter proposed as part of the project, see Chapter 2) is not planned for the Bhelumia-Bheduria Project area.

The hydrology of the Bhelumia area is related to discharge conditions in the lower Meghna River. Discharges in that river could potentially be altered by large-scale interventions in the upper Meghna basin and in the lower Ganges and Padma basins. However, the largest such interventions planned within the context of the FAP relate to structural protection of urban areas and important agricultural zones. Retention of large volumes of water is not being considered for any of these developments, and any flow changes in the lower Meghna and its distributaries near Bhola Island would likely be too small to detect against the normal variability in flows.

Large-scale alterations in some environmental and social development and resource management policies in Bangladesh could potentially affect the people and resources in the Bhelumia-Bheduria area and interact with project-related impacts. One example is a change in land use ownership policies which would bear on the present situation where a few landowners control large areas and demand very high rents from tenants (see Sections 3.4.4 and 3.4.5). A second is a major improvement in birth control programs, which might reduce the very high rate of population increase in the project area. These types of national change are very slow or unlikely to take place within the time frame of the proposed project, and the interactive effects are expected to be negligible.

5.2 Regional Developments Outside Bangladesh

Developments in river basins outside of Bangladesh affect discharges and water quality within main rivers in the country. Examples are retention of water behind the Farakka Barrage in India, which restricts dry season discharges in the lower Ganges and its distributaries such as the Gorai River, and eventual retention of water behind the Tipaymukh Dam in India, which will affect both wet- and dry-season discharges in the Barak and Meghna rivers.

Hydrological changes in the Tetulia River as a result of changes in the Meghna and Ganges are possible, but would likely be very small in relation to present discharge levels and probably difficult to detect. The consequent secondary effects on levels of inundation within the project area would be smaller yet.

At present there are no regional developments planned on a scale that would be expected to have any measurable effect on development in the Bhola Island area.

5.3 Global and Continental Impacts

The global impact of major concern for a low-lying area such as Bhelumia-Bheduria is the possibility of a sea-level rise following an increased rate of polar ice-cap melting, which would in turn be due to an increased global mean temperature following increased atmospheric heat retention (the "greenhouse effect"). Actual likely amounts of change in sea-levels are highly speculative, but a round figure of a 1 m rise is frequently quoted. For an area such as Bhelumia-Bheduria where a change in mean maximum water levels of 20 cm could produce a measurable changes in land types and agricultural production (see Sections 4.2.1 and 4.2.2), an increase of 1 m would produce physical environmental and ecological changes of unprecedented scale. Most village homesteads in the area are at elevations within centimeters of maximum annual flood levels, and in most years some homestead courtyards are inundated (see Sections 3.2.3 and 3.5.1). An 1 m increase in water levels would probably render the whole area permanently uninhabitable, and it would be reduced to the status of a large char, able to sustain crops only during limited periods in the dry season.

Chapter 6

PEOPLE'S PARTICIPATION AND SCOPING OF PUBLIC OPINION

6.1 Background

People's participation has been identified (FPCO 1993) as a key process in sustainable development by giving a wide cross-section of affected people an opportunity to share responsibility in key decisions regarding project development. This is to be done through a series of steps:

- assessment of local people's perceptions and needs;
- identification of specific groups and consultation with them;
- attention to marginal groups such as the poor, ethnic minorities, women, fishermen, boatmen, and those dependent on fragile resources;
- identification of essential land and water resources utilized by communities; and
- development of an organizational structure for ongoing consultation.

The aim of the FAP 16 fieldwork was to involve local people in project planning and designing. Informal group discussions were conducted with men and women from various social and economic categories in 12 *mouzas* inside and outside the project area (see Annex 27). Special attention was given to the landless and marginal farmers, occupational groups such as fishermen and boatmen, and other vulnerable groups (such as women involved in mat-making) who are most likely to be affected by project interventions. In two villages, discussions were held with people living outside the proposed embankment. Discussions were focused on the villager's occupations and livelihoods, the local agrarian structure, their perceptions of flooding and flood-related problems, and their views on remedial measures.

6.2 Participation Context

The majority of the villagers interviewed were illiterate, but were open, highly responsive, and knowledgeable about their local problems and the environment. They understood their water management needs clearly and had concrete suggestions to make about the measures to be adopted (Annex 27). The poor will feel free to express their views if discussions are held separately with groups of people from similar socioeconomic categories and with the women of these groups.

Fieldwork indicated that people had a clear understanding of social issues such as rural power structures, concentration of wealth, and the processes leading to landlessness. Villagers who are affected, regarded indebtedness resulting from tidal flooding, drainage congestion, and erosion as contributing to increased poverty and land loss, and cited payment of dowry as one of the important reasons for landlessness. In areas where people face severe flooding and flood-related problems, they expressed a willingness to participate in a water management program. They even offered to contribute their labor. Mobilization, to gain the cooperation of those not directly affected, would be needed during operation and maintenance of the project.

In some areas villagers expressed distrust of their elected representatives, but they appeared to have confidence in their traditional village *matabars* (informal leaders). *Matabars* adjudicate divorces, abandonment cases, and land disputes at the *salish* (informal village court). Although some are leaders by virtue of their inherited status, a majority are large and medium farmers with some level of literacy.

6.3 People's Perceptions of Flooding and Views on Remedial Measures

The Bengali word *joar* means daily high tide and *bhata* the daily low tide. The high tide during full moon is locally called *jo*. Inundation caused by *jo* damages standing crops, both at their early and mature stages. Unusually high *jo* damages homestead compounds and their surrounding vegetation. Eighty three percent of the people in the 12 *mouzas* visited regard tidal flooding as a serious problem. Pest attacks and the high cost of agricultural inputs were also considered by many farmers to be important deterrents to increasing crop production (Annex 27).

Drainage congestion was considered a problem in six of the 12 *mouzas* visited. Villagers realize that congestion is caused by siltation of *khals* and by man-made obstructions such as unplanned roads. Salinity affects agricultural production in four *mouzas*. Land is lost and households displaced due to riverbank erosion in one-third of the *mouzas* visited (Annex 1).

Villagers of the two *mouzas* (Paschim Char Kali and parts of Pangasia, which are inside the proposed embankment) said that they were not much affected by tidal flooding, while those outside the project area (such as Char Hossain and Char Gazi) reported that their homesteads and agricultural crops were damaged almost every year. In Pangasia and Char Bheduria, drainage congestion is not a problem, but they are erosion-prone and agricultural lands are subject to river erosion.

Villagers inside the proposed embankment opined that the embankment should be constructed high enough for protection against tidal surges. However, a community of landless households living outside the project area indicated that they will incur increased damages because they will remain completely unprotected from tidal floods and surges.

Women in *mouzas* closer to the rivers indicated that during *jo* their homesteads are flooded. During the floods of 1990 people in the area had to leave their houses for seven to 10 days and take shelter on the road, or build *machas* (high platforms) to live on. Since tubewells were submerged, they drank river water. They were also unable to store food and fuel and remain in their homes.

In group discussions, 91 percent of the villagers present were in favor of embankment construction. Seventy five percent of them favored construction of sluice gates at selected locations; however, fishermen and boatmen said that this would adversely affect their livelihoods due to obstruction in navigation. Nearly 60 percent suggested construction of bridges and culverts at specific locations. Drainage improvement was also recommended.

Man-made breaches, particularly of village roads, are made mainly to drain out water. A lack of roads was perceived to be a problem in one-third of the *mouzas* visited. The construction, raising, and improving of roads was proposed by 41 percent of the villagers.

6.4 Institutionalization of People's Participation

Impromptu discussion with groups of villagers during RRA surveys is an invaluable method of involving local people in the early stages of project identification and planning. The poor and women will feel free to voice their opinions in this context. However, efforts to institutionalize participation (through project committees, for example) run the risk of being dominated by locally powerful political and economic interest groups. For this reason, long-term people's participation in the Bhelumia-Bheduria project area should not be based solely on elected bodies such as union parishads. It will also require inputs from genuinely representative local people's organizations involving people from all socioeconomic categories.

The study area has a comparatively low level of social organization and NGO activity. Village leaders generally are said to represent the interests of all social groups. Participation efforts might benefit from using the existing network of formal and informal socio-political institutions.

In the designing and implementing of specific project interventions, particularly water management in the project area, it is recommended that the local, knowledgeable people from various social and occupational groups, including the landless, should be identified and developed as spokespersons. Women from all social groups should also be properly represented.

Regular meetings with spokespersons and village leaders, at selected sites, initially to discuss project plans and alternatives, should be the second step in the process of popular participation. Large and absentee landowners and other elites should be interviewed separately.

A high priority should be given to representation of the interests of those communities living outside the project boundary who may be adversely affected by the project. Meeting sites could be selected according to a range of criteria, e.g., the degree to which they represent different hydrological features, land types, occupational groupings, and key geographical locations in relation to project interventions.

The EIA team believes that the approach described herein will make possible the establishment of representative structures whereby spokespersons are elected from *mouza*- or village-level to Union- or project-level committees. During the construction, operation, and maintenance phases, any funds allocated should be properly utilized, and committee members should be held accountable for funds dispersed.

The success of people's participation in the project will depend to a great extent on the development of genuinely representative people's institutions and the effectiveness of the interaction between these institutions and local formal/informal bodies.

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Chapter 7

ENVIRONMENTAL MANAGEMENT PLAN

A full Environmental Management Plan (EMP) should be drawn up when the project has been fully appraised and approved. At that stage, the details of the EMP can be fully integrated with the project design, since many features depend closely on this. In addition, at that stage the details of supplementary programs requiring the participation of agencies such as the Department of Agricultural Extension (DAE) and Department of Fisheries (DOF) and any collaborating NGOs can be established. The following presents the preliminary requirements of the EMP.

7.1 Main Impacts and Recommended Mitigation Measures

Table 7.1 summarizes the most significant environmental and social impacts of the proposed Bhelumia-Bheduria Project and lists the recommended mitigation measures. Costs of the measures are addressed in Chapter 8.

7.2 Pre-construction and Construction Requirements

Navigation Lock

A navigation lock at the Tetulia entrance of the Bheduria Canal is needed to overcome serious potential impacts on fishermen and boat transport operators. The final design criteria will require additional study of potential water levels on either side of the lock, the required capacity of the lock, and the modes of operation.

Code of Good Engineering Practice

A code of good engineering practice should be established to ensure minimal negative environmental and social impacts associated with the construction and operation the project facilities. These include:

- preconstruction alignment surveys to select embankment alignments that minimize disruption to existing homesteads as well as minimizing the loss of productive land;
- construction monitoring and testing to ensure adequate compaction and reinforcement of the embankment to prevent premature erosion and breach risk; and
- establishment of health and sanitation practices in construction labor camps to minimize the risks of food and water contamination.

Coordination of Cooperating Agencies

A coordinating committee should be established to ensure communication and cooperation among the agencies that will develop the project and those that will have to deal with preventing significant impacts; these include BWDB, DAE, DOF, and various social agencies concerned with human labor, health, and welfare.

7.3 Operating and Maintenance

Effective operating and maintenance (O&M) of the project, especially pertaining to embankments and

Table 7.1 Impacts and Associated Mitigation Measures for Bhelumia-Bheduria Project

Impact		Mitigation		Resp.
A.	Water Resources			
1.	Siltation of canals inside project		Maintenance of canals through clearing and excavating to correct side and bed slope	BWDB
2.	Siltation in vicinity of regulators and sluices		Appropriate O&M	BWDB
3.	Local erosion of embankment from rain, runoff, rats, settlements		Monitoring and O&M	BWDB
B.	Land Resources			
1.	Loss of some homesteads, homestead land, and vegetation due to embankment construction	1.	Careful embankment alignment to avoid homesteads as much as possible	BWDB
		2.	Relocation of affected homesteads to new sites	BWDB
2.	Loss of agricultural land from embankment construction (permanent due to embankment, temporary due to dumping of excavation spoil)	1.	Careful embankment alignment to avoid encroaching on productive lands	BWDB
		2.	Good environmental engineering practices to minimize damage	BWDB
3.	Reductions in soil fertility due to absence of sediment deposition	1.	Increased use of organic fertilizers and mulches	DAE
		2.	Judicious application of synthetic fertilizers	
4.	Higher crop loss risks in HYVs due to pests	1.	Practice of Integrated Pest Management	DAE
		2.	Judicious application of pesticides	
C.	Wildlife			
Reduction in populations and harvests of economic wildlife, e.g., turtles			Promote alternative resources for affected people	*
D.	Water Quality			
Increased risk of agro-chemical contamination		1.	Extension programs to inform farmers and minimize excess use	DAE
		2.	Health education programs to increase risk awareness	NGOs
E.	Fisheries			
1.	Reduction in fish harvests inside project area due to blockage of fish migrations	1.	Local stocking programs for canals	DOF
		2.	Culture fisheries development at village and community levels	
		3.	Fish passes on all main canals on the Tutulia River side	
2.	Reduced access of fishermen to fishing areas outside project area by closure of Bheduria Canal		Boat lock on Bheduria Canal	BWDB
E.	Socioeconomic			
1.	Displacement of poorer and landless households due to embankment construction	1.	Careful alignment of embankment to avoid displacements where possible	BWDB
		2.	Relocation of displaced households to new sites	
2.	Disruption to water-based transportation by closure of Bheduria Canal		Boat lock on Bheduria Canal	BWDB

*There is currently no wildlife agency in Bangladesh to undertake wildlife mitigation.

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the proposed navigation lock, should be ensured by:

- clearly defining the responsibilities and rights of BWDB and various community groups and beneficiaries, with good communication links between all parties;
- dedicating staff and budgetary resources to ensure adequate O&M; and
- routine maintenance and inspection of embankments, regulators, sluices, canals, and any structures and facilities permitted on them (housing, reforestation projects, etc.).

7.4 Monitoring Plans

Because of the relatively small size of the proposed Bhelumia-Bheduria Project and the fact that, apart from fisheries, it would have relatively modest impacts, an extensive monitoring program is not required. However, a requirement for periodic checking of specific issues should be included in the final EMP to ensure that they are not overlooked with the passage of time. These include the following.

Inspection of Embankment

The completed embankment should be subject to periodic detailed checking by geotechnical engineers to ensure its structural soundness and reliability in the face of severe tidal and storm surges.

Monitoring Navigation Lock Efficiency

The operating performance of the Bheduria Canal lock should be checked at periodic intervals to ensure its efficient operation and ability to enable fishermen and boat transport operators to gain rapid access to either the safety of the canal or the navigational space of the Tetulia River.

Water Quality Monitoring

Regular chemical and biological quality tests of water within the project area, especially that used by communities, should be undertaken to ensure early detection of any build-up of hazardous chemicals and health contaminants.

7.5 Environmental Enhancement

Two basic extension programs would enhance some of the benefits of the project.

Embankment Vegetation and Social Forestry

Planting embankments with fodder, vegetable, and tree crops such as epil-epil has become commonplace in many parts of Bangladesh, and can increase crop, timber, and fuel wood production while simultaneously stabilizing the embankment and reducing the rates of erosion from rainfall and overtopping. Most effective embankment plantation programs are run by NGOs.

Agricultural Extension Programs

The potential agricultural and horticultural production gains in the area, brought about by protection from damaging floods and drainage congestion, could be further enhanced by the application of available knowledge of cropping patterns, the use of new crop varieties, crop diversification, and more efficient use of fertilizers, seeds, and pesticides. This could be effected by cooperating agencies such as DAE.

7.6 People's Participation

The requirements for people's participation are outlined in Chapter 6. Such participation programs should continue throughout project construction, which is expected to last a number of years, to ensure that all communities are aware of the intentions of the project, its potential benefits, and its limitations in terms of restricted protection against major tidal surges and storms. Feedback from local communities should be obtained to ensure incorporation of effective local suggestions into project design and operation, e.g., operating schedules for the proposed Bheduria Canal navigation lock.

7.7 Reporting and Accountability

Since EIA of water resource projects is relatively new in Bangladesh, the institutional framework for full accountability of project development and the achievement of environmental planning and protection aims, is not yet in place. A major first step toward achieving this would be the appointment of an *environmental officer (EO)* who would be charged with all environmental supervision of the project during construction, and who would interact with the project engineers to ensure that mitigation measures are developed. The EO should report periodically (e.g., monthly) through the standard BWDB regional reporting channels on the status of the project, its progress in terms of environmental protection measures, and any problems that have arisen and require resolution. The ultimate accountability for the project lies with the BWDB.

7.8 Disaster Management (Contingency) Plans

A full disaster management plan should be devised and included in the final EMP. An EO, if appointed as suggested above, would be in a ideal position to develop the detailed features of such a plan, and its potential implementation in collaboration with local BWDB officials and officials from other agencies. The key features of the plan should address:

- identification of all refuge sites, including the new cyclone shelter, to be used in the event of a major disaster such as a cyclone or breaching of the embankment;
- establishment of an effective early warning system to be used for potential disasters, including appointment of disaster monitors and supervisors; and
- frequent disaster preparedness training for local communities, to advise them of the above measures and to devise means by which their early reaction to warning signals and appropriate action might be obtained.

JJ 8

Chapter 8

ECONOMIC EVALUATION OF PROJECT IMPACTS AND ENVIRONMENTAL MANAGEMENT

A full economic assessment of the project should appear in a separate analysis and report. The objective of this chapter is to:

- checklist all environmental impacts, both beneficial and negative, which should be taken into account in the economic analysis (Table 8.1);
- provide an estimate of the most significant environmental benefits or losses which should be accounted for (Table 8.1);
- identify the mitigation and environmental management items which should be included (Table 8.2);
- provide a provisional estimate of the costs of the environmental management and mitigation measures (Table 8.2).

A number of potentially significant environmental and social items were not quantified or costed in the study for reasons given in the text. These are listed in Table 8.3.

Table 8.1 Estimated Benefits and Losses/Expenses of Major Environmental Impacts: Bhelumia-Bheduria Project

Impact	Benefits	Expenses and/or Losses	Periodicity
Increase in paddy production	5,000 tonnes		Annually
Increase in agricultural inputs		10% increase	Annually
Decline in fish harvests:			Annually
a. unmitigated project		a. 100 tonnes	
b. mitigated project		b. No change	
Increase in fish harvesting costs:			Annually
a. unmitigated project		a. ≈25% increase	
b. mitigated project		b. No change	
Increase in culture fish production	5% increase in net gains		Annually
Water-borne transportation:			Annually
a. unmitigated project		a. ≈10-15% increase in costs	
b. mitigated project		b. No change	
Increase in agricultural labor	63,000 person-days		Annually

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Table 8.2 Costs of Major Mitigation and Environmental Management Measures: Bhelumia-Bheduria Project

Item	Estimated Cost	Periodicity
Environmental Officer	Tk.200,000 (20 lakh)	Annually
Navigation lock construction	Tk.600,000 (60 lakh)	Initial construction
Navigation lock operation and maintenance	Tk.60,000 (6 lakh)	Annually
Canal and embankment maintenance	Included in engineering estimates	Annually
Embankment plantation program	Tk.300,000 (30 lakh)	Annually
Fish stocking programs	Tk.100,000 (10 lakh)	Annually
Fish passes	Tk.500,000 (5 lakh)	Initial construction
Agricultural extension program	Tk.50,000 (5 lakh)	Annually
Water quality monitoring program	Tk.100,000 (10 lakh)	Annually
People's participation program	Tk.150,000 (15 lakh)	Planning and construction phases

Table 8.3 Non-Quantified Environmental Benefits and Losses: Bhelumia-Bheduria Project

A. *Benefits*:

Increase in homestead crop production
Increase in biomass energy availability
Increase in tree products from embankment plantations
Land transportation benefits
Increase in general nutrition for some social groups
Improvements to health for some groups from drinking water provision
Minor benefits to women
Minor benefits to educational status

B. *Losses*:

Decline in soil fertility
Rat damage to embankment
Increase in water borne disease
Reductions in water quality
Human health risks for some from agro-chemical contamination
Higher hazards from severe storms and embankment breaches
Decline in protein nutrition for poorer classes
Social inequity of gains

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Chapter 9

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ANNEXES

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Annex 1

Household Survey Method

The study required that the data be representative of both agro-ecological and socioeconomic conditions in the study area. Each of the inhabited *mouzas* in the study area was sampled. From each mouza, 5 percent of the total households were randomly selected on the basis of the household figures found in the 1991 census report (BBS 1992), updated to 1992 with the Union Parishad data. These households were further subdivided according to the occupational category followed by EIP. Distribution of households according to occupational category was computed on the basis of the list of households obtained from the Union Parishad Offices as well as through discussion with Union Parishad Chairmen and key informants. Reconnaissance surveys were conducted to verify the concentrations of fishing communities in Char Chandra Prashad and Char Bheduria.

The total number of households actually sampled was 424, distributed as shown in the table on the following page. Of 14 *mouzas* in the study area, 12 were actually covered by the survey. Houses in Char Chatkimara in Bhelumia Union had been completely displaced by erosion, and Char Patabunia was found to be uninhabited. Displaced households from Char Chatkimara had settled in Char Bheduria and taken up fishing as the main profession, thus giving a high percentage of professional fishermen not only for Char Bheduria but also for the entire study area.

Percentage Distribution of Household Heads by Mouza and Primary Occupation

Mouza	1	2	3	4	5	6	7	8	9	10
Pangasia (N=10)	0	0.5	0.2	0.5	0.2	0.2	0.5	0.2	0	0
Char Samaiya (N=26)	0.7	2.1	0	1.7	0.5	0.2	0.2	0.2	0.2	0.2
Char Bheduria (N=108)	3.1	4.5	1.9	1.2	0.7	0.7	12.3	0	1.2	0
Char Ramesh (N=53)	2.8	2.6	0.5	3.3	0.5	0.5	1.2	0.2	0.5	0.5
Paschim Charkali (N=38)	0.5	2.1	0.7	1.2	1.4	0.2	1.4	0.2	0.5	0.7
Bagmara (N=13)	0.5	0.9	0	0.9	0.2	0.2	0	0	0	0.2
Chandra Prashad (N=68)	3.5	3.8	0	3.3	0.7	0.7	1.4	0.5	1.4	0.7
Char Chandra Prashad (N=21)	0.9	0.9	0	0.2	0	0.7	1.7	0	0.2	0.2
Kunjaputti (N=47)	1.4	2.4	0.2	4.5	0	0.2	0.9	0.2	0.5	0.7
Char Hossain (N=10)	0.5	0.7	0	0	0.2	0	0.5	0	0.2	0.2
Char Gazi (N=20)	0.5	0.7	0.9	0.9	0	0.2	0.7	0.2	0.2	0.2
Tum Char (N=10)	0	0.7	0	0.5	0	0	0.5	0.2	0.5	0
Total Number (N=424)	61	93	19	77	19	17	90	9	23	16

Source: Household Baseline Survey, 1992

N = Number of Households

Column headings:
1. Farming Own
2. Farming Own+Share
3. Share Cropper
4. Farm Labor
5. Nonfarm Labor
6. Service
7. Fishing
8. Boatman
9. Business
10. Other

Annex 2

Impact Scoring Categories

Beneficial Impacts			Sustainable	Sustainable with Mitigation	Not Sustainable
Sensitive	Immediate	High Magnitude	+10	+7	+4
		Low Magnitude	+6	+4	+2
	Gradual	High Magnitude	+7	+5	+3
		Low Magnitude	+4	+3	+2
Less Sensitive	Immediate	High Magnitude	+6	+4	+2
		Low Magnitude	+3	+2	+1
	Gradual	High Magnitude	+4	+3	+2
		Low Magnitude	+2	+2	+1

Negative Impacts			Irreversible	Reversible with Mitigation	Reversible
Sensitive	Immediate	High Magnitude	-10	-7	-4
		Low Magnitude	-6	-4	-2
	Gradual	High Magnitude	-7	-5	-3
		Low Magnitude	-4	-3	-2
Less Sensitive	Immediate	High Magnitude	-6	-4	-2
		Low Magnitude	-3	-2	-1
	Gradual	High Magnitude	-4	-3	-2
		Low Magnitude	-2	-2	-1

Annex 3

Land Type Classification System

Land Type Designation	Flooding Depth (cm)	Nature of Flooding	Agricultural Significance
F_0	0 - 30	Intermittent	Suited to HYV rice in wet season
F_1	30 -90	Seasonal	Suited to local varieties of Aus and T. Aman in wet season
F_2	90 -180	Seasonal	Suited to B. Aman in wet season
F_3	> 180	Seasonal	Suited to B. Aman in wet season
F_4	> 180	Seasonal or Perennial	Depth, rate, and/or timing of flooding do not permit cultivation of B. Aman in wet season

Source: MPO (1986, cited by ISPAN 1992a)

Annex 4

Fertility Status of the Topsoils in the Bhelumia-Bheduria Project Area

Soil Series	Land type	pH	Org. Matt. %	EC ds/m	Ca	Mg	K	NH_4	P	S	B	Cu	Fe	Mn	Zn
					meq/100 gm soil			μg/g							
Ramgati I	High	6.8	1.3	0.15	6.5	2.0	0.15	25	23	75	0.2	17.9	385	19	3.3
Ramgati II	High	7.2	1.0	0.27	5.3	1.9	0.17	25	30	30	0.1	19.3	481	22	3.2
Ramgati III	High	7.3	1.1	0.18	5.7	1.9	0.15	25	25	12	0.1	18.4	425	23	2.6
Average		7.1	1.1	0.20	5.8	1.9	0.15	25	26	39	0.1	18.5	430	21	3.0
Nilkamal I	Med. high	6.5	2.3	0.16	9.7	4.0	0.15	20	7	23	1.3	14.5	178	19	1.1
Nilkamal II	Med. high	6.5	2.5	0.13	9.1	4.1	0.12	20	6	145	1.3	13.1	70	20	0.8
Nilkamal III	Med. high	6.4	2.5	0.17	10.2	4.5	0.18	20	5	45	1.0	14.2	74	16	0.8
Average		6.5	2.4	0.15	9.7	4.2	0.15	20	6	71	1.2	13.9	107	18	0.9

Source: Field Survey, 1992. Laboratory Analysis, BINA, 1992

Annex 5

Present Crop Production and Damage in the Bhelumia-Bheduria Study Area

Annex 5.1 Project Area

Crop	Damage Free (a)		Damage by Flood (b)		Damage by Pests (c)		Total Production (Tonnes) a+b+c	Production Lost to Floods (tonnes)	Production Lost to Pests (tonnes)
	ha	t/ha	ha	t/ha	ha	t/ha			
B. Aus (L)	1,150	1.7	856	0.5	699	1.0	3,082	1,027	489
T. Aus (L)	181	2.0	-	-	-	-	362	-	-
T. Aus (H)	65	2.5	-	-	-	-	163	-	-
B. Aus (H)	174	2.0	20	0.4	-	-	356	32	-
T. Aman (L)	2,283	2.3	842	0.7	818	1.5	7,067	1,348	654
T. Aman (H)	374	3.0	70	0.6	90	2.0	1,344	168	90
Boro (H)	385	4.3	65	1.1	105	2.0	1,938	208	242
Paddy	-	-	-	-	-	-	14,312	2,783	1,475
Pulses	938	0.7	-	-	-	-	657	-	-
Chilli	604	0.86	174	0.40	50	0.60	619	80	13
S. Potato	151	12.0	-	-	-	-	1,812	-	-
Watermelon	133	40	-	-	-	-	5,320	-	-
Wheat	146	1.5	-	-	-	-	219	-	-
Oilseed	92	0.5	-	-	-	-	46	-	-
Vegetables	50	3.0	-	-	-	-	150	-	-
Other rabi crops	54	-	-	-	-	-		-	-

Source: Field Survey, 1992

Annex 5.2. Adjacent Area

Crop	Damage Free		Damage by Flood		Damage by Pests		Total Production (tonnes)	Production Lost to Flood (tonnes)	Production Lost to Pests (tonnes)
	ha	t/ha	ha	t/ha	ha	t/ha			
B. Aus (L)	459	1.7	190	0.5	155	1.0	1,030	228	109
T. Aman (L)	476	2.3	220	0.7	210	1.5	1,564	352	168
T. Aman (H)	52	3.0	-	-	-	-	156	-	-
Boro (H)	10	4.3	-	-	-	-	43	-	-
Paddy	-	-	-	-	-	-	2,793	580	277
Pulse	162	0.70	-	-	-	-	113	-	-
Chilli	71	0.86	190	0.40	20	0.60	105	41	5
S. Potato	33	12.0	-	-	-	-	396	-	-
Watermelon	41	40	-	-	-	-	1,640	-	-
Wheat	52	1.5	-	-	-	-	78	-	-
Oilseed	69	0.5	-	-	-	-	35	-	-
Other rabi crops	41	-	-	-	-	-		-	-

Source: Field Survey, 1992

Annex 6

Present Agricultural Inputs in the Bhelumia-Bheduria Project Area

Annex 6.1 Draught Animals, Seeds, and Fertilizers

Crop	Person days	Animal pair days	Seed (Kg)	Fertilizers (Kg/ha)				Pesticides (kg/ha)
				Urea	TSP	MP	2n	
B. Aus(L)	140	35	100	70	30	-	-	0.6
T. Aus (L)	160	38	25	94	31	-	-	
T. Aus (H)	165	40	25	150	31	-	-	
T. Aman (L)	130	30	30	75	30	10	-	0.6
T. Aman (H)	170	30	30	130	91	18	2	0.7
Boro (H)	195	30	30	200	139	19	15	0.7
Chili	145	33	4	60	63	4	-	0.5
S. Potato	90	35	-	-	40	-	-	
Pulses	40	10	30	20	-	-	-	
Oilseeds	90	30	10	40	31	-	-	
Wheat	115	28	124	95	97	-	-	
Watermelon	250	30	-	200	500	20	-	

Source: Field Survey, 1992

Annex 6.2 Labor Requirements

Crop	Area (ha)	Person Days Per Hectare												Total person days
		J	F	M	A	M	J	J	A	S	O	N	D	
B.Aus	2,899			15	35	35	15	30	10					140
T.Aus (L)	181			10	40	30	15	25	25	15				160
T.Aus (H)	65			10	40	30	20	20	25	20				165
T. Aman (L)	3,943						10	35	30	10	10	15	20	130
T. Aman (H)	534						10	40	30	25	15	25	25	170
Boro (H)	555	30	30	25	25	25	20					10	30	195
Chili	828	30	30	15	20	30	20							145
S. Potato	151	10	10	20								20	30	90
Pulses	938		10	10								10	10	40
Oilseeds	92	20	10	10	20							10	20	90
Wheat	146	10	10	10	30							30	25	115
Watermelon	133	50	20	20	30	30						50	50	250
Total person		53	57	90	152	152	120	252	169	57	47	102	135	1,387

Source: Field Survey, 1992

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Annex 7

Plant Species of Economic Importance in the Bhelumia Bheduria Study Area

Local Name	English Name	Scientific Name	Abundance (%)	Household (%)	Average No./ Household
		FRUITS, OTHER USES			
Aam	Mango	*Mangifera indica*	4	71.00	17.60
Alachi	Cardamum	*Elettaria cardamomum*	0.03	0.50	0.12
Amrah	Hog plum	*Spondias spp.*	1.00	20.30	4.84
Ata (Nona)	Bullockheart	*Annona reticulata*	0.5	8.00	0.43
Badam	Indian almond	*Terminalia catappa*	0.2	9.40	1.09
Bel	Wood apple	*Aegle marmelos*		2.10	0.10
Boroi	Plum	*Zizyphus jujuba*	0.1	2.00	0.50
Chalita	Elephant apple	*Dillenia indica*	0.02	7.30	0.25
Dalim	Pomegranate	*Punica granatum*	0.3	0.90	0.01
Deoa	Monkey dack	*Artocarpus lacucha*	0.03	5.40	0.24
Gab	Mangosteen	*Diospyros spp.*	0.3	16.50	5.08
Jalpai	Olive	*Olea europaea*	0.03	.70	0.01
Jaam	Blackberry	*Eugenia jambolana*	0.3	18.90	1.26
Jambura	Grapefruit	*Citrus grandis*	0.2	2.00	0.10
Jamrul	Wax apple	*Eugenia javanica*	0.03	5.20	0.12
Kala	Banana/Plantain	*Musa spp.*	23	75.00	102.48
Kamala	Orange	*Citrus reticulata*	0.02	1.00	0.03
Kamranga	Carambola	*Averrhoa carambola*	0.02	4.30	0.10
Kanthal	Jackfruit	*Artocarpus heterophyllus*	4	32.30	2.88
Karamcha	Karanda	*Carissa carandus*	0.01	0.50	0.25
Khejur	Date palm	*Phoenix sylvestris*	3.0	43.4	11.76
Lebu	Lemon	*Citrus spp.*	0.1	6.13	0.29
Lichu	Litchi	*Litchi chinensis*	0.03	0.94	0.12
Narikel	Coconut	*Cocos nucifera*	2.0	45.3	8.13
Pepe	Papaya	*Carica papaya*	0.4	16.51	2.08
Peyara	Guava	*Psidium guajava*	0.3	9.70	2.58
Safeda	Sapota	*Achras sapota*	0.01	0.24	0.01
Sharifa	Custard apple	*Annona squamosa*	0.1	3.54	0.38
Supari	Betelnut	*Areca catechu*	27.0	81.13	117.82

Local Name	English Name	Scientific Name	Abundance (%)	Household (%)	Average No./ Household
Tal	Palm	*Borassus flabellifer*	6.0	12.50	1.09
Tetul	Tamarind	*Tamarindus indica*	0.2	11.32	0.70
		TIMBER, OTHER USES			
Akashmoni	Acacia tree	*Acacia moniliformis*	0.01	0.24	0.20
Arjun	White murdha	*Terminalia arjuna*	0.01	0.47	0.03
Babla	Gum arabic	*Acacia spp.*	0.01	0.71	0.29
Bansh	Bamboo	*Bambusa spp.*	0.01	0.10	0.02
Chambal		*Artocarpus chaplasha*	0.1	4.95	0.29
Debdaru		*Polyalthia longifolia*	0.1	0.94	0.02
Gamari	White teak	*Gumelina arboria*	0.01	0.25	0.10
Hijal	Indian oak	*Barringtonia acutangula*	0.01	0.24	0.01
Hunal		*Oroxylum indicum*	0.02	0.24	0.03
Jhiga		*Lannea grandis*	2	25.94	12.78
Jilapi		*Inga dulcis*	0.04	0.24	0.13
Koroi		*Albizia spp.*	1.0	18.87	4.34
Krishnachura		*Delonix regia*	0.3	0.71	0.10
Mahogany	Mahogany	*Swietenia mahogany*	0.3	18.16	5.42
Mandar	Coral tree	*Erythrina variegata*	15.0	76.98	49.87
Royna		*Aphanamixis polystachya*	0.1	5.19	1.27
Sajna	Round drum	*Moringa olifera*	0.02	0.24	0.04
Sal/gajari		*Shorea robusta*	0.2	0.47	0.10
Shimul	Silk cotton	*Bombax malabaricum*	0.1	4.72	1.20
Sisoo	Sisoo	*Dalbergia sisoo*	0.04	3.30	0.28
Sonal/B.Lath		*Cassia fistula*	0.01	1.18	0.20
Sristri	Raintree	*Samanea saman*	7.0	71.70	23.97
Tejpata	Bay leaf	*Pimenta acris*	0.04	4.72	0.20
Telikadam	Ipil-Ipil	*Leucaena leucocephala*	0.03	5.90	1.73
Varanda	Castor oil	*Ricinus communis*	0.02	2.47	2.13
		VEGETABLES, SPICES			
Barbati	String bean	*Vigna sinensis*		27.36	
Begun	Eggplant	*Solanum melongena*		12.26	
Danta	Amaranths	*Amaranths lividus*		5.66	
Dharas	Okra	*Hibiscus esculentus*		0.71	

Local Name	English Name	Scientific Name	Abundance (%)	Household (%)	Average No./ Household
Dhundhul	Smooth loofah	*Lufa cylindrica*		2.36	
Halud	Turmeric	*Curcuma longa*		2.00	
Jhinga	Ribbed gourd	*Luffa acutangula*		5.66	
Kachu	Arum	*Colocasia spp.*		2.83	
Kankrol	Spiny gourd	*Momordica cochinchin-ensis*			
Korolla	Bitter gourd	*Momordica chantea*		1.42	
Kumra	Sweet gourd	*Cucurbita maxima*		25.00	
Lalshak	Red amaranths	*Amaranthus gangeticus*		14.86	
Lao	Bottle gourd	*Lageneria vulgaris*		75.00	
Marich	Chili	*Capcicum spp.*		3.77	
Mou sim	Country bean	*Dolichos lablab*		0.71	
Mula	Radish	*Raphanus sativus*		7.55	
Palong shak	Spinach	*Spinacea oleracea*		0.94	
Pan	Betel leaf	*Peper betel*			
Patol	Pul wal	*Trichosanthes diocia*		1.18	
Peaj	Onion	*Allium cepa*		4.48	
Puishak	Indian spinach	*Basella alba*		7.31	
Rekha	Snake gourd	*Trichosanthes anguina*		7.55	
Rosun	Garlic	*Allium sativum*			
Shosha	Cucumber	*Cumis sativus*		0.24	
Sim	Country bean	*Dolichos lablab*		71.7	
Tarmuj	Watermelon	*Citrulus vulgaris*			

Source: Household Baseline Survey, 1992

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Annex 8

Biomass Energy Sources and Use in the Bhelumia-Bheduria Study Area

Annex 8.1 Energy Sources and Proportional Contribution (kg) Per Household by Mouza

Mouza	Straw	Wood	Leaves	Dhaincha	Hogla	Dung	Husk	Total
Pangasia	148	105	96	27	0	0	0	376
Char Samaiya	589	469	145	45	17	17	0	1282
Char Bheduria	2292	2498	120	103	67	0	5	5018
Char Ramesh	1223	913	497	59	18	55	0	2747
Paschim Charkali	1052	1220	402	30	0	0	0	2704
Bagmara	1236	166	191	22	0	20	0	1635
Chandra Prashad	1515	1632	856	161	14	0	0	4178
Char Chandra Prashad	375	323	124	131	0	14	0	967
Kunjaputti	837	1268	870	88	10	0	0	3073
Char Hossain	250	128	64	15	5	5	0	467
Char Gazi	715	235	102	32	31	27	0	1111
Tum Char	230	390	29	51	0	0	0	700
Total	10462	9347	3496	764	162	138	5	24258
Percentages	43.0	38.3	14.4	3.13	0.6	0.55	0.02	100.0

Source: Household Baseline Survey, 1992

Annex 8.2 Qualities and Energy Efficiency of Firewood Species

Species	Weight (kg/cft*)	Specific Gravity	Calorific Value (Kcal/kg**)
Am (*Mangifera indica*)	21	-	-
Arjun (*Terminalia arjuna*)	29	0.74	5,030-5,128
Deshi Badam (*Terminalia catappa*)	15	0.46	4,398
Hijal (*Barringtonia acutangula*)	18	-	-
Khejur (*Phoenix sylvestris*)	18	-	-
Mahogany (*Swietenia mahogany*)	20	0.63	-
Mandar (*Erythrina spp.*)	9	0.20	4,307
Neem (*Azadirachta indica*)	24	0.85	5,000
Raintree (*Samanea saman*)	24	0.50	4,550
Shaora (*Strebulus asper*)	21	-	-
Shimul (*Bombax malabaricum*)	11	0.39	4,885
Sisoo (*Dalbergia sisoo*)	23	0.82	4,903-5,175
Supari (*Areca catechu*)	28	0.80	5,444
Tal (*Borassus flabellifer*)	31	-	-
Teli Kadam (*Leucaena spp.*)	-	-	4,200-4,600
Tetul (*Tamarindus indica*)	38	-	-

Source: RRA (K.U. Ahmad 1984; ** Alam and Mohluddin 1992)*

Annex 9

Wildlife Species in Bhelumia-Bheduria Study Area

CODES USED IN THE TABLES:
STATUS: C = Common, UC = Uncommon, E = Endangered, T = Threatened, R = Resident, M = Migratory
FOOD BEHAVIOR: I = Insectivorous, P = Piscivorous, G = Granivorous, A = Predator, MO = Molluscs/crustaceans, F = Fructivorous, V = Aquatic vegetation, S = Scavenger, H = Herbivorous, and O = Other

Bangla name	English name	Scientific name	Remarks		
		REPTILES			
Terrestrial:					
Kochop	Tortoise	*Kachuga tecta*	C	R	H
Tiktikee	Wall lizard	*Hemidactylus*	C	R	I
Tokkhok	Gecko	*Gecko gecko*	UC	R	I
Roktochosa	Garden lizard	*Calotes* sp.	C	R	I
Angila	Skink	*Mabuya carinata*	C	R	I
Kalo gui	Monitor lizard	*Varanus bengalensis*	T	R	A
Atail kacho	Blind snake	*Typlina porrectus*	C	R	I
Tashira	Striped K. back	*Amphiesma stolata*	C	R	I
Nila sap	B.B. tree snake	*Dendrilaphis tristis*	C	R	I
Draj sap	Rat snake	*Ptyas mucosus*	C	R	A
Gokhra sap	Cobra	*Naja naja*	C	R	A
Shonkhine	Banded krait	*Bungarus fasciatus*	C	R	A
Aquatic:					
Kasim	Flap-shell turtle	*Lissemys punctata*	C	R	P
Kasim	Soft-shell turtle	*Chitra indica*	C	R	P
Sona gui	Yellow lizard	*Varanus flaviscence*	T	R	P/A
Dora sap	C.K. watersnake	*Xenochrophis piscator*	C	R	P
Matia sap	C. watersnake	*Enhydris enhydris*	C	R	P
Lal dora	Dark B.M. snake	*Xenochrophis cerasogaster*	C	R	P
		AMPHIBIANS			
Sona bang	Bullfrog	*Rana tigrina*	T	R	I
Kotkoti bang	Cricket frog	*R. cynophyctis*	C	R	I
Kotkoti bang	Skipper frog	*R. limnecharis*	C	R	I
Kuno bang	Toad	*Bufo melanostictus*	C	R	I

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Bangla name	English name	Scientific name	Remarks		
		BIRDS			
Terrestrial					
Bhuban cheel	Black kite	*Milvus migrans*	C	M/R	S
Sada cheel	Black-wing kite	*Elanus caeruleus*	E	R	I/A
Showkoon	White-backed Vulture	*Gyps bengalensis*	T	R	S
Tilla baz	Crested serpent eagle	*Spilornis cheela*	C	R	A
Baz	Kestrel	*Falco tinnunculus*	C	R/M	A
Lal ghughu	Red turtle dove	*Streptopelia tranquebarica*	C	R	G
Jalali cobutor	Blue R. pigeon	*Columba libia*	C	R	G
Mala gugu	Ring dove	*Streptopelia decaocto*	C	R	G
Botcol	Green pigeon	*Treron pompadora*	C	R	G/F
Tila ghughu	Spotted dove	*Streptopelia chinensis*	C	R	G
Teya	Parakeet	*Psittacula krameri*	C	R	G
Chok galoo	Hawk cuckoo	*Cuculus varius*	C	R	I
	Plaintive cuckoo	*Cacomantis merulinus*	C	R	I
Kokil	Koel	*Eudynamys scolopacea*	C	R	I
Kanakoka	Lesser coucal	*Centropus bengalensis*	C	R	A
Lokhipacha	Barn owl	*Tyto alba*	UC	R	A
	Scops owl	*Otus sunia*	C	R	A
	Brown hawk owl	*Ninox scutulata*	C	R	A
Bhutum pacha	Spotted owlet	*Athena brama*	C	R	A
	Red-wing lark	*Mirafra erythroptetra*	C	R	I
	Bush lark	*Mirafra assamica*	C	R	I
	Tree pipit	*Anthus trivialis*	C	R	I
	C. wood shrike	*Tephrodornis pondicerianus*	C	R	I
	Black W. cuckoo shrike	*Coracina melaschistos*	C	M	I
	Small minivet	*Pericrocotus cinnamomeus*	C	R	I
	White tailed fantail fly-catcher	*Rhipidura albicollis*	C	R	I
	Grey H. flycatcher	*Culicicapa ceylonensis*	C	R	I
Nishi chor	Nightjar	*Caprimulgus macrunus*	UC	R	I
	Ashy swallow shrike	*Cypsiurus balasiensis*	C	M	I
	Chestnut headed bee eater	*Merops leschenaulti*	C	R	I
Sui chora	Common bee eater	*Merops orientalis*	C	R	I
	Dusky leaf warbler	*Phylloscopus fuscatus*	C	M	I

Bangla name	English name	Scientific name	Remarks		
	Fantail warbler	*Cisticola exilis*	C	R	I
	Inornate warbler	*Phylloscopus inornatus*	C	M	I
	Greenish warbler	*Phylloscopus trochiloides*	C	M	I
	Collared bush chat	*Saxicola torquata*	C	M	I
	Pied bush chat	*S. jerdoni*	C	M	I
Nilkontho	Roller	*Coracias bengalensis*	C	R	I
Huopu	Hoopoe	*Upupa epops*	C	R	I
	Lineated barbet	*Megalaima lineata*	UC	R	F
Boshonto baure	Coppersmith barbet	*Megalaima haemacephala*	C	R	F
	Rufous woodpecker	*Micropternus brachyurus*	C	R	I
Kat thokra	Golden-backed wood-pecker	*Dinopium javanense*	C	R	I
Shobuz kat thokra	Scaly-bellied green woodpecker	*Picus myrmecophoneus*	C	R	I
Ababil	Common swallow	*Hirundo rustica*	C	M	I
	House swift	*Apus affinis*	C	R	I
	Palm swift	*Cypsiurus parvas*	C	R	I
Shipahi bulbul	Red-whiskered bulbul	*Pycnonotus jocosus*	C	R	I
Bulbul	Red-vented bulbul	*Pycnonotus cafer*	C	R	I/F
Doyal	Magpie robin	*Copsychus saularis*	C	R	I
Taowfique	Iora	*Aegithina tiphia*	C	R	I
	Grey tit	*Parus major*	UC	R	I
Tuntune	Tailor bird	*Orthotomus sutorius*	C	R	I
Sat bhai	Common babbler	*Turdoides striatus*	C	R	I
Tila munia	Spotted munia	*Lonchura punctulata*	C	R	G
Kalo munia	Black-headed munia	*Lonchura malacca*	C	R	G
	Purple-rumped sunbird	*Nectarinia zeylonica*	C	R	O
Mautushi	Purple sunbird	*Nectarinia asiatica*	C	R	O
Kutum	Black-headed oriole	*Oriolus chinensis*	C	R	I/F
	Long-tailed shrike	*Lanius schach*	C	R	I
	Brown shrike	*Lanius cristatus*	C	M	I
Finga	Black drongo	*Dicrurus macrocercus*	C	R	I
Harichacha	Tree pie	*Dendrocitta vagabunda*	C	R	I
Pati kak	House crow	*Corvus splendens*	C	R	S
Dar kak	Jungle crow	*Corvus macrorynchos*	C	R	S
Bhat salik	Common myna	*Acridotheres tristis*	C	R	G
Go salik	Pied myna	*Sturnus contra*	C	R	I

Bangla name	English name	Scientific name	Remarks		
Jhuti salik	Jungle myna	*Acridotheres fuscus*	C	R	I
Kat shalik	Grey H. myna	*Sturnus malabaricus*	C	R	I
Chorui	House sparrow	*Passer domesticus*	C	R	G
	Paddy field pipit	*Anthus novaeseelandiae*	C	R	I
	Yellow B. bunting	*Emberiza aureola*	C	R	G
Babui	Baya	*Ploceus philippinus*	UC	R	G
Aquatic					
Pancowri	Little cormorant	*Phalacrocorax carto*		R	P
Go bok	Cattle egret	*Bubulcus ibis*	C	R	I
Boro bok	Great egret	*Egretta alba*	C	R	P
Sada bok	Little egret	*Egretta garzetta*	C	R	I/P
Sada bok	Intermediate egret	*Egretta intermedia*	C	R	I/MO
Kali bok	Black bittern	*Ixobrychus flavicollis*	UC	R	P
Lal bok	Cinnamon bittern	*Ixobrychus cinnanmeocus*	UC	R	I/P
Kani bok	Pond heron	*Ardeola grayii*	C	R	P/I/MO
Nishi bok	Night heron	*Nycticorax nycticorax*	UC	R	P
Nol bok	Grey heron	*Ardea cinerea*	T	R	P
Chonkho cheel	Brahminy kite	*Haliaster indus*	C	R	P
Bali hash	Lesser whistling teal	*Dendrocygna javanica*	C	R	P
Choto duburi	Little grebe	*Podiceps ruficollis*	T	R	V
Mechopacha	Brown fish owl	*Bubo zeylonensis*	E	R	P
	Pallas's Fishing eagle	*Halieetus leucoryphus*	E	R	P
Kura	Grey-headed fishing eagle	*Icyhthophaga ichthyaetus*	T	R	P
	Pied harrier	*Circus melanoleucos*	C	M	O/P
	Pheasant-tailed jacana	*Hydrophasianus chirurgus*	UC	R	MO
Jal pipi	Bronze-winged jacana	*Metopidius indicus*	C	R	V
Dahuk	Water hen	*Gallicrex cinerea*	C	R	P
Kalo pipi	Coot	*Fulica atra*	UC	R	V
Hot titi	Red-wattled lapwing	*Vanellus indicus*	C	R	V
	Golden plover	*Pluvialis fulva*	C	M	I
	Little ring plover	*Charadrius dubius*	C	M	V/MO
	Pintail snipe	*Gallinago stenura*	C	M	V/MO
	Fantail snipe	*Gallinago gallinago*	C	M	V/MO

Bangla name	English name	Scientific name	Remarks		
	Woodcock	*Scolopax rusticola*	C	M	V/MO
	Common sandpiper	*Tringa hypoleucos*	C	M	V/MO
	Wood sandpiper	*Tringa glareola*	C	M	V/MO
	Common red shank	*Tringa totanus*	C	M	I
	Common green shank	*Tringa nebularia*	C	M	I
	River tern	*Sterna hirundo*	UC	R	P
Choto machranga	Common kingfisher	*Alcedo atthis*	C	R	P
Machranga	White-throated king-fisher	*Halcyon pileata*	C	R	P
Dora mach ranga	Pied kingfisher	*Ceryle rudis*	UC	R	P
	White wagtail	*Motacilla alba*	C	R/M	I
	Pied wagtail	*Motacilla maderaspatensis*	UC	M	MO
	Grey wagtail	*Motacilla cinerea*	C	M	V
	Yellow wagtail	*Motacilla flaya*	C	M	MO
	Yellow-headed wagtail	*Motacilla citreola*	C	M	V
		MAMMALS			
Boro badur	Flying fox	*Pteropus giganteus*	UC	R	F
Badur	False vampire bat	*Megaderma lyra*	C	R	I
Khak shial	Jackal	*Canis aureus*	C	R	A
Shial	Fox	*Vulpes bengalensis*	C	R	O
Kattas	S.I. civet	*Viverina malaccensis*	C	R	A
Beje	Mongoose	*Herpestes edwardsi*	C	R	A
Indur	L. bandicoot rat	*Bandicota bengalensis*	C	R	G
	G. bandicoot rat	*Bandicota indica*	C	R	G
	House rat	*Rattus rattus*	C	R	O
Chika	I. Shrew	*Suncus murinus*	C	R	S
Sehsu	Gangetic dolphin	*Platanista gangetica*	E	R	P

Source: Field Survey, 1992

Annex 10

Aquatic Biota of the Bhelumia-Bheduria Study Area

Annex 10.1 Plankton

Scientific Name	Plankton Concentration (H=High, M=Moderate, L=Low)				
	Pond	Canal	River	Creeks	Floodplain
Diatoms	-	L	L	M	M
Chlamydomonas	-	L	-	L	M
Phacus	-	L	-	L	L
Spirogyra	-	-	-	M + L	M
Microcystis (blue-green algae)	L	-	-	-	L + -
Cyclops	H	L	L	M	L
Daphnia	H	L	L	M	L
Vorticella sp	L	L	L	L	-
Rotifers	M	L	L	M	L

Source: Field Survey, 1992

Macroinvertebrates

Bangla name	Scientific name
Shamuk	*Pila globosa*
Jhinuk	*Lamellidens marginalis*
unidentified	Freshwater clam
Jhinuk	*Unio sp*
Gura kacho	*Tubifex sp*
Kacho	*Pheretima posthuma*
Insect larvae	

Source: Field Survey, 1992

Annex 10.2 Aquatic Macrophytes

Bangla Name	Scientific Name
Hogla	*Typha spp*
Modhu	*Hygrophila auriculata*
Halencha	*Enhydra fluctuans*
Kalmi	*Ipomoea aquatica*
Dholkalmi	*Ipomoea fistulosa*
Ghechu	*Aponageton sp*
	Cryptocoryne sp
	Hydrilla sp
	Najas sp
Ram karalla	*Ottelia alismoides*
Jhangi	*Uricularia sp*
Chandmalla	*Nyphoides sp*
Topa pana	*Pistia stratiotes*
	Hygroryza sp
	Leeria sp
Kochuripana	*Eichhornia crassipes*
Cochopana	*Monochria sp*
Khudi pana	*Lemna minor*
Duck weed	*Spirodella sp*
Duck weed	*Wolffia arrhiza*
Guri shapla	

Source: Field Survey, 1992

Annex 11

Water Quality Measurements Taken in Bhelumia-Bheduria Study Area

No.	Sampling Site	Mouza	Temp (°F)	pH	DO (mg\l)	Ammonia (mg\l)	Nitrites (mg\l)	CO_2 (mg\l)
1	Pond	Bheduria	82	7.5	8	1.0	Nil	2.5
2	Pond	Bheduria	80	7.8	7	0.8	Nil	3
3	Pond	Char Samaiya	82	8.0	8	0.6	Nil	3
4	Pond	Kunjaputti	81	8.0	10	0.5	Nil	3
5	Pond	C.Prashad	82	7.5	3	1.0	.01	6
6	Pond	CC.Prashad	82	8.0	8	0.8	Nil	2.5
7	Pond	Char Gazi	80	7.5	2	1.2	0.05	4
8	Pond	Tum Char	81	7.8	8	0.2	Nil	2
9	Gazir Khal	Char Gazi	88	7.3	9	0.8	Nil	1
10	Bheduria Khal	Tum Char	84	7.5	6	0.2	Nil	2
11	Darogar Khal (Low tide)	Pangasia	84	8.0	7	0.5	Nil	2
	(High tide)		82	8.0	9	0.5	Nil	2
12	Napiter Khal	Char Chandra Prashad	82	7.5	8.0	0.4	Nil	3
13	Tetulia River	Char Bheduria	80	7.8	7	0.2	0.01	3
14	Tetulia River	Patabunia	81	7.7	6	0.2	0.02	4
15	Jangalia River (near Bholaghat)		80	7.9	8	0.5	0.03	5

Source: Field Survey, 1992

Annex 12

Fish Species Occurring in Bhelumia-Bheduria Study Area

Codes:

Habitat: R = River, C = Canal, CR = Creeks, P = Pond, and ALL = Various water bodies
Status: F = Fairly Common, C = Common, and R = Rare

Bangla Name	Scientific Name	Status	Habitat
Air	*Mystus aor*	F	R C
Baacha	*Eutropiicthys vacha*	C	R
Baim	*Mastacembelus armatus*	C	ALL
Bata	*Labio bata*	C	R P
Batashi	*Pseuttotropius atheronoides*	C	ALL
Bele	*Glossogobius giuris*	C	R C CR
Bheda	*Nandus nandus*	R	P
Boal	*Wallago attu*	F	ALL
Bojori tengra	*Mystus tengra*	C	R C
Chanda	*Chanda nama*	C	ALL
Chapila	*Gudusia chapra*	C	ALL
Chela	*Oxygaster bacaila*	C	ALL
Chep chela	*Chela atpar*	R	ALL
Chetal	*Notopterus chital*	R	R C P
Chingree icha	*Caridina gracilirostris*	F	ALL
Darkina	*Esomus dauricus*	C	ALL
Foli	*Notopterus notopterus*	C	R C P
Ghaura	*Clupisoma garua*	C	R
Ghonia	*Labio gonius*	R	R P
Golda chringree	*Macrobrachium rosenbergii*	F	ALL
Golsha	*Mystus bleekeri*	C	R
Gozar	*Canna marulius*	R	P
Ilish	*Hilsha ilisha*	F	R
Kajuli	*Ailia coila*	R	ALL
Kalibaush	*Labeo calbasu*	R	R P
Kanchki	*Corica soboma*	C	R
Kani pabda	*Ompok bimaculatus*	C	R C

Bangla Name	Scientific Name	Status	Habitat
Katla	*Catla catla*	C	R P
Kholisha	*Colisa fasciata*	C	ALL
Koi	*Anabas testudineus*	C	P C CR
Magur	*Clarius batracus*	C	C CR P
Mola	*Amblypharyngoden microlepis*	C	ALL
Mrigal	*Cirrhinus mrigala*	C	R P
Pabda	*Ompok pabda*	C	R C
Pangas	*Pangasius pangasius*	F	R C
Poa	*Pama pama*	C	R
Punti	*Puntius puntio*	C	ALL
Reyeg	*Cirrhinus reba*	R	R P
Rita	*Rita rita*	R	R
Rui	*Labeo rohita*	C	R P
Shada chewa	*Tryauchen vagina*	F	R
Shilong	*Silonia silondia*	C	R
Shing	*Heteropneustes fossilis*	C	C CR P
Shol	*Channa striatus*	R	P
Shorpunti	*Puntius sarana*	C	R
Taki	*Channa Punctatus*	R	P CR
Tara baim	*Macrognathus aculeatus*	R	C CR P
Tengra	*Batasio tengra*	C	ALL
Titpunti	*Puntius ticto*	C	ALL
Topshi	*Polynemus sexfilis*	R	R

Source: Field Survey, 1992

Annex 13

Breeding, Migration, and Extraction Periods of Commercially Important Fish

Species	Gravid Available	Spawning Periods	Spawning Grounds	Rearing Areas	Rearing Periods	Extraction Period Peak	Extraction Period Lean	Remarks
Hilsha	Mid. Jan-Mid. Aug	Oct-Jan.	Upstream	Upstream, sea	6 - 8 months	Jun-Sep	Oct-May	Jatka catch Oct-Feb.
Shrimp	Jun-Jul	Mid Jul.	Downstream	Upper narrow canals, creeks	Whole year	Jul-Nov	Dec-Jan	Adjacent chars, low areas, and creeks are shrimp habitat
Air, Boal	Jun-Jul	Jul-Aug	Down to Tetulia River	River, major canals	Whole year	Jul-Oct	Nov-Jan	From Bheduria Khal & Tetulia River
Chewa, Chingree (Gura)	Dec-Jan	Mar-Apr	Tetulia River Char-land	Tetulia River, canals	6 - 8 months	Nov-Mar		From Bindijal within project area & chars of adjacent areas
Pangus	May-Jul	Jun-Sep	Freshwater of southern part	Down to upstream	Whole year	June-Oct	Nov-May	In chapjal & also caught in hilsha nets
Carps			Upstream	Canals, rivers	Whole year	Jun-Sep		Spawn available in study area Jun - Jul, 5" to 7" long

Source: Field Survey, 1992

Annex 14

Annual Fish Production and Purchases in the Bhelumia-Bheduria Study Area

Markets/ Arots	Species	No. Cen- ters	Daily Pur- chase (kg)		Fishing Months		Rate (Taka/kg)		Annual purchase (Taka x 1000)		
			Peak	Lean	Peak	Lean	Peak	Lean	Peak	Lean	Total
Bhelumia Bazar	Shrimp, Air, Boal	3									1131
Napiter Khal	Hilsha	3	800	160	3	9	27	32	1944	1382	3326
Chatlar Khal	Hilsha	2	400		6		27		1944		1944
Banker Hat	Chewa and Gura chingree	2	300		4		35		1260		1260
Bank of Tetulia River	Hilsha	10	2000	300	4	8	40	45	9600	3240	12,840
Bhola from Bhelumia	All	All									11,314
Total per year											31,816,075

Source: Field Survey, 1992

Annex 15

Fishing Gear and Boats Used in Bhelumia-Bheduria Study Area

Annex 15.1 Fishing Gear Use

Gear Type	Cost (Taka) Net	Boat	Engine	No. Handlers	CPUE* (Taka)	Season	No. in Area	Species Caught
Khuchijal	100			1	30-50	Year	150-200	Small fish
Jhakijal	300			1-2	100-200	Year	W/boat=211 W/O +200	Small fish, shrimp
Hooks	20-100	500-1,200		1-2	100-300	Year	144 W/Boat	Shrimp
Moijal	300			1-2	100-200	Year	+200	Small fish, shrimp
Sonjal	7,000	5,000		4-5	300-400	Oct-Mar	50	Air, boal, pangas, big shrimp
Chapjal	10,000-15,000	10,000	10,000-20,000	5-7	400-500	Oct-Mar	42	Air, boal, pangas, big shrimp
Berjal (small)	50,000-60,000	10,000-20,000		5-7	500-1,000	Year	151	Hilsha, faisha, poa
Berjal (Large)	100,000	20,000-30,000	30,000	10-12	1,000-2,000	Year	20	Hilsha, faisha, poa
Current jal	30,000-50,000	10,000-20,000	15,000-20,000 (Y/N)	3-5	1,000-2,000	Year	472	Hilsha, faisha, poa
Bindijal	7,000-8,000	3,000-5,000		6	400-500	Nov-Feb	32	Chewa, baila, shrimp, other small fish
Berjal	5,000-10,000	3,000-5,000	Sticks-300-500	2-3	200-500	Nov-Mar	20	All fish, shrimp
Katha	Tree branches = 300-500 for 6 months (Catch after every 15 days)			5-10	500-1,000	Year	W/boat 275 W/O +300	Carps, air, boal, shrimp
Mosarijal	125,000	10,000	30,000	10-12		Dec-May	7	Any fish
Hafsa	600,000-700,000	200,000	50,000	30-50	100,000-200,000	Dec-Feb	2	River & marine fish

Source: Field Survey, 1992

* CPUE = Cost Per Unit Effort

Annex 15.2 Distribution of Fishing Boats Using Different Gear Types in the Study Area

	Large				Small				
Canal	Current	Son/ Chap	Ber (Suta)	Total	Hooks	Khata	Bindi	Jhaki	Total
Uttar Majher Hat Khal	72	5	33	110	13	20	2	20	55
From Bheduria road to Launch Ghat	22	12	6	40	2	8	5	15	30
Chikonmala Kala	46	20	14	80	25	46	4	35	110
Bankerhat Khal	68	7	60	135	26	50	4	42	120
Somiter Bazaar	20	-	5	25	2	10	2	6	20
S.Bheduria Hajierhat Khal	40	10	10	60	19	8	3	22	52
Camper Khal	42	12	6	60	5	7	4	4	20
Doskhali Khal	20	5	5	30	12	20	2	22	56
Kunjaputti Khal	30	5	5	40	10	32	2	18	62
Napiter Khal	42	6	7	55	20	38	2	15	75
Chatler Khal	70	10	20	100	10	36	2	12	60
Other boats									150
Fishing Trawlers									7
Totals	472	92	171	735	144	275	32	211	819

Sources: Tax collection list for the Tetulia River, lease owners, and local people using the canals.

Annex 16

Culture Fish in the Bhelumia-Bheduria Study Area

Annex 16.1 Number of Culture Ponds

Mouza	Inundated			Noninundated			Total
	Large	Medium	Small	Large	Medium	Small	
Mid Bheduria	-	3	28	-	1	-	32
Paschim Char Pata	-	1	8	-	-	-	9
Pangasia	1	5	12	1	5	21	45
Uter Bheduria	4	18	133	6	7	6	174
Pata Bheduria	1	13	14	1	10+(5)*	21	65
Char Ramesh	3	22+(4)	136+(8)	3	33	63	272
Paschim Charkali	3	25	67+(6)	13	33	67	214
Char Samaiya	-	5	2	2+(2)	73+(6)	32	122
Char Karimuddin	-	-	-	-	-	-	0
Char Gazi	-	9+(1)	28+(2)	1	12	6	59
Char Hossain	-	-	13	-	-	1	14
Kunjaputti	2	60+(4)	87	1	18	5	177
Chandra Prashad	1	58	138	8	42+(1)	38	**286**
Char Chandra Prashad	4	18	12	4	20	31	89
Patabunia	-	-	-	-	-	-	0
Tum char	-	-	-	4	13	18+(1)	36
Bagmara	2	10	5+(1)	2	22	18	60
Subtotal	21	247+(9)	683+(17)	46+(2)	289+(12)	327+(1)	GT
GT	21	256	700	48	301	328	1654

Source: Field Survey, 1992

* Numbers in () = Pond fully covered by water hyacinth

Annex 16.2 Pond Classification, Expenditures, and Income

Type	Type/ Size	Size/area (dec.)	Annual Expend. (Tk)	Annual Income (Tk)	Number of Ponds	Minimum Income (Tk per Year)
Inundated	Large	≥66	None	800-2,000	21	16,800
	Medium	33-65	None	500-800	256	128,000
	Small	1-32	None	200-500	700	140,000
Not inundated	Large	≥66	≥3,000	≥10,000	48	480,000
	Medium	33-65	1,000-3,000	5,000-10,000	301	1,505,000
	Small	1-32	500-1,000	2,000-5,000	328	656,000

Source: Field Survey, 1992

Annex 17

Mouza Areas, Household Numbers, and Populations in the Bhelumia- Bheduria Study Area

Mouza	Area (km²)	No. of Households	Population			
			Male	Female	Total	Density/km²
Project Area						
Pangasia	1.90	388	1,118	1,052	2,170	1,142
Char Samaiya	5.51	500	1,542	1,366	2,908	528
Char Bheduria	8.85	1,716	4,852	4,489	9,341	1,055
Char Ramesh	4.94	1,070	2,998	2,743	5,741	1,162
Paschim Charkali	5.05	932	2,655	2,435	5,090	1,008
Bagmara	6.20	178	504	481	985	159
Chandra Prashad	8.55	1,362	3,795	3,479	7,274	851
Char Chandra Prashad	3.61	403	1,202	1,122	2,324	644
Kunjaputti	4.62	965	2,648	2,507	5,155	1,116
Tum char	2.50	194	546	532	1,078	431
Char Hossain	0.03	06	14	09	23	767
Char Gazi	1.48	94	290	265	555	375
Sub Total	53.24	7,808	22,164	20,480	42,644	801
Adjacent Area						
Char Bheduria	2.82	542	1,532	1,418	2,950	1,046
Char Hossain	0.91	195	456	285	741	814
Char Gazi	5.08	314	971	886	1,857	366
Subtotal	8.81	1,051	2,956	2,589	5,548	630
Totals	62.05	8,859	25,123	23,069	48,192	777

Source: BBS (1992a) and GIS

Note: 32% of the area of Pangasia, 76% of Char Bheduria, 69% of Bagmara, 3% of Char Hossain, and 23% of Char Gazi fall inside the project area. All other mouzas are 100% inside the study area.

Annex 18

Reasons for Establishment of Settlements Inside and Outside Bhelumia-Bheduria Project Area

	Reason (percent of households)							
	Inherited Land	Bought Land	Landlord Pressure	Kinship Connection	Marriage Connection	Riverbank Erosion	Other	Total
Project Area								
Pangasia	0.9	0.5	0	0.2	0	0.7	0	2.4
Char Samaiya	3.3	1.2	0	0.5	0	0.7	0.5	6.1
Char Bheduria	13.0	2.4	0	0.5	0.2	9.0	0.5	25.5
Char Ramesh	6.6	1.9	0	0.5	0.2	3.1	0.2	12.5
Paschim Charkali	4.0	0.5	0	0	0.2	3.3	0.9	9.0
Bagmara	2.1	0.7	0	0.2	0	0	0	3.1
Chandra Prashad	11.3	2.1	0.2	0.5	0.3	1.2	0.5	16.0
Char Chandra Prashad	1.9	1.4	0	0	0	0.9	0.7	5.0
Kunjaputti	9.7	0.2	0	0	0	0.7	0.4	11.3
Tum Char	1.2	0.5	0	0.2	0	0.2	0.2	2.4
Subtotal	52.0	11.3	0.2	2.6	0.9	19.9	4.0	92.9
Adjacent Area								
Char Hossain	1.4	0	0	0	0	0.9	0	2.4
Char Gazi	1.2	1.2	0.3	0.5	0	1.4	0.2	4.7
Subtotal	2.6	1.2	0.3	0.5	0	2.3	0.2	7.1
Study Area Total	56.6	12.5	0.5	3.1	0.9	22.2	4.2	100.0

Source: Household Baseline Survey, 1992

Annex 19

Age of Settlements by Mouza (by Percent)

	Age (in Years)							
Mouza	**1-5**	**6-10**	**11-20**	**21-30**	**31-40**	**41-50**	**51+**	**Total**
Inside Project								
Pangasia	0	0.5	0.5	0.2	0.2	0.5	0.5	2.4
Char Samaiya	0.2	0.9	1.9	1.2	0	0.5	1.4	6.1
Char Bheduria	5.4	5.4	3.5	2.6	1.4	1.4	5.7	25.5
Char Ramesh	1.4	1.2	2.4	1.2	1.2	2.1	3.1	12.5
Paschim Charkali	1.4	2.8	1.4	1.2	0.7	0.5	0.9	9.0
Bagmara	0.9	0	0.7	0.2	0.5	0.5	0.2	3.1
Chandra Prashad	2.1	1.7	3.1	1.2	1.4	.2	6.4	16.0
Char Ch. Prashad	0.5	1.2	0.2	0.5	0.7	0	1.7	4.7
Kunjaputti	0.9	0.9	0.5	0.5	3.1	2.8	2.4	11.1
Tum Char	0.2	0.9	0.5	0.5	0	0	0.5	2.6
Subtotal	13.2	15.6	14.7	9.1	9.2	8.5	22.7	92.9
Outside Project								
Char Hossain	0.2	0.2	1.4	0.5	0	0	0	2.4
Char Gazi	1.7	0.2	1.4	0.5	0.2	0.5	0.2	4.7
Subtotal	1.9	0.4	2.8	1.0	0.2	0.5	0.2	7.1
Study Area Total	15.1	16.0	17.5	10.1	9.4	9.0	22.9	100.0

Source: Household Baseline Survey, 1992

Annex 20

Primary Occupation of Household Heads

	Occupation (Percent of Households)											
Mouza	Farming (own)	Farming (own+share)	Share Cropper	Farm Labor	Nonfarm Labor	Service	Fishing	Boatman	Business	Broker	Other	Total
Project Area												
Pangasia	0	0.5	0.2	0.5	0.2	0.2	0.5	0.2	0	0	0	2.4
Char Samaiya	0.7	2.1	0	1.7	0.5	0.2	0.2	0.2	0.2	0.2	0	6.1
Char Bheduria	3.1	4.5	1.9	1.2	0.7	0.7	12.3	0	1.2	0	0	25.5
Char Ramesh	2.8	2.6	0.5	3.3	0.5	0.5	1.2	0.2	0.5	0.2	0.2	12.5
Paschim Charkali	0.5	2.1	0.7	1.2	1.4	0.2	1.4	0.2	0.5	0	0.7	9.0
Bagmara	0.5	0.9	0	0.9	0.2	0.2	0	0	0	0.2	0	3.1
Chandra Prashad	3.5	3.8	0	3.3	0.7	0.7	1.4	0.5	1.4	0	0.7	16.0
Char Chandra Prashad	0.9	0.9	0	0.2	0	0.7	1.7	0	0.2	0	0.2	5.0
Kunjaputti	1.4	2.4	0.2	4.5	0	0.2	0.9	0.2	0.5	0	0.7	11.1
Tum Char	0	0.7	0	0.5	0	0	0.5	0.2	0.5	0	0	2.4
Subtotal	13.4	20.5	3.5	17.3	4.3	3.8	20.0	1.9	5.0	0.7	2.6	92.9
Outside Project												
Char Hossain	0.5	0.7	0	0	0.2	0	0.5	0	0.2	0	0.2	2.4
Char Gazi	0.5	0.7	0.9	0.9	0	0.2	0.7	0.2	0.2	0.2	0	4.7
Subtotal	1.0	1.4	0.9	0.9	0.2	0.2	1.2	0.2	0.4	0.2	0.2	7.1
Study Area Total	14.4	21.9	4.5	18.2	4.5	4.0	21.2	2.1	5.4	0.9	2.8	100.0

Source: Household Baseline Survey, 1992

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Annex 21

Water Transportation in the Bhelumia-Bheduria Study Area

Annex 21.1 Numbers and Uses of Boats by Mouza As Reported in Household Survey*

Mouza	Fishing	Agricultural	Household	Income	Total
Pangasia	4	0	0	0	4
Char Samaiya	0	0	0	2	2
Char Bheduria	27	5	0	14	46
Char Ramesh	2	0	0	8	10
Paschim Charkali	7	0	0	5	12
Bagmara	0	0	0	0	0
Chandra Prashad	1	10	2	5	18
Char Chandra Prashad	1	0	9	0	10
Kunjaputti	2	3	0	4	9
Char Hossain	1	0	0	0	1
Char Gazi	1	2	0	2	5
Tum Char	2	0	0	1	3
Total	48	20	11	41	120

Source: Field Survey, 1992

* 5 percent of all households in study area sampled

Annex 21.2 Paddy Carried by Boat from the Charlands of the Tetulia River

Khal	Trip	Total Paddy with Straw Carried by Boat (mt.)
Napiter Khal	75	37.5
Chatal Khal	120	60
Chargazir Khal	1,500	750
Shamitar hat	150	75
Total	1,845	922.5

Source: Field Survey, 1992

Annex 21.3 Distribution of Boats by Mouza

Canal	Large Fishing Boat	Small Fishing Boat
Uttar Majher Hat Khal	110	55
From Bheduria road to Launch ghat	40	30
Chikonmala Kala	80	110
Bankerhat Khal	135	120
Somiter Bazar	25	20
S.Bheduria Hajierhat khal	60	52
Camper Khal	60	20
Doskhali Khal	30	56
Kunjaputti Khal	40	62
Napiter Khal	55	75
Chatler Khal	100	60
Total	578	660

Source: Field Survey, 1992

Annex 22

Natural Hazards in the Bhelumia-Bheduria Study Area

Annex 22.1 Flooding Characteristics Within Last Five Years

Flood Variables	Location	1991	1990	1989	1988	1987
Maximum Flood Depth (Average in feet)	On Crop Field	4.41	3.96	4.84	4.63	4.15
	On Home yard	1.70	1.50	2.25	2.00	1.75
	On House Plinth	1.00	0.75	1.50	1.25	1.00
Maximum Flood Duration (Average Days)	On Crop Field	6.48	4.50	7.58	6.59	5.00
	On Home yard	3.50	2.00	3.75	3.60	2.50
	On House Plinth	1.50	1.00	2.00	1.50	1.00

Source: Household Baseline Survey, 1992

Annex 22.2 Hazards Affecting Sampled Households Within Last 10 Years

Number of Times Event Occurred in last 10 years	Percent (number in sample) Households Affected by Hazard in Last 10 Years					
	Flood	Storm Surge	Drought	Saline Intrusion	Erosion	Cyclone
1 - 3	30 (124)	89 (24)	87 (252)	57 (60)	32 (7)	13 (46)
4 - 6	60 (243)	11 (3)	9 (25)	23 (24)	14 (3)	40 (148)
7 - 9	10 (39)	0 (0)	4 (12)	15 (16)	18 (4)	45 (164)
10 >	<1 (2)	0 (0)	<1 (1)	6 (6)	36 (8)	3 (10)
Affected Total Percent	100 (408)	100 (27)	100 (290)	100 (106)	100 (22)	100 (368)
Percentage of Total Households Sampled (424)	96%	6%	68%	25%	5%	87%

Source: Household Baseline Survey, 1992

Annex 22.3 Average Damage (Tk.) to Households due to Flood and Tidal Surges in the Last Five Years (% in Parentheses)

Element at Risk	Damage due to Flood					Damage due to Tidal Surge				
	1987	1988	1989	1990	1991	1987	1988	1989	1990	1991
Household Assets	0	1420 (9.0)	1440 (8.0)	0	1451 (9.0)	0	0	36 (1.3)	500 (35)	333 (21)
House structure	0	1919 (12.0)	967 (5.4)	500 (7.5)	1305 (8.1)	0	0	125 (4.4)	0	198 (12.6)
Vegetable garden	152 (2.7)	611 (3.8)	519 (2.9)	268 (4.0)	718 (4.5)	0	0	11 (0.4)	0	2
Stored crops	0	0	0	0	2000 (12.5)	0	0	2050 (72.7)	0	900 (57)
Standing crops	3200 (57)	2869 (18.0)	3764 (21.0)	4076 (61.0)	6591 (41.0)	0	26 (100)	318 (11.3)	931 (65)	77 (4.9)
Livestock	0	6613 (41.6)	7000 (39.0)	0	467 (3.0)	0	0	0	0	0
Poultry	0	192 (1.2)	414 (2.3)	200 (3.0)	505 (3.1)	0	0	64 (2.3)	0	15 (1.0)
Tree/Tree crops	436 (7.8)	778 (9.9)	1277 (7.2)	352 (5.3)	461 (2.9)	0	0	56 (2.0)	0	54 (3.5)
Pond Fish	1824 (32.5)	1513 (9.5)	2553 (14.2)	1287 (19.2)	2546 (15.9)	0	0	160 (5.6)	0	0
Total	5612	15915	17934	6683	16044	0.0	26	2820	1431	1577

Source: Household Baseline Survey, 1992

Annex 22.4 Average Flood Damage (Tk.) by Mouza and Occupation in 1991 (% in parentheses)

Occupation	Mouza (listed by name in next table) 1	2	3	4	5	6	7	8	9	10	11	12
Farming Own Land	0	5000 (38.9)	67579 (93.3)	3082 (26.1)	935 (12.5)	150 (1.7)	1911 (22.8)	1700 (26.0)	530 (3.8)	175 (1.4)	300 (1.1)	0
Farming Own+Share	0	1470 (11.4)	423 (0.6)	1080 (9.1)	2483 (33.0)	7600 (85.0)	310 (3.7)	833 (12.8)	1234 (13.4)	5750 (46)	20200 (77.0)	1750
Share Cropping	400 (3.4)	0	1350 (.8)	1000 (8.5)	347 (4.6)	0	0	0	0	0	2000	0
Farm Labor	4000 (34.2)	900 (7.0)	350 (.5)	280 (2.4)	750 (10.0)	988 (11.0)	288 (3.4)	0	525 (5.7)	0	1067 (4.1)	0
Nonfarm Labor	0	0	700 (1.0)	230 (2.0)	320 (4.3)	200 (2.3)	217 (2.6)	0	0	1000 (8.4)	0	0
Service	0	500 (3.9)	350 (.5)	1600 (13.5)	700 (9.3)	0	3067 (36.7)	733 (11.3)	4000 (43.5)	0	1200 (4.6)	0
Fishing	1200 (10.2)	2000 (15.5)	1052 (1.5)	940 (8.0)	1580 (21.0)	0	250 (3.0)	3250 (49.9)	0	1150 (9.2)	1000 (3.8)	0
Boatman	200 (1.7)	0	0	150 (1.3)	0	0	150	1.8	0	0	0	0
Business	0	0	600 (0.8)	1050 (8.8)	0	0	205 (2.5)	0	350 (3.8)	400 (3.2)	300 (1.1)	0
Rickshaw Puller	0	0	0	0	0	0	0	0	0	0	0	0
Other	5925 (50.5)	3000 (23.3)	0 (0)	2400 (20.3)	400 (5.3)	0 (0)	1967 (23.5)	0 (0)	2750 (29.8)	4000 (32.2)	200 (0.7)	0 (0)
Total	11725 (100)	12870 (100)	72404 (100)	11812 (100)	7515 (100)	8938 (100)	8365 (100)	6516 (100)	9209 (100)	12475 (100)	26267 (100)	1750 (100)

Source: Household Baseline Survey, 1992

Annex 22.5 Resource Damage to Households Due to Flood in 1991 (% in parentheses)

	Average Flood Damage (in Tk.)								
Mouza	H/H Assets	Housing	Vegetable Garden	Stored Crop	Standing Crops	Live-stock	Poultry	Trees	Pond Fish
1.Pangasi	0.00	1333 (8.0)	100 (1.2)	0	1150 (2.1)	0	0	0	2950 (8.6)
2.C.Samaiya	200 (1.95)	1644 (10.0)	688 (8.3)	0	3875 (7.0)	0	0	1190 (16.3)	3275 (9.6)
3.C.Bhedu	1533 (15.0)	1215 (7.3)	401 (4.8)	0	17067 (31.2)	0	0	288 (4.0)	2156 (6.3)
4.C.Rames	300 (3.0)	1117 (6.7)	3366 (40.5)	0	2996 (5.5)	0	60 (2.0)	450 (6.2)	1950 (5.7)
5.P.Chark	0	991 (6.0)	416 (5.0)	6000 (100)	1638 (3.0)	100 (7.1)	550 (18.1)	181 (2.5)	2667 (7.8)
6.Bagmara	0	1500 (9.0)	425 (5.10)	0	4943 (9.0)	0	0	1542 (21.0)	5050 (14.7)
7.Chandra	4120 (40.30)	952 (5.8)	269 (3.3)	0	1876 (3.4)	0	0	188 (2.6)	2467 (7.2)
8.C.Chandra	0	2111 (12.7)	375 (4.5)	0	3778 (7.0)	300 (21.4)	250 (8.2)	1065 (14.6)	4750 (13.9)
9.Kunja	70 (.07)	1363 (8.2)	772 (9.3)	0	2652 (4.8)	0	0	221 (3.0)	1667 (4.9)
10.C.Hose	4000 (39.1)	1175 (7.0)	930 (11.2)	0	3600 (6.6)	1000 (71.5)	1200 (39.5)	564 (7.7)	1190 (3.5)
11.C.Gazi	0	1050 (6.3)	335 (4.0)	0	8377 (15.4)	0	275 (9.0)	399 (5.5)	1100 (3.2)
12.Tum C.	0	2176 (13.0)	238 (2.8)	0	2700 (5.0)	0	700 (23.2)	1207 (16.6)	5000 (14.6)
Total	10223	16618	8315	6000	54652	1400	3035	7295	34222
Percent	100	100	100	100	100	100	100	100	100

Source: Household Baseline Survey, 1992

Annex 22.6 People's Perception of Hazard Risks

Hazard	Level of Risk Perception (%)					Total (%)	Affected Households
	No Risk	Low	Moderate	High	Extreme		
Flood Risk	45.4	3.2	13.7	24.1	13.7	100	54.6
Storm Surge	95.9	0.8	1.7	1.1	0.5	100	4.1
Salinity	85.8	6.0	7.0	1.0	0.2	100	14.2
Cyclone	50.5	3.2	31.4	12.2	2.7	100	49.5
Drought	61.0	0.3	15.4	23.0	0.3	100	39.0
Erosion	95.0	1.0	1.0	2.0	1.0	100	5.0
Drainage Congestion	0	96.0	1.0	2.0	0.5	0.5	4.0

Source: Household Baseline Survey, 1992

Annex 22.7 Average Flood Damage Per Household (% in parentheses)

Mouza	Average Damage (Tk.) per Affected Household (%)				
	1991	1990	1989	1988	1987
Pangasia	3233	4725	800	2725	-
	(60)	(20)	(10)	(50)	-
Char Samaiya	4987	1531	3286	4167	3760
	(73)	(31)	(96)	(65)	(19)
Char Bheduria	3276	1340	3765	2672	1111
	(75)	(14)	(86)	(56)	(8)
Char Ramesh	2799	6875	3293	2427	1025
	(66)	(8)	(70)	(49)	(4)
Paschim Charkali	2065	-	2528	3254	-
	(89)	-	(66)	(61)	-
Bagmara	14306	8328	7936	8394	-
	(69)	(46)	(54)	(54)	-
Chandra Prashad	2178	695	2816	1940	1020
	(81)	(9)	(87)	(71)	(7)
Char Ch. Prashad	5714	1515	4572	2882	6000
	(71)	(19)	(48)	(43)	(10)
Kunjaputti	3054	3100	6870	5732	1150
	(64)	(6)	(47)	(85)	(4)
Char Hossain	5185	2200	4280	2140	-
	(100)	(20)	(50)	(60)	-
Char Gazi	4946	3016	4655	7938	-
	(70)	(30)	(55)	(20)	-
Tum Char	5835	1998	7321	3553	560
	(80)	(30)	(70)	(30)	(10)

Source: Household Baseline Survey, 1992

Annex 22.8 Average Drought Damage (% in parentheses)*

Mauza	Average Damage per Household (Tk.) 1991	1990	1989	1988
Pangasia	2700			
	(50)			
Char Samaiya	2600		5000	
	(15)		(4)	
Char Bheduria	2324		1400	
	(25)		(1)	
Char Ramesh	2312			4600
	(32)			(4)
Paschim Charkali	2829		1167	3925
	(18)		(8)	(11)
Bagmara	10350			
	(15)			
Chandra Prashad	860			
	(29)			
Char Ch. Prashad	6750	2750		
	(19)	(10)		
Kunjaputti	2044		5000	2625
	(34)		(4)	(17)
Char Hossain	1000			
	(10)			
Char Gazi	6667		8000	
	(15)		(5)	
Tum Char	3500			
	(30)			

Source: Household Baseline Survey, 1992

* Blanks indicate no data and/or no damage reported

Annex 23

Agricultural Projections: Future Without Project

Annex 23.1 Estimated Future Crop Damage Without Project

Crop	Damage-free		Damage by flood		Damage by pests		Production (ton)	Production lost by flood (ton)	Production lost by pest (ton)
	ha	t/ha	ha	t/ha	ha	t/ha			
B. Aus(L)	1,156	1.7	825	0.5	699	1.0	3,077	990	489
T. Aus(L)	142	2.0					284		
T. Aus(H)	65	2.5					163		
B. Aus(H)	174	2.0	20	0.4			356	32	
T. Aman(L)	2,089	2.3	770	0.7	752	1.5	6,472	1,232	602
T. Aman(H)	518	2.9	90	0.6			1,556	207	
Boro(H)	589	4.3	150	1.1	105	2.0	2,908	480	242
Paddy							14,816	2,941	1,353
Pulses	581	0.70					407		
Chili	660	0.86	124	0.40			618	57	
S. Potato	150	12.0					1,800		
Watermelon	133	40					5,320		
Wheat	190	1.5					285		
Oilseed	95	0.5					48		
Vegetables	50	3.0					150		
Other rabi crops	49								

Source: Field Survey, 1992

Annex 23.2 Agriculture Labor Requirements for Crops Without Project

Crop	Area (ha)	Person Days per Hectare												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
B.Aus	2589			15	35	35	15	30	10					140
T.Aus(L)	181			10	40	30	15	25	25	15				160
T.Aus(H)	75			10	40	30	20	20	25	20				165
T.Aman(L)	3890						10	35	30	10	10	15	20	130
T.Aman(H)	587						10	40	30	25	15	25	25	170
Boro(H)	925	30	30	25	25	25	20					10	30	195
Chili	828	30	30	15	20	30	20							145
S. Potato	151	10	10	20								20	30	90
Pulses	918		10	10								10	10	40
Oilseeds	92	20	10	10	20							10	20	90
Wheat	146	10	10	10	30							30	25	115
Watermelon	133	50	20	20	30	30						50	50	250
Total(000 P/D)		64	68	94	151	150	123	243	167	58	48	106	146	1418

Source: Field Survey, 1992

Annex 24

Estimated Future Crop Production and Damage in the Bhelumia-Bheduria Study Area Following Project Development

Annex 24.1 Scenario 1 (no change in land types)

Crop	Damage-free		Damage by pests		Production (tonnes)	Production Lost to Pests (tonnes)
	ha	t/ha	ha	t/ha		
B. Aus (L)	1,595	1.7	560	1.0	3,272	392
T. Aus (L)	231	2.0	-	-	362	-
T. Aus (H)	125	2.5	-	-	312	-
B. Aus (H)	210	2.0	-	-	420	-
T. Aman (L)	3,074	2.3	816	1.5	8,294	653
T. Aman (H)	488	3.0	99	2.0	1,662	99
Boro (H)	907	4.3	212	2.0	4,324	488
Paddy	-	-	-	-	18,646	1,632
Pulses	894	0.70	-	-	626	-
Chilli	778	0.86	50	0.60	699	13
S. Potato	151	12.0	-	-	1,812	-
Watermelon	133	40	-	-	5,320	-
Wheat	146	1.5	-	-	219	-
Oilseed	92	0.5	-	-	46	-
Vegetables	50	3.0	-	-	150	-
Other rabi crops	54	-	-	-		-

Source: Field Survey, 1992

Annex 24.2 Scenario 2 (change in land types)

Crop	Damage-free		Damage by pests		Production (tonnes)	Production lost to pests (tonnes)
	ha	t/ha	ha	t/ha		
B. Aus (L)	1,594	1.7	560	1.0	3,270	392
T. Aus (L)	231	2.0	-	-	362	-
T. Aus (H)	125	2.5	-	-	312	-
B. Aus (H)	210	2.0	-	-	420	-
T. Aman (L)	2,598	2.3	691	1.5	7,012	552
T. Aman (H)	986	3.0	202	2.0	3,362	202
Boro (H)	907	4.3	212	2.0	4,324	488
Paddy	-	-	-	-	19,062	1,634
Pulses	893	0.70	-	-	625	-
Chilli	778	0.86	50	0.60	699	13
S. Potato	151	12.0	-	-	1,812	-
Watermelon	133	40	-	-	5,320	-
Wheat	146	1.5	-	-	219	-
Oilseed	92	0.5	-	-	46	-
Vegetables	50	3.0	-	-	150	-
Other rabi crops	54	-	-	-	-	-

Source: Field Survey, 1992

Annex 25

Agriculture Labor Requirements for Crops with Project

Annex 25.1 Agriculture Labor Requirements for Crops with Project Development (Scenario 1)

Crop	Area (ha)	Person Days Per Hectare												Total persons
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
B.Aus	2,365			15	35	35	15	30	10					140
T.Aus(L)	231			10	40	30	15	25	25	15				160
T.Aus(H)	125			10	40	30	20	20	25	20				165
T.Aman(L)	3,890						10	35	30	10	10	15	20	130
T.Aman(H)	587						10	40	30	25	15	25	25	170
Boro(H)	1,119	30	30	25	25	25	20					10	30	195
Chilli	828	30	30	15	20	30	20							145
S.Potato	151	10	10	20								20	30	90
Pulses	894		10	10								10	10	40
Oilseeds	92	20	10	10	20							10	20	90
Wheat	146	10	10	10	30							30	25	115
Watermelon	133	50	20	20	30	30						50	50	250
Total(000 P/D)		70	74	96	152	150	125	239	167	60	48	108	152	1440

Source: Field Survey, 1992

Annex 25.2 Agriculture Labor Requirements for Crops with Project Development (Scenario 2)

Crop	Area (ha)	Person Days Per Hectare												Total Persons
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
B.Aus	2,364			15	35	35	15	30	10					140
T.Aus(L)	231			10	40	30	15	25	25	15				160
T.Aus(H)	125			10	40	30	20	20	25	20				165
T.Aman(L)	3,289						10	35	30	10	10	15	20	130
T.Aman(H)	1,188						10	40	30	25	15	25	25	170
Boro(H)	1,119	30	30	25	25	25	20					10	30	195
Chilli	828	30	30	15	20	30	20							145
S.Potato	151	10	10	20								20	30	90
Pulses	893		10	10								10	10	40
Oilseeds	92	20	10	10	20							10	20	90
Wheat	146	10	10	10	30							30	25	115
Watermelon	133	50	20	20	30	30						50	50	250
Total(000 P/D)		70	74	96	152	150	125	242	167	69	51	114	155	1464

Source: Field Survey, 1992

Annex 26

Predicted Changes in Selected Socioeconomic Parameters in the Project Area (without project)

Parameter	1981	1991	2001	2011
Total Population	35,236	42,644	50,043	58,142
Growth Rate (%)	3.3	1.7	1.6	1.5
Density/km²	662	801	940	1,092
Farm Population	22,747	26,962	31,640	36,760
Farm Households	4,062	4,993	6,457	7,991
Average Size of Farm Households (no.)	5.6	5.4	4.9	4.6
Average Farm Size (ha)	1.1	0.9	0.7	0.6
Total Land Availability per capita for Farm Population (ha)	0.23	0.20	0.17	0.14
Agricultural Land Availability per capita Farm Population (ha)	0.20	0.17	0.14	0.12
Agricultural Labor Requirements (man-days annually '000)	N.A.	1,386	1,402	1,418
Landlessness (%)	60	64	70	76
Gross Food grain availability per capita (rice and wheat)				
Per day (gm)	N.A.	934	826	718
Per year (kg)	N.A.	341	301	262
Total gross food availability (rice, wheat, potato, pulses, vegetables)				
Per day (gm)	N.A.	1,102	972	841
Per year (kg)	N.A.	402	355	307

Data for population, farm households, farm size and landlessness are based on Population Census 1981, 1991 and Agricultural Census 1983-84. Food availability data from FAP 16 Land Use Survey, 1992.

People's Perception of Flooding and Flood Related Problems and Suggested Solutions

Mouza	Union	Perceived Problems							Suggested Solutions					REMARKS
		TF	DC	Sa	Er	PA	HCI	LR	CE	CS	CCB	SCI	CR	
Project Area														
Pangasia	Illisha				*	*	*	*	*	*		*	*	Opening of the closed culvert near Matabbar bari in north Pangasia.
														Sluice gate on Mazirhat Khal.
Char Samaiya	Char Samaiya	*	*	*		*	*		*	*	*	*		Sluice gate on the offtake of Ujirer Khal.
														Bridge on the Atharobari Khal and culverts on village roads.
Char Bheduria	Bheduria	*		*	*	*	*	*	*		*	*	*	Construction of bridges and culverts on village roads.
Char Ramesh	Bheduria	*				*	*		*	*		*		Sluice gate on Kunjaputti and Saheber khals.
														Culverts on village roads.
Paschim Charkali	Bheduria					*	*		*	*		*		Sluice gate on Saheber Khal. Culverts on earthen roads.
Bagmara	Bhelumia	*	*			*			*	*		*		Sluice gate on Ujirer Khal.
														Construction of unplanned roads creates drainage congestion.
Chandra Prashad	Bhelumia	*	*		*		*		*	*	*	*		Sluice gate on Napiter, Chatler, Goaliar and Gazir khals.
														Bridge on Bhelumia Khal.
														Construction of culverts near Khan bari and Molla bari.

(CONTINUED)

Mouza	Union	Perceived Problems							Suggested Solutions					REMARKS
		TF	DC	Sa	Er	PA	HCI	LR	CE	CS	CCB	SCI	CR	
Char Chandra Prashad	Bhelumia	*	*	*	*	*	*			*	*	*		Sluice gate on Chatler and Napiter khals.
														Construction of culverts and cyclone shelter.
														Construction of embankment on the southwest of Tetulia.
Kunjaputti	Bhelumia	*	*	*					*		*			Culvert on the mid-point of Banglabazar and Bechu Khan bari.
														Sluice gate on the offtake of Dosh Khal and closure of Rishir Khal.
Tum Char	Bhelumia	*				*	*	*	*			*	*	Construction of bridge on the Bhelumia Khal.
														Construction of culverts in village roads.
Adjacent Area														
Char Hossain	Bhelumia	*	*			*	*	*	*	*	*	*	*	Sluice gate on the offtake of Satbaria Khal.
														Construction bridges and culverts.
Char Gazi	Bhelumia	*				*	*		*	*	*	*	*	Construction of cyclone shelter.
														Sluice gate on Satbaria and Camper Khal.
														Bridge on Gazir Khal and culverts on village roads.
Total (%)		83	50	33	33	83	83	33	91	75	58	91	41	

Source: Household Baseline Survey, 1992

TF = Tidal Flood
DC = Drainage Congestion
Sa = Salinity
Er = Erosion

PA = Pest Attack
HCI = High Cost of Inputs
LR = Lack of Roads

CE = Construction of Embankments
CS = Construction of Sluice gate
CCB = Construction of Culvert/Bridges
SCI = Supply of Inputs
CR = Construction of Roads