Government of the People's Republic of Bangladesh

Ministry of Irrigation, Water Development and Flood Control
Flood Plan Coordination Organization

BANGLADESH ACTION PLAN FOR FLOOD CONTROL

COMPARTMENTALIZATION PILOT PROJECT (FAP 20)

SIRAJGANJ CPP INTERIM REPORT

ANNEX 6: ENVIRONMENTAL ISSUES

(FINAL DRAFT)

June 1993

Euroconsult/Lahmeyer International/Bangladesh Engineering & Technological Services/House of Consultants

under assignment to

DIRECTORAAT GENERAAL INTERNATIONALE SAMENWERKING
Government of the Netherlands

and

KREDITANSTALT FÜR WIEDERAUFBAU
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ANNEX 6: ENVIRONMENTAL ISSUES

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i SUMMARY AND RECOMMENDATIONS

The CPP Sirajganj is located in the Middle Bangali floodplains along the Jamuna River and is known as one of the most productive ecosystems in the world. But immense population growth during the past decades in these floodplains has created increasing scarcity of natural resources like good quality surface water and ground water, fertile cropland, permanent wetlands, homestead forests, biomass energy and floodplain fisheries as well.

The most important environmental issue of the Sirajganj CPP is gradual conversion of the highly diversified floodplain ecosystem into a specialised cropping landscape leading to biological imbalances in the region. Another important issue is the hazards and risks arising from human interferences such as the construction of BRE and a number of road embankments with far too small and few culverts within the CPP and this contributed to the changes in floodland ecosystem of these area making them vulnerable to seasonal and unpredictable river floods, river bank erosion, siltation of natural channels, drainage congestion, drought, etc. Technical hazards arising from indiscriminate use of agrochemicals in the croplands and toxic emissions from the industries, and health hazard due to poor sanitation and waste disposal system in the rural as well as urban areas are also of important concern.

All the sensitive environmental resources of the Sirajganj CPP are at present in impaired conditions. Immediate measures are necessary to combat all these impairments such as extinction of permanent beels, declination of aquatic flora and fauna including fresh water fishes, degrading conditions of homestead forests and terrestrial habitats, shortage of biomass energy and fodder and biological imbalances.

Public health and nutrition are also in a poor state in the CPP Sirajganj. Water related diseases such as diarrhoea, bacillary dysentry, cholera, hepatitis, typhoid etc. are the more acute although some endemic diseases like malaria, kalazar and filariasis are also known. All these diseases are related to polluted drinking water and to oral faecal contact.

Competition over resource utilization is a common fact due to rapid population increase in the floodplains of the CPP area. Most important trends are the continued conversion of croplands and homestead forests into settlements and seasonal wetlands into croplands. As a result land is becoming scarer day by day and biological imbalances are likely through the destruction of natural habitats.

Development targets of the CPP are therefore aimed at sound environmental management by maintaining the long term natural resource base of the floodplains and developing a multiple user oriented guidelines of controlled flooding and water management plan for the benefit of agriculture, fisheries and other related sectors in the context of compartmentalization. It is assumed that all mitigation measures such as provision for sufficient sluice gates with adequate discharge design and reduced natural hazards to allow fish migration and to keep minimum interference into natural flood pattern would be implemented.

The Sirajganj CPP area is already under environmental impacts due to BRE and some other human made interferences with the nature. Assessment of extra impacts caused by the activities of the CPP is a complex at this stage when information on some areas such as present aquatic and terrestrial habitat status, water quality, soil fertility, environmental pollution and health situation are not available. Therefore a preliminary EIA of likely impacts based on conceptional model predictions is made and the holistic environmental appraisal for the preferred development option 2A of the CPP is presented in figure S1. The unique approach of CPP of stepwise planning leaves sufficient space for future amendments and corrective measures during implementation and operation. A final environmental impact assessment and environmental management plan will be made before the final implementation starts and therefore some special studies including surveying and monitoring of some important and sensitive environmental resources of the CPP area are proposed as follows:

***Environmental Survey**

- Ecological Status: Inventory of biological resources of major terrestrial and aquatic habitats of the CPP area Sirajganj and a draft EMP for the conservation of floodplain ecosystem.
- Homestead and Embankment Plantation: Identify key areas for rural homestead plantations and embankment roads plantation, and outline of planning, design and implementation.
- Environmental Pollution Survey: Identify the types, sources and magnitude of water and soil pollution in urban and rural areas. Special attention will be given to agrochemical, industrial and human faecal pollution.
- Wetland Conservation: Identify key wetland areas with high potential for migratory and resident wildlives, and outline of a multiple beel use programme and implementation proposals.
- Urban Health Survey: Identify the major hazards and risks related to polluted water and unplanned waste disposals in the Sirajganj town and proposals for safe measures and to improve the urban water related health situation.

***Environmental Monitoring**

- Groundwater Availability: Observation on groundwater fluctuations over time and development of a simple model for local groundwater recharge assessment.
- Soil Fertility: Evaluation of physical and chemical soil properties and their changes due to FCD. Special attention will be paid to soil nutrient and moisture balances.
- Water Quality: This monitoring programme will include only those impairments which had been identified in the environmental pollution survey.

Key elements of future environmental impact management initiatives are:

- Mitigation further wetland losses by developing a community based "wetland conservation programme".
- Mitigating likely increases of pesticide uses by initiating an "integrated pest management" programme.
- Enhancing rural homestead plantations by promoting fast growing multipurpose tree species.
- Enhancing underutilized embankment plantations by promoting a "social forestry programme" on road and river embankments.
- Promoting integrated urban health, sanitation and waste management programme which are aimed at controlling washed-related health hazards in Sirajganj town.

A non-formal environmental awareness and education programme should be initiated at the village level. An important outcome would be to support values and motivions conductive to behaviour patterns and measures that are instrumental in preserving and improving the floodplain environment. Target groups could be water user groups of the CPP area and other affected individuals or local NGO's.

Figure S1: Holistic Environmental Appraisal for Option 2A of CPP Sirajganj

Environmental Elements	Extra CPP-Impact: Beneficial – High	Beneficial – Medium	Beneficial – Minor	Adverse – Minor	Adverse – Medium	Adverse – High	Mitigation Cost	Type of Impact
Regular Flooding of Croplands		x	o				High	IM
Cumulative Off-site Effects				o				LT
Flood-free Land for Homesteads		o						IM
Loss of Land to River Erosion			o					
Containment of BRE-Breach Floods		o off-site			local o			IM
River Flood Damage			o					IM
Drainage Network Conditions		o						IM
Groundwater Availability				x o			Medium	LT
Surface Water Quality				x o			Medium	LT
Groundwater Quality				x o			Medium	LT
Soil Fertility Status				x	o		Medium	LT
Aquatic Habitat Status				x	o		High	IM
Terrestrial Habitat Status			o					IM
Wildlife				x	o		Medium	LT
Biological Imbalances				x	o		Medium	LT
Capture Fisheries				x o			High	IM
Culture Fisheries			x o				High	LT
Crop Production		o						LT
Homestead Plantation		x	o				Low	LT
Biomass Energy Production			x o				Low	LT
Fodder Production		x	o				Low	LT
Communicable Diseases								
Water-based			x o				High	LT
Vector-borne			o					LT
Non-communicable diseases								
Occupational Risks				x o			Medium	IM
Water Pollution			x	o			High	LT
Navigation			x o				High	IM
Construction Impacts				x			Medium	IM
	High	Medium	Minor	Minor	Medium	High		
	Beneficial			Adverse				

o = Without Mitigating Measures
x = With mitigation/enhancement + associated measures.
Type of Impact: LT/IM = Long-term or gradual versus immediate changes

ii ABBREVIATIONS

BWDB	Bangladesh Water Development Board
BADC	Bangladesh Agricultural Development Corporation
BRE	Brahmaputra Right Embankment
BSIC	Bangladesh Small Industries Corporation
CPP	Compartmentalization Pilot Project
DAE	Department of Agricultural Extension
DOE	Department of Environment
DOF	Department of Forestry
DOH	Department of Health
DOHE	Directorate of Health Education
DPHE	Department of Public Health Engineering
DTW	Deep Tubewell
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCD/I	Flood Control Drainage and Irrigation
GOB	Government of Bangladesh
IWTA	Inland Water Transport Authority
IUCN	International Union for the Conservation of Nature
LLP	Low Lift Pump
LGED	Local Government Engineering Department
MOT	Manually Operated Tubewell
MPO	Master Plan Organization
NWR	North West Region
NCS	National Conservation Strategy
NCA	Net Cultivable Area
NGOs	Non-Governmental Organizations
PET	Potential Evapotranspiration
STW	Shallow Tubewell
TGA	Total Gross Area
UDD	Urban Development Directorate

1 INTRODUCTION

1.1 Background

This Annex to the Interim Report of the Sirajganj Compartmentalization Pilot Project (CPP) covers environmental issues at an early project planning stage and describes future activities related to:

- environmental analysis and impact assessment
- future environmental management initiatives including monitoring, mitigating and enhancing measures.

The approach of the Flood Action Plan (FAP) requires that environmental issues are adequately addressed in the CPP at all planning stages. The FAP is aimed at mitigating flood hazards in Bangladesh. The flood protection policy adopted in the FAP is that of controlled flooding and controlled drainage.

> Firstly, this involves the building of major embankments along the main rivers to prevent usually early, rapidly rising, high or prolonged river floods from damaging crops and property on adjoining floodplains. Regulators sluices in the embankments should allow normal flooding of agricultural land to occur to appropriate depth and periods for crop production, to allow fish to migrate between the rivers and the floodplains or beels (water bodies) for feeding and spawning and to evacuate excess rainwater flooding from cropland when river water levels are sufficiently low (CPP.1990)
>
> Secondly, the protected area behind the major river embankment would be divided into compartments, making use of existing road embankments and other infrastructure where possible, to facilitate retention or drainage of water, as required for multiple uses. The overall objective of compartmentalization is to provide, through water management, a more secure environment for intensive agriculture, fisheries and integrated rural/urban development, and thereby improve the economic security and quality of life values of the floodplain population (CPP.1990). The compartments should manage excessive floodwater from local BRE-breaches, from adjacent rivers and from heavy local rainfall with impeded runoff. Compartments should also secure normal floods and floodland fisheries (CPP.1992).

The CPP (FAP 20) focuses on the compartmentalization aspect. It aims at establishing water management systems for the development of protected areas so that criteria and guidelines for full scale development can be made available for the Flood Action Plan in terms of:

- physical works and their management (i.e. hydrological modelling, hydraulic infrastructure design, improving agriculture and fisheries/aquaculture and communications)
- social issues and programmes

- the environment, its preservation and enhancement
- institutional arrangements
- economic justification (CPP.1990)

The concept is now being examined at two pilot areas, ie. Tangail and Sirajganj. This report covers the Sirajganj area. The Interim Report and the Environmental Impact Assessment for Tangail have been submitted in 1992 (CPP.1992 and FAP 16/19.1992).

1.2 Scope and Assessment Objectives

The nature and role of the environmental component study of the CPP was set out in the Terms of Reference (CPP 1990). Environmental outputs of the project are aimed at:

- ensuring that adverse environmental impacts are avoided or reduced to an acceptable level
- identifying where specific measures to improve (enhance) the environment can be taken.

Special reports should cover the following issues:

- physical and chemical effects on soil, water ways, surface water and groundwater resources,
- human activities
- flora and fauna
- environmental analysis

It is understood by the CPP that the environmental component of the project should concentrate on monitoring the real impacts of compartmentalization and conducting special surveys which are directly related to potential impacts of the project. Therefore, the CPP's environmental studies should focus on:

- compiling available regional and local information to describe the present state of the environment and pattern of rural development in the project area (environmental profile)
- describing the framework conditions for development, including the external and internal driving forces
- scoping of CPP-specific important environmental components for further analysis and assessment
- conducting special field surveys for selected issues
- conducting a holistic assessment of predicted environmental impacts of various options of CPP-related flood control and drainage activities
- collaborating with other CPP sections during design and implementation phases towards environmentally sound development
- monitoring relevant environmental elements during the implementation and operation of CPP
- producing an environmental management plan in cooperation with other relevant CPP-sections, eg for mitigation and enhancement measures

- establishing criteria specific for EIA-analysis, monitoring plans and environmental management plans which are specific for future compartmentalization projects.

This Annex covers the description of the existing environment, the scoping of important environmental components, a preliminary holistic assessment of technical options and an outline of future works (special surveys, monitoring, mitigating measures).

Related CPP-activities. A clarification of pertinent environmental components is required to avoid duplication of surveys and anaylsis on impacts caused by hydrological, agriculture and fisheries development and sociological or economic impacts. These impacts are already covered by in-depth surveys, special studies and assessments conducted by relevant CPP-sections, such as hydrology, engineering, agriculture, fisheries, sociology and institutional aspects. The environmental issues which are here addressed are related to (see Figure 1.1):

- natural resources such as water, land and eco-biological resources
- their uses for economic development
- other quality of life values such as public health and conservation of cultural heritage sites.

1.3 Approach and Methodology

This Annex summarizes and evaluates existing knowledge on potential environmental impacts of flood and drainage control proposals of the Sirajganj CPP. It focuses on extra impacts caused by the CPP-activities.

The Brahmaputra Right Embankment (BRE), although outside the scope of CPP activities, has specific environmental impacts which are relevant for CPP Sirajganj. The BRE impact is therefore considered in the environmental analysis.

Following the literature review and reconnaissance field information, the results were compiled for a brief description of framework conditions for development (Chapter 3) and the environmental profile of the CPP-area (Chapter 4). Based on these findings, the future work programme was drawn-up for detailed analysis of specific problems (Chapter 8). Hence, this Annex is only the first step to contribute to environmentally sound development and to develop an environmental management plan for the Sirajganj CPP.

External and cumulative impacts are a complex but important issue of the CPP environmental impact assessments. Important external impacts are related to:

- water resources developments within the North West region may (see FAP 2 studies and proposals)
- the construction of the Jamuna Bridge crossing the Jamuna River between Porabari and Sirajganj
- the rehabilitation or retirement of the Brahmaputra Right Embankment (BRE).

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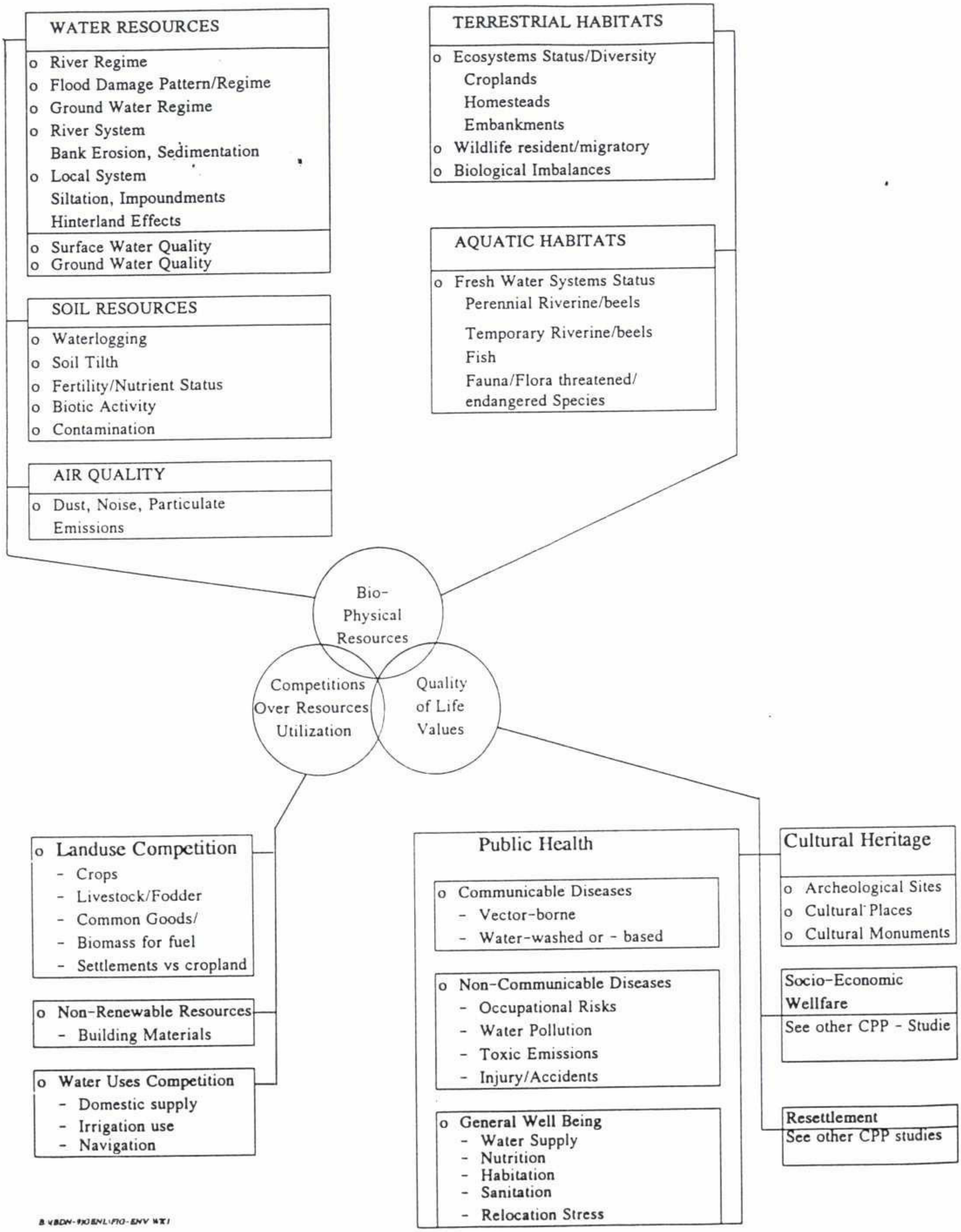
Figure 1.1: Environmental Quality Account System



This Annex deals with the area within the CPP boundary as defined by CPP. It is recognized that the impacts will probably extend beyond the boundary in respect of areas up- and downstream of the CPP which might be affected by backwater and flow pattern changes as a result of water regulation through the CPP. This may cause sequential changes in water-related resource uses such as fisheries and navigation. Furthermore, it must be considered that a series of compartmentalization projects in the region may cause aggregated impacts on water resources.

1.4 Data Sources

At this stage of the Sirajganj CPP environmental study, the resource and development profile for CPP are mainly derived from two data sources:

- Regional FAP 2 studies which provide the regional framework for environmental planning: Volume 1 (The Regional Plan), Volume 4 (Initial Environmental Evaluation), Volume 10 (Hydrology), Volume 14 (Ecology) and Volume 15 (Health, Cultural Heritage)
- Surveys and sector studies by CPP: Hydrology/Engineering, Fisheries, Agriculture, land use-, household- and needs assessment surveys.
- Additional environmental baseline and monitoring surveys are proposed to produce specific data for the environmental management plan (see Chapter 8). A full analysis of these informations will be given in the final EIA-report.

Other relevant FAP studies were also reviewed (eg. FAP 16 studies) and several institutions in Sirajganj and Dhaka were consulted.

A reconnaissance field visit to Sirajganj CPP was conducted during the period April to May 1993. Initial field data and information were collected on existing hydraulic infrastructure (operation and maintenance), town sanitation and drainage systems, roads, khal and beel status, land use pattern and the use of agro-chemicals. This was achieved through observations as well as discussions with government institutions and local resource persons. In March 1993, a specific environmental Needs Assessment Analysis was carried out of subcompartment 9, ie. the town of Sirajganj.

2 THE SIRAJGANJ CPP

2.1 The Project Area

Location. The Sirajganj CPP is located in the North West Planning Region (FAP 2 study area) at the Jamuna River. It occupies about 5% of the regional planning unit 8 (PU 8), the Middle Bangali Basin (Map 2.1). The gross area totals 1100 ha of which some 2,212 ha are rural and urban homesteads. The town of Sirajganj occupies some 1100 ha and is located at the southeastern border of the CPP-area.

Boundaries. The compartment is bordered in the East by the Brahmaputra Right Embankment (BRE) of the Jamuna River between Sirajganj town and Banglabazar village. In the West, the Ichamati river forms the boundary between Bhadraghat and Brahmagacha. As defined by CPP, the southern border follows the new Bogra road which crosses the Ichamati river at Soyadhan. In the North, the boundary follows district roads between the Ichamati Khal and the Ichamati branch.

Administrative Units. About 95% of the CPP-area is in the Sirajganj Sadar Thana. The remaining areas are within the Thanas of Kazipur (2%), Raiganj (2%) and Kamarkhand (1%). About 125 rural villages are within the CPP-area with a total population of about 292,000 people including some 132,000 inhabitants of the town of Sirajganj (estimate for 1993).

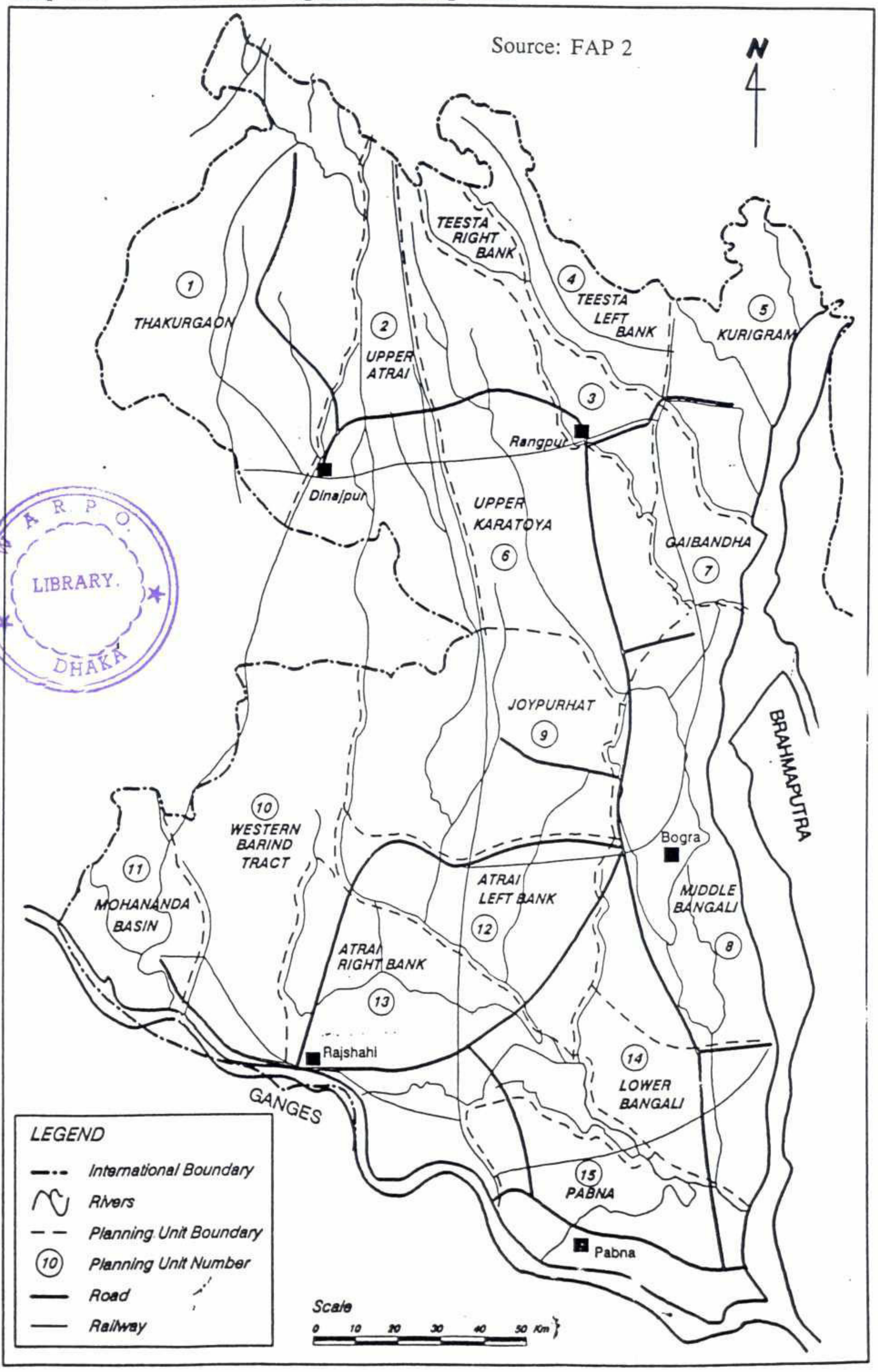
History. The CPP-area was defined in the Terms of Reference of the CPP (CPP.1990) to examine the compartmentalization concept in a cultivated area which has been protected by a major river embankment for the past 25 years: the Brahmaputra Right Embankment (BRE). The area has high proportions of higher land (F0 and F1 land), in contrast to the Tangail area with substantial lowland floodplains (F3 to F4). The CPP is expected to provide information on the compartmentalization concept in case of major BRE-breaches, ie. information about engineering and water management options for temporary storage of such excessive flood water within subcompartments before safe releases are possible to the Ichamati River at the western CPP-boundary (FAP 2.1992).

Subcompartment Designation. Sirajganj CPP is divided into nine subcompartments including Sirajganj urban area (Map 2.2). The boundaries are primarily based on hydrological and infrastructure criteria such as existing culverts/bridges, rivers/khals and embankment roads.

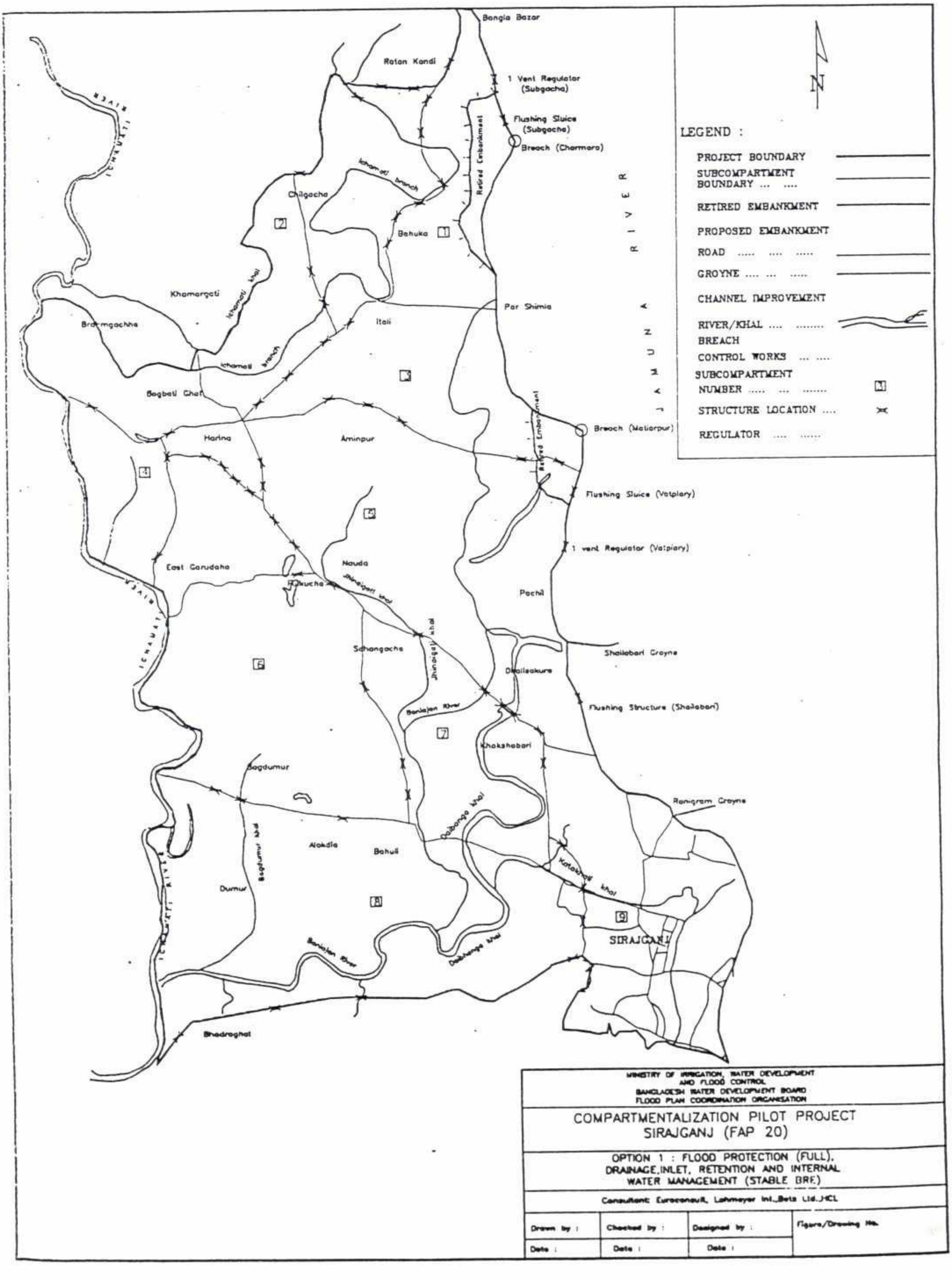
2.2 CPP-Development Proposals and Options

General Objectives. The Sirajganj CPP aims at establishing appropriate water management systems for the development of flood protected areas so that criteria and principles of design, implementation and operation can be made available for the Flood Action Plan. This can be achieved by structural and non-structural means such as:

Map 2.1: North West Regional Planning Units



Map 2.2: Sub-Compartment Boundaries of CPP Sirajganj



- layout, design and alignment of embankments between subcompartments and along rivers/khals (new or rehabilitated river or road embankments)
- water control structures such as regulators (sluices, gates for in- and outlets) at rivers/khals and culverts/bridges at road or embankment crossings
- channnel improvements (design, alignment, re-excavation) for improved drainage
- operation and maintenance of hydraulic structures
- upgrading of roads
- proposals for associated measures in the fields of agriculture/livestock, fisheries and infrastructure developments and additional environmental mitigation or enhancement measures
- incorporating participatory approaches at all planning and implementation stages and proposals for mitigation measures.

Regional flood control works. The CPP is part of the regional FAP planning (Map 2.3) and of a wide network of existing flood control, drainage and irrigation infrastructure (FCD or FCD/I) such as the Brahmaputra Right Embankment (Map 2.4).

Concept of compartmentalization. The CPP assumes that the BRE is strengthened and sealed. The BRE provides flood control from the Jamuna River, although minor breaches cannot be excluded in the future. Several breaches of the existing BRE along the Jamuna River occurred since 1984 and made the CPP area vulnerable to extensive flood damages. Therefore, the CPP should test and verify possibilities

- to contain temporarily such excess flood water from local BRE-breaches in water management units (subcompartments)
- to prevent flood water from major BRE-breaches in upstream sections from entering the CPP areas, or contain water from upstream breaches in the upper CPP subcompartments.

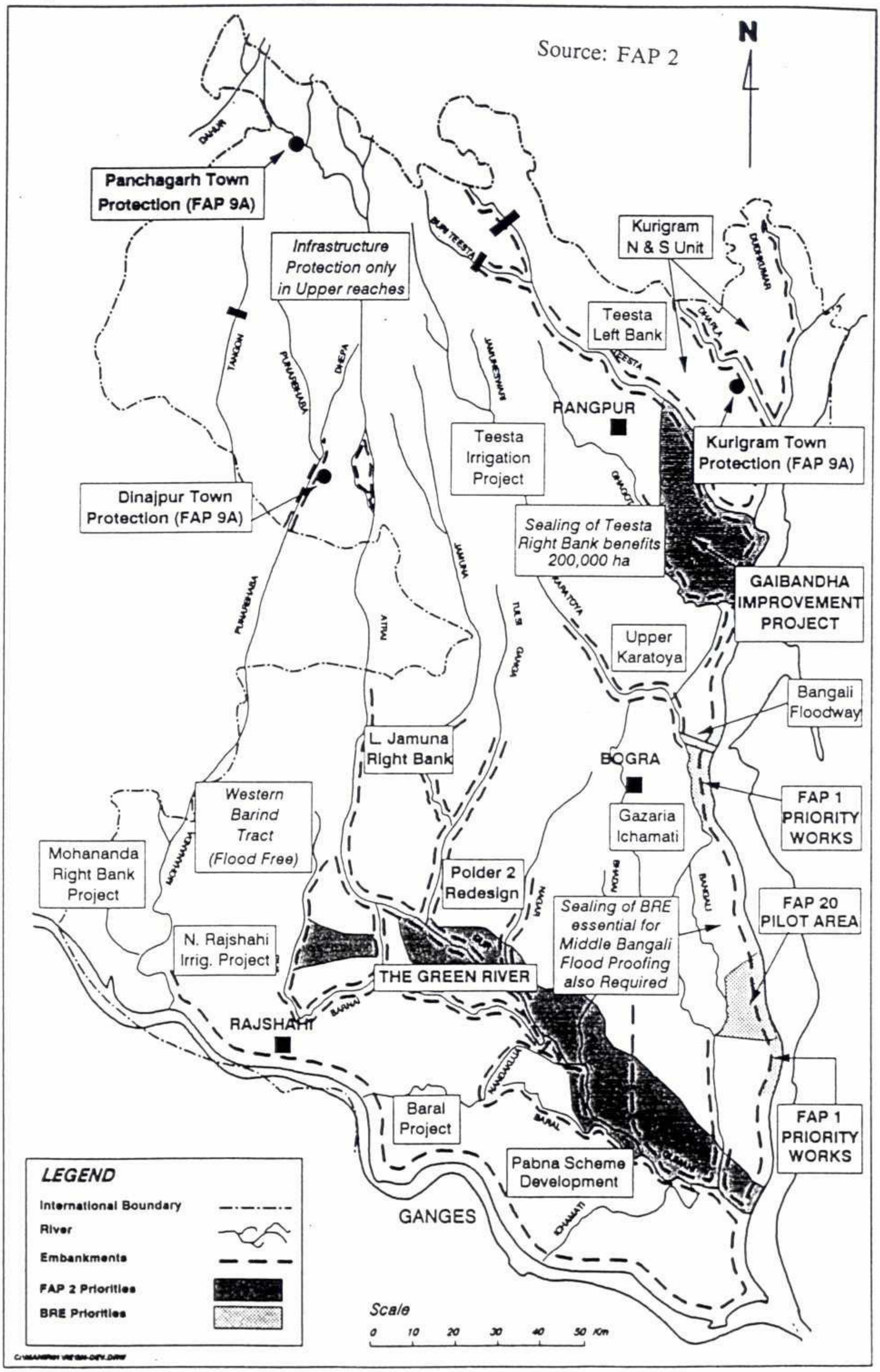
However the following flood and drainage control measures are the major subject of the CPP:

- internal floodwater management caused by early, high or prolonged floods from the adjacent Ichamati River
- internal water management of floods caused by high local rainfall.

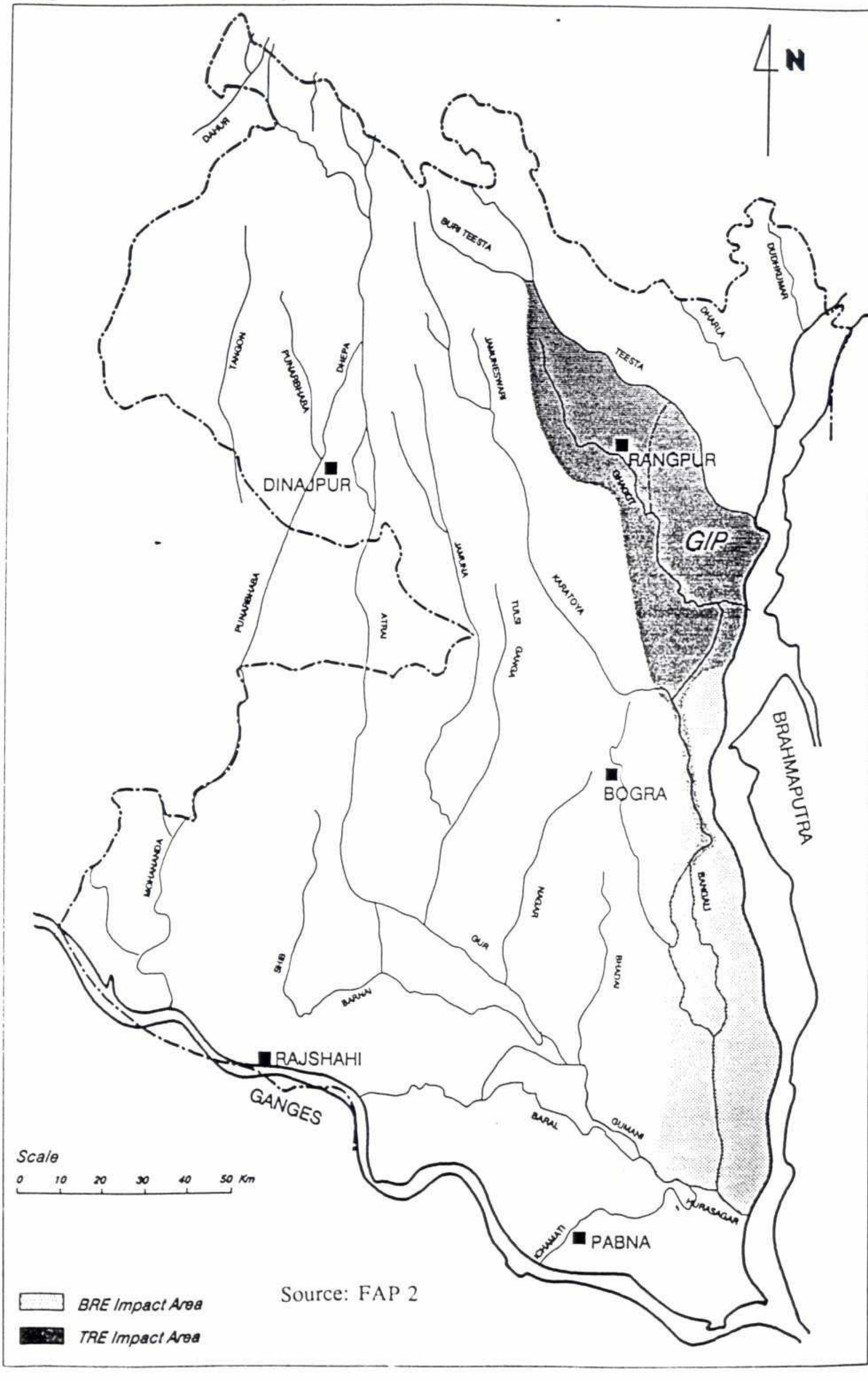
Compartment water management is defined as the controlled flooding and drainage for the multiple usage of water, including objectives for agriculture and irrigation, capture and culture fisheries, road and water based transport, sanitation and domestic/urban purposes. In addition, subcompartments should temporarily contain floodwater from BRE breaches in emergency cases in order to reduce damage.

Controlled flooding would allow natural flooding of floodplains to occur without causing damage to crops, fisheries, infrastructure and rural/urban properties. Within flood protected compartments, intake regulators and drainage sluices will be managed to control the timing, depth and duration of flooding on the land during the rainy season within limits that ensure growing conditions for the major crops (FAP 2.1992).

Map 2.3: North West Regional Water Development Plan

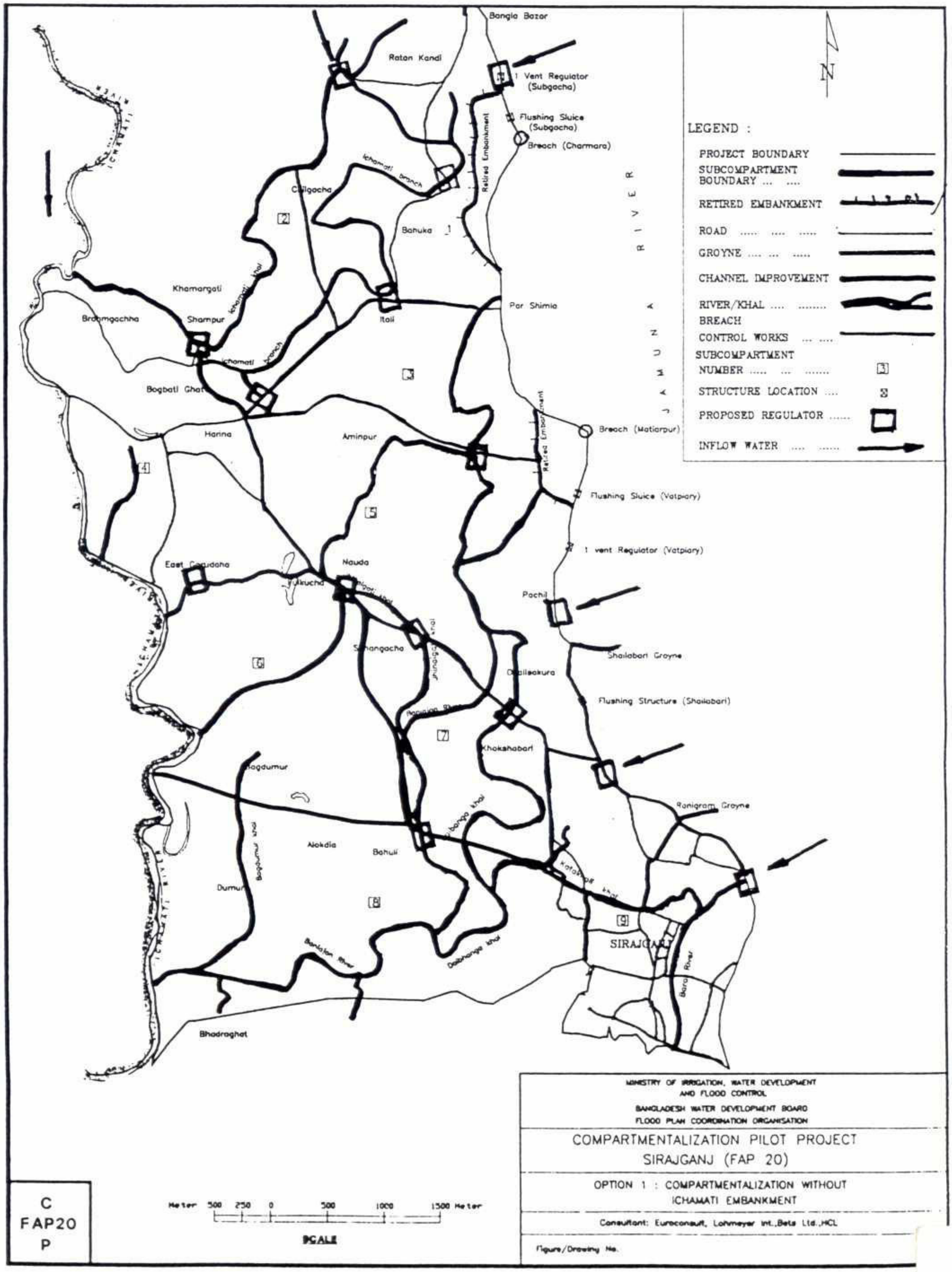


Map 2.4: Indicative Impact Area from BRE and TRE



Source: FAP 2

Map 2.5: Proposed Structures for Option 1 of CPP Sirajganj



Specific CPP engineering measures

Option 1: BRE, drainage, inlet, retention and internal water management.

The following measures are recommended: (see detailed description in the Main Report). Map 2.5 shows the location and type of proposed structures. Further technical details are given in the Annex Engineering. Design criteria have been formulated by CPP and designs of the BWDB Design Office are used.

Option 2A: River flood protection (Ichamati River), drainage, retention and internal water management.

The measures are shown on Map 2.6. The alignment of the Ichamati embankment follows existing roads and other infrastructure. Detailed engineering description are provided in the Main Report.

Option 2B: River flood protection (Ichamati River), drainage, retention and internal water management.

Map 2.7 indicates the location and type of structures. Same as option 2A, but the alignment of the Ichamati embankment will follow the river course.

Construction Phase. As for CPP Tangail, a phased implementation is planned for CPP Sirajganj which provides opportunities for technical modifications and mitigating measures at any stage of the project. The schedules for implementation will be outlined at a later stage.

Operational Phase. The efficiency of controlled flooding will depend on appropriate operation and maintenance of the hydraulic infrastructure. Institutional development and the active participation of local people will be important components of the project (see relevant CPP studies). The CPP aims to develop standards and regulations for operation of water control works which meet the multipurpose criteria of compartment water management:

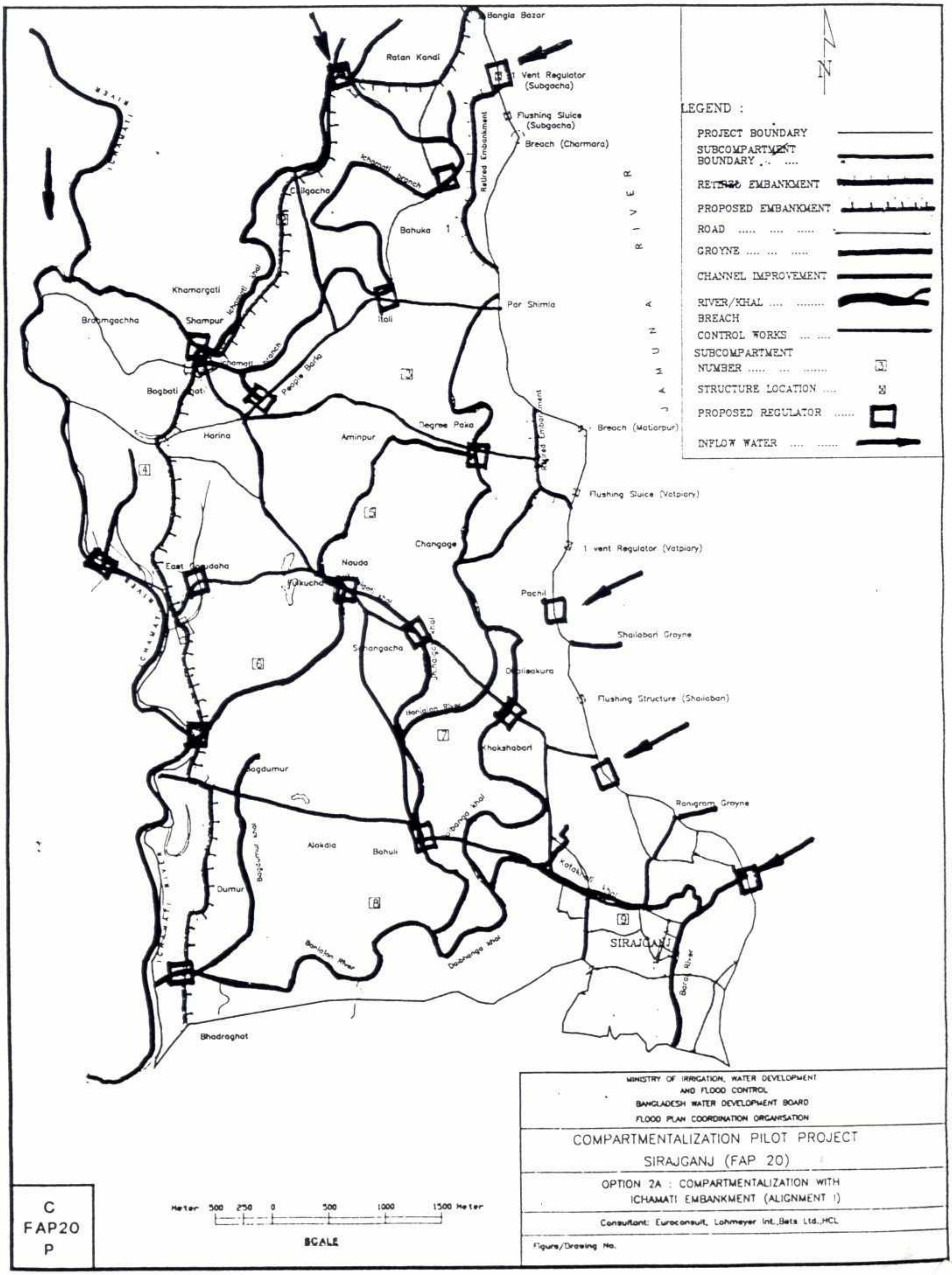
- agricultural targets: flooding of croplands at appropriate times and for adequate length to allow maximum production of a diverse range of crops; reduce risks of flood damages to irrigation infrastructure
- fisheries targets: enhance wetland habitats in beels and khals and thereby secure capture fisheries; promote pond or aquaculture fisheries through controlled flooding

It is proposed to amend these production oriented targets by a set of targets aiming at environmentally sound development (propsals in Chapter 7).

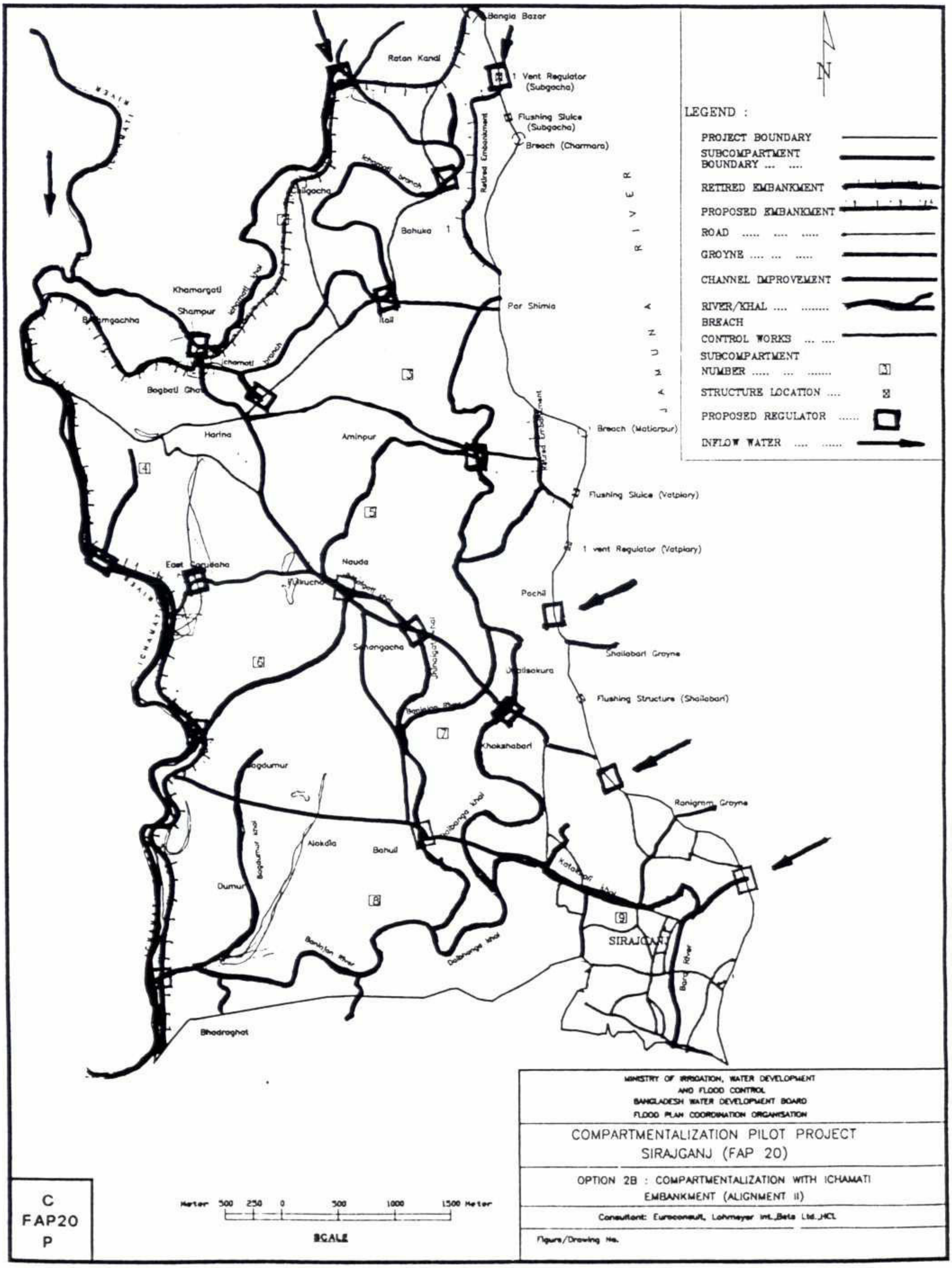
Associated measures are considered to improve drainage conditions in Sirajganj town:

- excavating of the Katakhali khal to improve sanitation/health standards and to reduce flood hazard
- flushing options to reduce health risks associated with polluted water.

Map 2.6: Proposed Structures for Option 2A of CPP Sirajganj



Map 2.7: Proposed Structures for Option 2B of CPP Sirajganj



These measures are not yet specified and should be part of special studies for Sirajganj town (see Chapter 8).

2.3 Public Participation in the CPP

The CPP approach is focused on people's participation and scoping of public opinion. There are various levels of people's participation:

- household survey which aims at obtaining socio-economic data on a wide range of issues of the target population
- needs assessment analysis identifies people's perceptions on flood-related problems and proposals for solutions. These local opinions are used by experts to formulate alternative project options. Environmental perceptions of the people in the CPP area are summarized in Section 5.1.
- peoples consultation process aims at taking these options back to the people for further discussion before finalization of the project plan
- development of an institutional framework for water management operations: water user groups at the field level, water management committees at the subcompartment level and one water management council at the compartment level
- planning of mitigating measures which eventually will lead to grass-root oriented development programmes in collaboration with other implementing agencies or departments (eg. BWDB, Departments of Agriculture, Livestock, Fisheries, Forestry, Environment, Health, Education) and relevant NGO's.

CPP aims at continuous efforts to involve local people in planning, implementation and operation and maintenance of physical infrastructure for water management. CPP adopts a 'bottom up' approach which is in line with the GOB Fourth Five Year Plan and planning for multipurpose projects including FAP.

3 DESCRIPTION OF FRAMEWORK CONDITIONS FOR DEVELOPMENT

This Chapter analyses the socio-economic and institutional framework conditions and the external and internal driving forces that are likely to affect sustainable development in the CPP Sirajganj area.

3.1 Population

Regional Setting. The Northwest Region has a population of over 25 M people in an area of about 35,000 km2 (1991 unadjusted census). The majority of 85% of the population lives in villages, although the region has 25 urban municipalities. The importance of urban centres is growing as outmigration from rural areas increases. The rate of growth in the country is starting to decline, but a population increase of about 50% is forecast over the next 20 years. In the District of Sirajganj, the growth rate was about 2.6% during the period 1961 to 1981. The growth rate in the Sirajganj Thana increased from 2.4 to 3.0% due to town migration from rural areas. Other urban Thanas had higher increases up to 7%, such as Pabna, Ishwardi, Chatmohor and Shahjadpur (FAP 2.1992.1 and 4; UDD 1991). For Sirajganj town (Pourashava), the following population figures are available:

1961	38,000	Source: UDD 1991:76
1974	69,000	Source: UDD 1991:76
1981	106,000	Source: UDD 1991:77 (census 1981)
1992	128,000	Source: Pourashava Sirajganj
2001	297,000	Source: UDD prediction 1991:77

Population and other key indicators for the Northwest Region and the CPP are given in Table 3.1.

Table 3.1: Population and Other Key Indicators for NWR and CPP

	NW-Region	Sirajgang Dist.	CPP area
Area (km2)	35,592	2,455	12,057 ha
Households	4.9 M	412,000	46,000
Population	25.4 M	2.35 M	292,000 (town 132,000)
Hh Size	5.17	5.55	5.60
Literacy rate	20%	18	
Sex (M/F)	105	105	
Density P/km2	757	957	2,422

Sources: NW-Region from FAP 2.1992.1:1-2; CPP from household survey data or estimates May 1993

3.2 People and Lifestyles in the Area

Economic Activities

The majority of people live in rural households, although the situation in the CPP is influenced by the vicinity of the town of Siragjanj. Agriculture (including fishery and homestead forestry) is the main source of employment and income generation for the majority of 70% of the people (UDD 1991).

Agriculture. The CPP area has a very high cropping intensity of about 184 % and paddy is the basic staple crop. In the CPP area, however, other crops than rice also play an important role such as sugarcane, pulses, oilseeds, jute, vegetables and spices (in descending order). Average farm size has been declining over the past years and the number of landless households is increasing.

The cropping pattern is largely dictated by flooding, soil drainage and moisture storage capacity. Irrigation facilities and improved access to local and regional markets are important factors which affect choice of cropping. Irrigated dry season paddy is becoming increasingly important (see Section 4.4.2 and Annex 4: Agriculture for details).

Fish supplies an estimated 60-80% of the animal protein intake in the diet in Bangladesh. Fresh water fish are preferred, and the inland waters provide 80% of the annual harvest. Capture fishery is practised in rivers (Ichamati, Jamuna), beels and seasonal floodplains; culture fisheries is related to ponds. Most of the capture fisheries is based on the river floodplains, however, the yields have decreased over the past years and this is generally attributed to the construction of the BRE, sedimentation in many beels and the encroachment of paddy into seaonal wetlands. This limits the available area of beels and floodplains and restrict fish migratory paths. Also overfishing is an increasing problem because fishermen want to maintain their yields from resources which already have been weakened (FAP 2.1992.14). In the area of Sirajganj, floodplain fisheries followed the regional trend of decline. Some decades before, capture fisheries was well developed in the region. But it started to decline significantly after the construction of the BRE (see Annex 5 Fisheries).

Homesteads. Food and income supply from homestead gardening and products from homestead plantations still play a vital role in rural villages and is especially important for the poor families. Typically, they are common goods which are accessible to all villagers and they provide food, fodder, fuel, timber and medicinal plants.

Industry. The contribution of the industrial sector to gross district income was 6% in 1983. The most important sectors in the greater Pabna Region (Districts of Sirajganj and Pabna) are shown in Table 3.2.

Table 3.2: Industry in the Region and in Sirajganj

	Greater Region	Sirajganj
- cotton textile	2.1 M yards	40 % of total
- jute industry	13,013 t/a	100 % of total
- engineering produces	10 numbers	30 % of total
- chemicals	10 numbers	40 % of total
- food industry	8 numbers	38 % of total

Source: UDD 1991 from BBS 1991

The cottage industry contributed to more than 50 % of the total value, and the weaving industry is predominant, with thousands of handlooms in urban and rural areas. In 1990, there were about 13,500 handloom establishments in the District of Sirajganj (ie. 38% of the Rajshahi Division and 6% of the national total (BBS 1992). In 1982, handloom industry provided about 60% of the total regional industrial employment. Some 2,800 persons were employed in handloom establishments in 1982, almost 2/3 of them were family members (UDD 1991).

The brick industry is another important commercial sector with about 10 brickfields in the CPP area. Brick- fields are exploited next to regional roads in order to guarantee easy access to villages and Sirajganj town.

Communication and Infrastructure

Potable water and sanitation have improved considerably in recent years. Efforts were made to ensure rural urban and water supply through sinking of tubewells. Nevertheless, standards are still very low and there is still a large number of households which have no permanent access to safe potable water. Primary sanitation facilities consist of latrines. Waterseal latrines are being promoted by the Department of Public Health Engineering. Presently, only a marginal number of urban households possess a sanitary latrine and in rural areas they are virtually absent (further details in Section 4.7).

Trade is distributed fairly even throughout the district of Sirajganj and the CPP area. There are five bazars at Sirajganj and about 41 local market places (hats) in the Sirajganj Thana (17% of the total Sirajganj District). Most important are the bazars of Sirajganj, Kalibari, Khalta, Gopinathpur and Kayalganty (UDD 1991).

Road Infrastructure. There is a good network of regional and local roads in the region. The Siragjanj town is one of the major inland river ports of Bangladesh. It is connected with the North-West region by rail, branching off at Ishwardi. A highway links it with the north-south highway from Bogra to Pabna. Primary and rural roads connect the town with almost all rural villages (see Table 3.3). Compared with other areas in the region, the status of road density and services in the Sirajganj Thana is low, although the situation has improved over the past decade.

Table 3.3: Regional Status of Roads and Traffic Services

	Pabna Region	Sirajganj District	Sirajganj Town
year	1982	1982	1989
Pucca roads	411	218	16
Semi-pucca roads	338	155	11
Katcha roads	3,422	1.570	35
buses	322	34	1 #R
trucks	418	49	59 #R
auto-rickshaws	111	2	13 #R
rickshaws	7680	3049	963 #R

Sources: UDD 1991 for data 1982; survey by FAP 20.1993;
#R registered at Sirajganj in 1989; roads in km, otherwise numbers are given

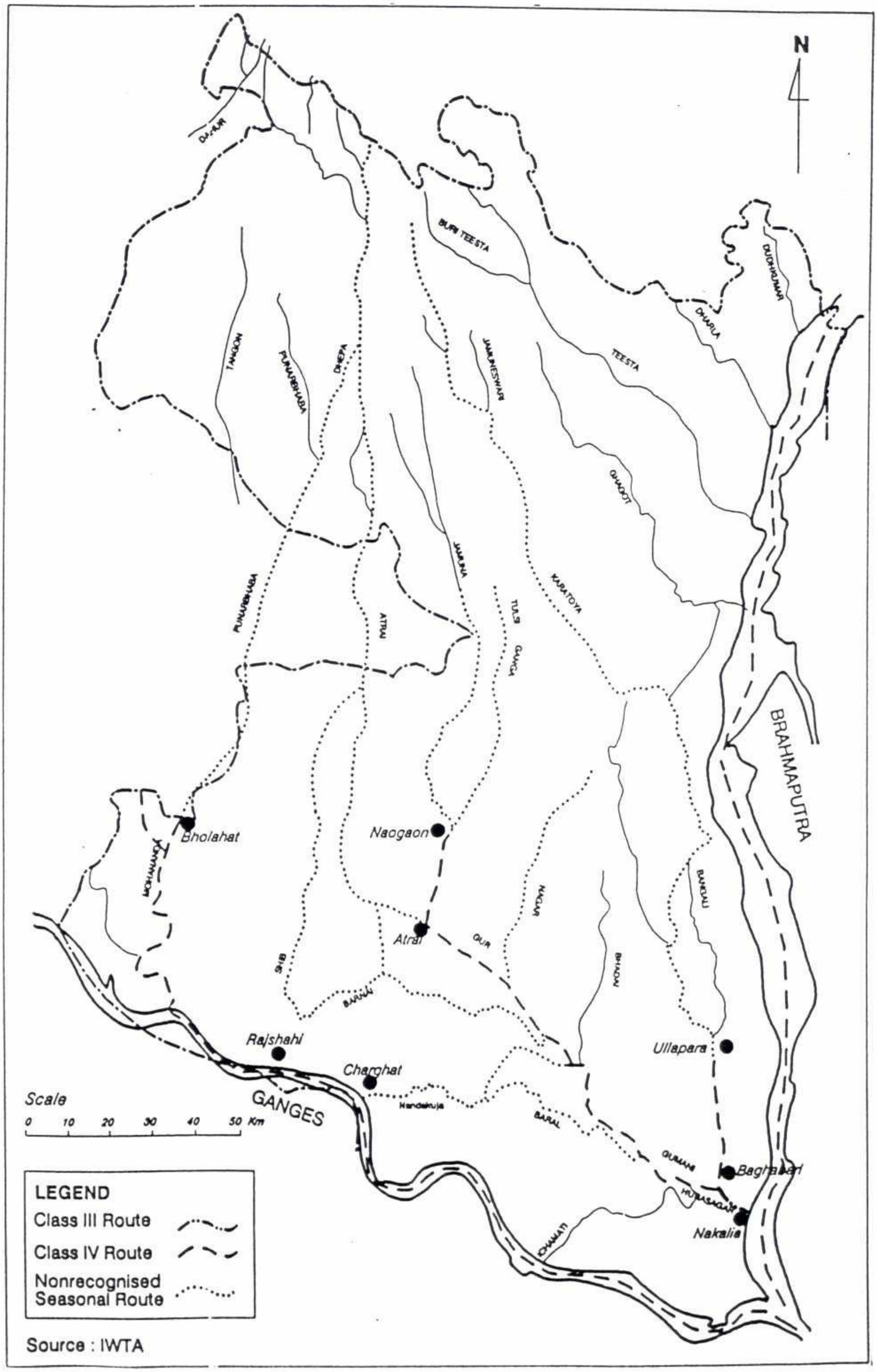
Navigation. Sirajganj plays an important role as a river port which provides facilities for passenger freight and bulk cargo across the Jamuna River. In total, 2,571 boats were registered at Sirajganj District in 1981 with a carrying capacity of some 330,000 maunds (about 13,000 t). This figure includes country boats which are however only used during the flood season (UDD 1991).

The Ichamati River is classified as seasonal feeder route (class 4) and country boats make an important contribution to the informal rural sector economy of the region (FAP 2.1992.2). Perennial boat operations are reported during the pre-BRE period. However, environmental changes in the rivers's network created operational problems and nowadays, water transport is only important during the flooding season. Infrastructure (road crossing) obstruct navigation routes in rivers and major khals. Recently, sedimentation reduced the navigability in many Ichamati River sections and especially BRE breaches contributed to the filling up with Jamuna River sands.

Specific country boat numbers for the Ichamati River were not available from the Inland Water Transport Authority (IWTA) which administers navigation and water transport. Important regional navigation routes are shown in Map 3.1.

The CPP area is of minor importance for seasonal local khal navigation. The khals are classified as "unrecognized routes". Formerly, non-routed short distance navigation in the floodplains and khals made an effective navigation system for the country boats connecting villages, village markets and bazars/hats during the rainy season. The importance of seasonal navigation declined after the construction of the BRE and the disruption of the seasonal flooding regime. Also boat access between the Jamuna River and the Ichamati River or local villages discontinued. Recently, roads connect most villages, although navigation still plays an important role in seasonal khal opeations during the mid monsoon period. Small fishing boat operations are restricted by embankment roads and inadequate numbers of bridges.

Map 3.1: North West Regional Navigation Routes



Electricity and Energy Use. The district is linked to the national power line. The number of electrified villages in the Sirajganj Thana increased over the past decade from 2 in the year 1982 to 101 in 1992. The rural power grid mainly serves irrigation infrastructure. In 1989, about 70% of the urban housholds in Sirajganj town were supplied with electricity (UDD 1991).

Most urban household use firewood for cooking. Some 60% of the households spent in the range of 150 to 250 Taka per month for fuel (average household income totals about 2000 Taka; survey in 1989. UDD 1991):

-	firewood	90 % of urban households
-	kerosin	3 %
-	electricity	4 %
-	gas (containers)	1 %
-	others	2 %.

Health and Educational Services. Sirajganj town plays an important role in the provision of health and educational services to both urban and rural population. Health sevices include the Sadar General Hospital, T.B. and Leprosy Clinic, Eye Hospital, Child and Maternity Hospital. Rural areas are provided with Helath Centres and Union Health Subcentres (see also Section 4.5.1). Educational services include 17 primary, 10 high and 3 degree colleges.

Living Standard. The rural villagers are poor and the economic standard of living is inadequate in the national context, although serious signs of starvation are rare. Development strategies must address such poverty by increasing productivity, creating and maintaining generating activities, and enhancing community facilities such as water supply, health facilities, housing and communication, etc.

3.3 The Driving Environmental Forces

There are several major driving forces that are likely to affect environment over the next decades. Pressure on rural land and on fragile eco-systems are of major environmental concern. While agricultural production has been increasing over time, it has not kept pace with population increases. As land becomes scarcer, farming is practised in a fragile floodplain ecosystem.

- Land carrying capacity. In 1993, the total population in Sirajganj CPP is estimated at 292,000, of which 132,000 are in the town. The per person available cultivable land is now about 0.06 ha (rural population) and 0.03 ha (rural plus urban population). The corresponding population densities are 1,672 people (rural) and 3,051 people (rural + urban) per net cultivable area (in km^2).
- The production potential of land changed over time. Large increases in rice production have resulted in recent years from wetland conversions to cropland and from agricultural technology changes. While land conversion to cropland is now almost completed in the CPP area and more land will be needed for urbanisation and rural settlements in the nearest future, opportunities for further production increases must come from technology improvements.

- Homestead plantantion degradation. While deforestation is virtually complete in the CPP area, there are still some homestead plantations which serve as a refuge for important fauna and flora species. These are increasingly diminished by further encroachments of rural settlements
- Permanent wetlands are virtually extinct in the Sirajganj CPP and FCD works will contribute to further wetland transformations, unless mitigation measures are implemented. Seasonal wetlands are becoming increasingly encroached upon and drained by FCD works to support crop production.
- Although it would be unrealistic to demand for large scale wetland conservation within the CPP, efforts must aim to preserve a few remaining habitats and to enhance faunal and floral diversity on key sites. Large scale wetland conservation should be initiated at the regional level.
- Modern farming systems and cultivation practices put considerable risk on biological balances and soil fertility.
- Local resources of biomass are the only source for fuel and building materials; the are becoming increasingly short for soil fertility management, fodder and other consumption purposes.
- Landlessness is a major characteristic of rural areas which is exacerbated in the CPP area by BRE-breaches and land losses to the Jamuna River. Many people are forced to establish their houses on flood control embankments which, in turn, intitiates an important structure failure meachnism.

3.4 Legal and Institutional Framework

3.4.1 Administrative Setting

The CPP Sirajganj is in the District of Sirajganj which is a part of the former District of Pabna. The Sirajganj District lies in the southeastern parts of the Northwest Region (NWR), along the Jamuna floodplains. The Northwest Regional Plan divided the region into various planning units (FAP 2.1992.1). Sirajganj is in the Planning Region 8, the Middle Bangali (see Map 2.1).

The Pourashava of Sirajganj is a sub-district town of the Sirajganj District. Sirajganj is classified as one of the important secondary towns of Bangladesh and as such it has a primary role to absorb and accomodate an increasing number of out-migrants from rural areas. The District has nine Thanas under its jurisdiction. It can be expected that the regional importance of the town will increase after the construction of the Jamuna Bridge just south of Sirajganj.

3.4.2 Regional Water Development Plan

The CPP is one of the 26 components of the Flood Action Plan and lies within the Northwest Region development activities (FAP 2.1992.1). The proposed regional activities are aimed at (see Map 2.3)

- sealing of the BRE (FAP 1 Priority Works) and flood proofing to reduce damages from breaches through the BRE. Developments behind the BRE (ie. compartments) related to the "second line of defence" should await the result of the CPP Siragjanj.
- implementation of the Green River strategy in the Lower Atrai, to provide partial protection close to the river and full FCD facilities in upland areas.
- development of the Teesta Right Bank, initially in association with the Gaibandha Improvement Project
- flood proofing and protection of towns and other infrastructure in the upstream reaches
- other schemes show lower returns but could be considered for development in the long-term.

The FAP 2 studies suggest that the environmental impacts are generally negative but not of over-riding importance. In case of sealing the major embankments, social impacts are entirely positive. However, long-term morphological impacts in the main rivers need to be studied.

The Regional Plan also proposes associated developments which includes:

- programmes to mitigate capture fisheries losses
- programmes for the development of navigation facilities
- programmes to mitigate adverse impacts on health status
- programmes of flood proofing, particularly behind the BRE, on the unprotected lands in the main rivers (charlands) and in the upper reaches where major CFD interventions are not mentioned.

Important issues remain to be addressed, such as the integration of various development plans, the balance between public and private involvement in implementation and the need for public participation, problems of standards of construction, and the problems of effective operation and maintenance of completed facilities. The environmental impacts are in detail assessed in terms of geomorphology, access to and quality of water, soil quality, biological resources as well as economic and social impacts and public health and nutrition (see FAP 2. 1992.1:Chapter 7 and in detail in FAP 2.1992.4).

3.4.3 Environmental Policy and Programmes

The national environmental policy is managed by the Ministry of Environment and Forestry (MOEF). The Department of Environment (DOE) acts as the implementing and enforcement agency. A National Conservation Strategy (NCS 1992) has been drawn up with assistance from the World Conservation Union (IUCN) and its final approval by the DOE is in process. Background papers were prepared by local specialists (IUCN 1990). However, the aims of the NCS can only be regarded as a statement of intent until sufficient legislative and enforcement controls have been introduced and sufficient basic financial and trained manpower resources are made available (FAP 2.1992.4).

In May 1992 the first official Environmental Policy was adopted by the GOB. This has introduced a new responsibility for work under FAP. The most important objectives which directly affect the planning for CPP are:

- remove the adverse environmental effects of previous water resources management and flood control projects
- adopt and extend environmentally and ecologically sound land use practices and conserve soil fertility
- maintain ecological balance, conserve wildlife and biodiversity and conserve and develop the national wetlands and the migratory bird sanctuaries
- protect, conserve and develop fish habitats
- re-evaluate FCD/I project known to cause adverse effects on fisheries. (after FAP 2.1992.4:1-2).

4 ENVIRONMENTAL PROFILE OF THE CPP-AREA SIRAJGANJ

This Chapter describes the natural resource base, the uses of such resources and other environmental issues of concern such as public health. It also describes the situation in the CPP Sirajganj in the context of regional and national settings and development trends. The data for CPP Sirajganj will be amended and up-dated for the final EIA-report, using information from special environmental surveys and monitoring (see Chapter 8).

4.1 Water Resources

4.1.1 Outline

The CPP area is a part of the Bangali floodplains along the River Jamuna. Before the construction of the Brahmaputra Right Embankment (BRE), the floodplain received floodwater during the monsoon season from the Jamuna River in the east and the Ichamati River in the west. Floods varied considerably in timing, length and depths from one year to the next, also depending on local rainfall. Although high floods had the capability to destroy some croplands, disastrous floods to human life and croplands were rare (FAP 12.1991).

The BRE changed the floodplain and wetland ecosystem of the CPP area. Since 1963, floodwater from the Jamuna entered in the CPP area only through four far too small sluices (one in operation in 1993) or during breaches, which occurred since 1984 in 3 out of 5 years in the river sections from Sirajganj to Kazipur (FAP 12.1991).

River bank erosion in the CPP areas occurs at some stretches along the Ichamati River and along most northern sections at the Jamuna River.

Hydrological Balance. Detailed and local information of floodwater volumes are not available. Impeded flood drainage (from local rainfall) causes frequent waterlogging and may hamper crop growth at some sites. The extent of flood damages from the Ichamati River is not yet assessed, as well as times and return periods of hazardous waterlogging. Most natural channels are silted up which contributes to impeded drainage.

Groundwater. The groundwater resources are increasingly used for domestic uses and irrigation. The water quality regarding microbiological criteria is in a desparate state and causes widespread health hazards, especially during the flood season.

Trends. Hydrological models show that the availability of groundwater is sufficient for future irrigation developments (FAP 2. 1992.10). However, local data indicate already a slight drawdown of the water table. Beneficial effects from the Jamuna River flood on the floodplain's ecosystem are further declining unless mitigating measures are implemented.

4.1.2 River Regimes and Morphology

Regional Setting. Flooding dictates the land use pattern in the CPP which is a part of the Lower Bangali floodplain adjacent to the Jamuna River. Under natural hydrological regimes, the floodplains receive floodwater from the main rivers during the monsoon season (June to October). The start, depth and retreat of the flood varies from place to place and from year to year and depends on the land elevation, local rainfalls and the intensity of river flood.

The main rivers and their tributaries in the Northwest Region are shown on Map 4.1. The peak water level in the Jamuna river and some related hydrological data are shown in the Appendix 4, Hydrology. The maximum range of peak levels at Sirajganj was just within some 1.6 m range: in 1988 the peak was at 15.11 m and in 1976 the peak was at 13.46m. The average peak water level is at 13.99 m. A detailed discussion of hydrological and engineering aspects regarding floods are given in Annexes 2 and 3 of this Report.

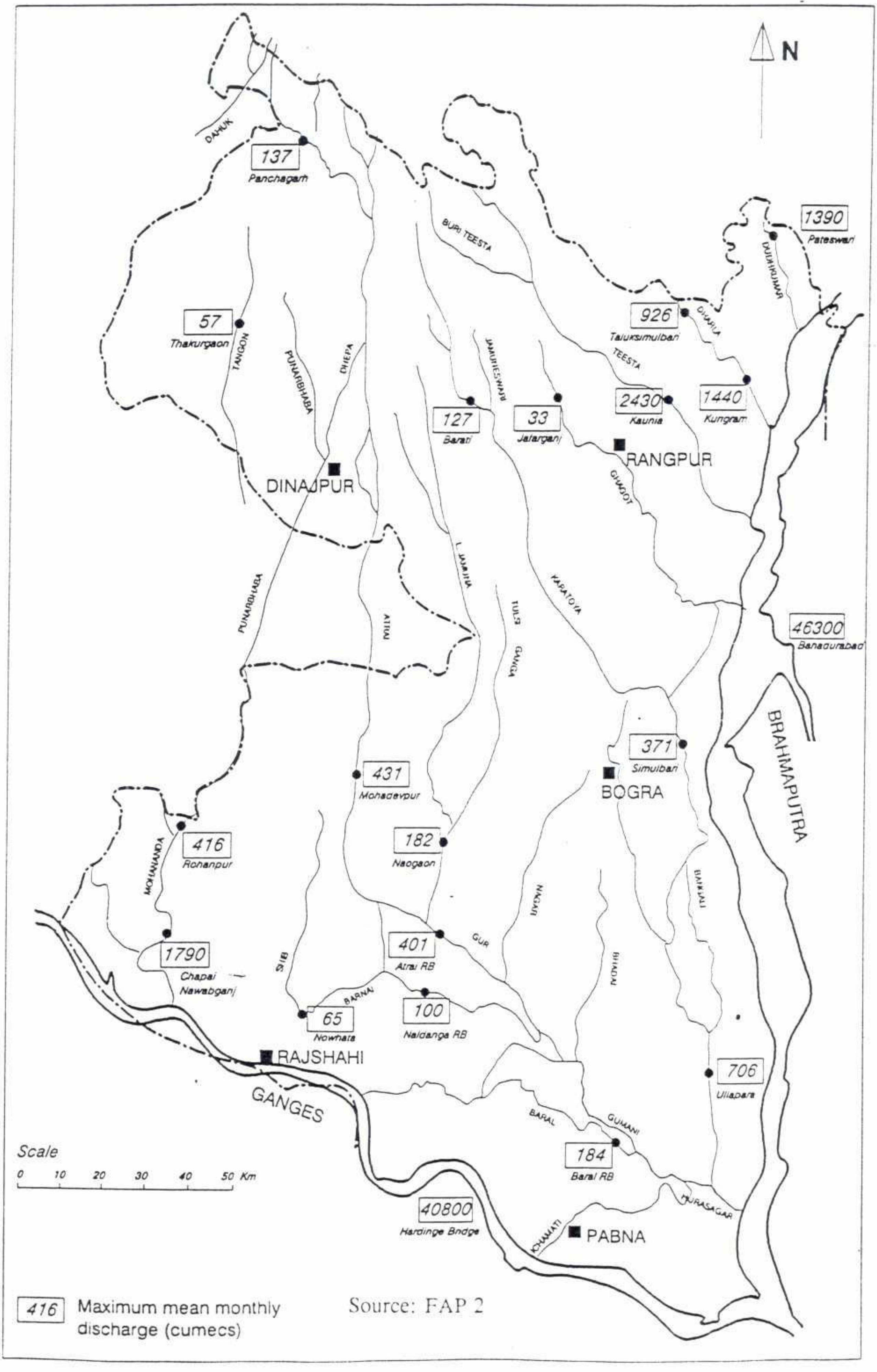
Jamuna Floods. Before the construction of the Brahmaputra Right Embankment (BRE), the Jamuna River was the major contributor to flooding in the Bangali floodplain (including CPP), and since 1984 she has also been at times of breaches of the embankments. Prior to the BRE, the Jamuna River over-flowed the bank and gradually flooded a large proportion of the area in almost every year. About 88% of land was flooded in the Kazipur reach, just north of the CPP area. The floodwater came in early July and gradually receded in late September to early October. Paddy and Jute crops in the low-land were submerged and suffered damage. Sometimes the extent of crop damage was 60%, especially close to the river (FAP 12.1991).

Currently, breaches have disastrous local effects, depending on the flood level in the river, the breach length and the river catchment behind the embankment (see 4.1.4).

River Network. The regional river network is a highly complex riverine floodplain system. The hydrological regime of the floodplain is dynamic, unstable and evolving. This is mainly caused by:

- erratic rainfall of very high intensities over the upper catchment outside and inside Bangladesh; 10- day totals of 700 mm are not uncommon even in Bangladesh catchments in the Upper Northwest Region
- temporary storage capacities (for redundant runoff) in upper catchment basins, rivers and floodplains are limited and runoff coefficients in upper catchments are often high; if high local rainfall coincides with high water levels in rivers, severe floods on the main rivers and adjacent floodplains are common
- human made obstructions to the natural flow in downstream reaches may further reduce channel discharge capacity; this, in turn, increases flood risks in upstream river sections
- human-made modifications at upstream reaches may increase downstream discharge and flow velocities
- high sediment loads especially during the peak flow season
- very flat gradients (1 in 5000 or less) of the major rivers.

Map 4.1: The River System in the North West Region



Source: FAP 2

These factors partly explain that many rivers are heavily meandering and have limited capacity for passing flood discharges. The braided rivers tend continuously to change their morphology and tend to flood considerable areas behind the river banks. The power of these hydrological processes place considerable limit on sustainable water development based on fixed structures.

As a result, flood damages to infrastructure, settlements and agricultural land tend to be higher in areas behind human-made embankments if breaches occur. Also, structural stability and proper functioning of regulating structures tend to be low, if such headwork structures need to be placed at a main embankment.

4.1.3 The Floodplain of the CPP

The major water bodies within the CPP area are the Ichamati branch river, Baniajan river, Ichamati khal, Daibhanga kahl, Katakhali khal, Kokshabari beel, Fulkucha beel, Bagbati beel and ponds. Locations of the waterbodies are shown in Map 4.2. The total area is about 266 ha, however there is a trend of decline and most waterbodies are becoming seasonally dry. In the dry season 1992/1993, all khals and even the Ichamati River fell dry in many sections. Permanent beels covered less than 55 ha.

4.1.4 Flood Risks and Damages in the CPP area

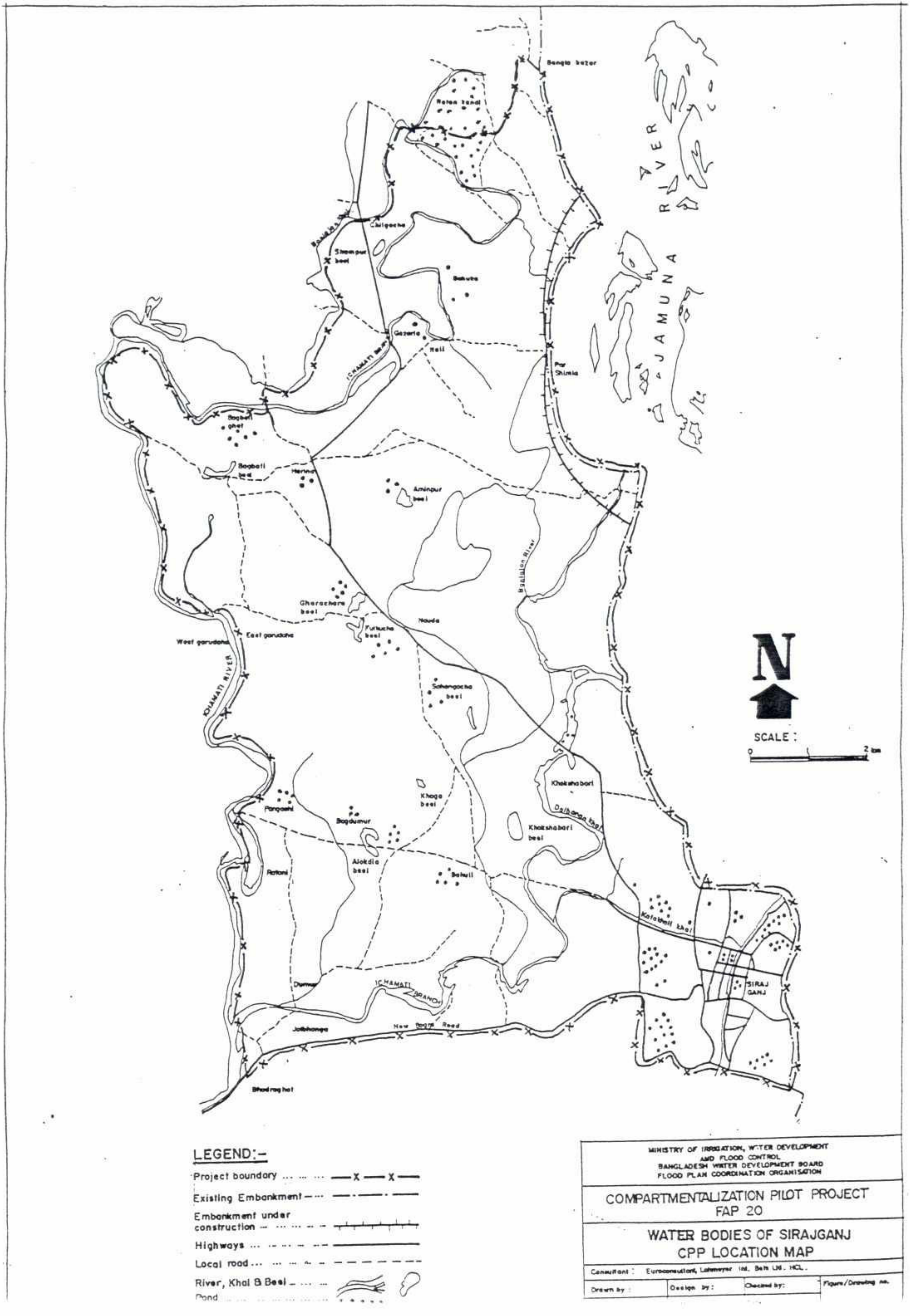
Flooding and drainage problems in the area may be separated into three categories depending on their cause and location:

1 areas flooded by <u>major river spills</u> during the monsoon period from June to September; this is due to breaches in the BRE of the Jamuna River. Flood damage is not related to the severity of the flood event because accidental breaches can occur with normal as well as extreme floods. Regular flooding through sluices in the BRE can be beneficial if sluices are properly operated. However, existing undershut sluices are far too small, the sill level is above the mean flood season water level and some sluices are out of operation.
Remedial action: sealing and maintenance of the BRE; river training; construction of sluices with adoption of new design criteria.

2 <u>monsoon flood of minor rivers</u>: in the CPP-area it is appropriate to differentiate between normal river monsoon flood and backflow or backwater effects of the Ichamati River; in many years these impacts can be interlinked. Overlappings between them are often critically influenced by the timing of the flood peaks on the rivers:

2a. The monsoon flood is a gradual increase in water level in the Ichamati River which is caused by storm runoff in the upper catchment. Heavy rainstorm may cause a flashflood in some years with one or more distinct peaks followed by a rapid recession. The rising water level in the Ichamati river causes either backflow through khals into the upstream micro- catchments of the floodplain or the flood spills over the river banks (overland flow).
<u>Remedial Action</u>: sluice gates at khal entrances, embankments along lowland stretches of the Ichamati River and improved drainage within CPP area to facilitate rapid flood recession.

Map 4.2: Locations of the Water Bodies in the CPP Area



2b. Backwater effect of minor rivers. This second type refers to outfall constraints at downstream sections of the Ichamati River, often caused by obstruct outflow from the Hurasagar to the Jamuna. High stages in the Jamuna may cause backing up of levels in the upstream river systems. Floods in the CPP area are due to reverse flow and prolonged high water levels in the Ichamati River. Flood recession in floodplain is only possible when the flood level in the Ichamati is receding (FAP 2.1992.10).

Remedial Action: Sluice gates at khal confluences to prevent unwanted backflow; improved land drainage within CPP to facilitate rapid flood recession when flood level in the Ichamati is receding. Otherwise, control options in the CPP area do not exist and regional measures would be appropriate.

3 Rainflood due to land drainage congestion. Heavy local rainfall may cause prolonged flooding if drainage is impeded. The flood problem in the CPP area may aggravate, if locally induced flooding coincides with high water levels in the Ichamati River. This kind of prolonged flood is related to drainage congestion, ie if natural or human-made obstructions in the rivers exist or rivers and khals are silted up. Also embankment road developments and other infrastructures in the area prevent the spontaneous overland flow, exacerbating the flooding condition and flood damages.

Remedial Action: improved drainage and increasing numbers of culverts in road embankments; proper planning of roads and flood proofing.

Flood Damage Assessment. Precise data on flood occurrences in the CPP areas are not yet available. Therefore, only a tentative and preliminary assessment of flood damages is given in Table 4.1.

Table 4.1: Tentative Assessment of Flood Damages in the CPP subcompartments (without BRE-breaches)

SC No	Type of Flood	Area Affected	Affected Month	Severity of Damage	Return Period
1	3,2b	139 ha	7-9	moderate	1:5
2	2a,b,3	330 ha	6-9	moderate	1:5
3	3,2a,b	220 ha	6-9	moderate	1:5
4	2a,b,3	639 ha	6-9	moderate	1:5
5	3,2b	547 ha	7-9	low	1:5
6	2b,3	636 ha	7-9	moderate	1:5
7	3,2b	151 ha	7-9	low	1:5
8	3,2a,b	564 ha	6-9	moderate	1:5
9	3,2a,b	25 ha	7-10	low	1:5

Source: CPP assessment. A 1:5 year flood is assumed;
figures of affected areas are those of F2-F3 land types (gross area)

BRE-breaches. The risk assessment of BRE-breaches is difficult because they may occur at any time, depending on various factors such as shifts of the main river course (bank erosion), flood height, rate of rise of the Jamuna River water and BRE- conditions. Breaches were frequent just north of the CPP, in the Kazipur reach (see Section 6.1). In this section of the BRE, breaches occurred in probably 3 out of 5 years since 1984 (FAP 12.1991). In some years, the northern sections of the CPP Sirajgang were also affected by overland flow from BRE-breaches. The following CPP subcompartments were - in descending order - seriously affected: SC 1 to 3 and 5. SC 7 was affected in 1988 (Khokshabari breach). Subcompartments 4, 6, 7 and 8 can be affected by BRE-breaches by overspills from the Ichamati River which is a natural drain of the BRE floodwater.

BRE-flood hazards are caused by damages to standing crops, soil erosion by floodwaves, river sand deposition and drainage congestion of the receding floodwaters. Damages to human live, livestock, buildings and infrastructure roads are frequent. Breaches are especially disastrous because they cause sudden rise in floodlevel and they carry sandy river sediments which may cover crops and fertile alluvial soils. The sediment load contributes to drainage congestion in khals and reduces river discharge capacity. The extent of breaches and damages for various years for the CPP area is tentatively assessed in Table 4.2.

Table 4.2: Preliminary Assessment of BRE-Flood Damages in the Sub-compartments

SC No	Type of Flood	Area Affected	Affected Month	Severity of Damage	Return Period
1	1	548 ha	7-9	v.high	1:2
2	1	554 ha	7-9	v.high	1:2
3	1	542 ha	7-9	v.high	1:2
4	1	1050 ha	7-9	moderate	1:3
5	1	1122 ha	7-9	moderate	1:5
6	1	636 ha	7-9	moderate	1:10
7	1	151 ha	7-9	high	1:10
8	1	564 ha	8-9	low	1:10
9	1	25 ha	8-9	unknown	1:10

Source: CPP assessment. Figures of affected areas are calculated for subcompartments 1 to 5 from F1+F2+F3 land types; otherwise F2+F3 land types are used.

4.1.5 Human Interference in the Past

Status. The hydrological cycle and flood pattern in the CPP Sirajganj area is already disrupted by human interferences. Most important in the region are numerous roads on embankments which disrupt drainage and worsened the impact of floods. Since 1963, the BRE embankment discontinued regular flooding from the Jamuna River. Secondary effects of these interferences are accelerated river erosion and floodplain drainage congestion, sedimentation of khals and siltation of beels.

History of Flood Control. Flood mitigation to protect physical infrastructure and cropland is practised since ancient times in the Bangladesh floodplains and so in the CPP Sirajganj area. Hence, flood and drainage patterns are already significantly affected by the existence of human-made structures, particularly road and river embankments of varying heights incorporating hydraulic structures such as bridges, culverts, sluices etc. Usually, far too few and too narrow structures had been built to re-establish the normal flood and drainage pattern. Map 4.3 shows the already existing "compartmentalization" of the CPP project area.

There is a long history of construction of flood embankments in the area and these are kept at various degrees of maintenance. These structures and the virtual total landscaping by terracing of paddy fields throughout the region created a water and land management system pre- existing in its own right, irrespective of any further flood control projects.

The Brammahputra Right Embankment (BRE). The most important element of the existing FCD infrastructure is the BRE along the Jamuna River (Map 2.3). The construction of a 225 km long embankment started in 1963. The goal was to protect some 240,000 ha of cropland from the Jamuna River floods, causing damage to B.Aus, B.Aman and Jute (FAP 12.1991). Major rehabilitation was carried out from 1975 onwards, including some embankment retirements. The attempt to stop disastrous floods is only partly achieved. Since the embankment was erected, the Jamuna River continued to shift its main course towards the west and considerable stretches of fertile croplands are lost since the late 1960s, eg. the river shifted some 6 km to the west. Actually, many sections of the river bank along the CPP project are prone to bank erosion.

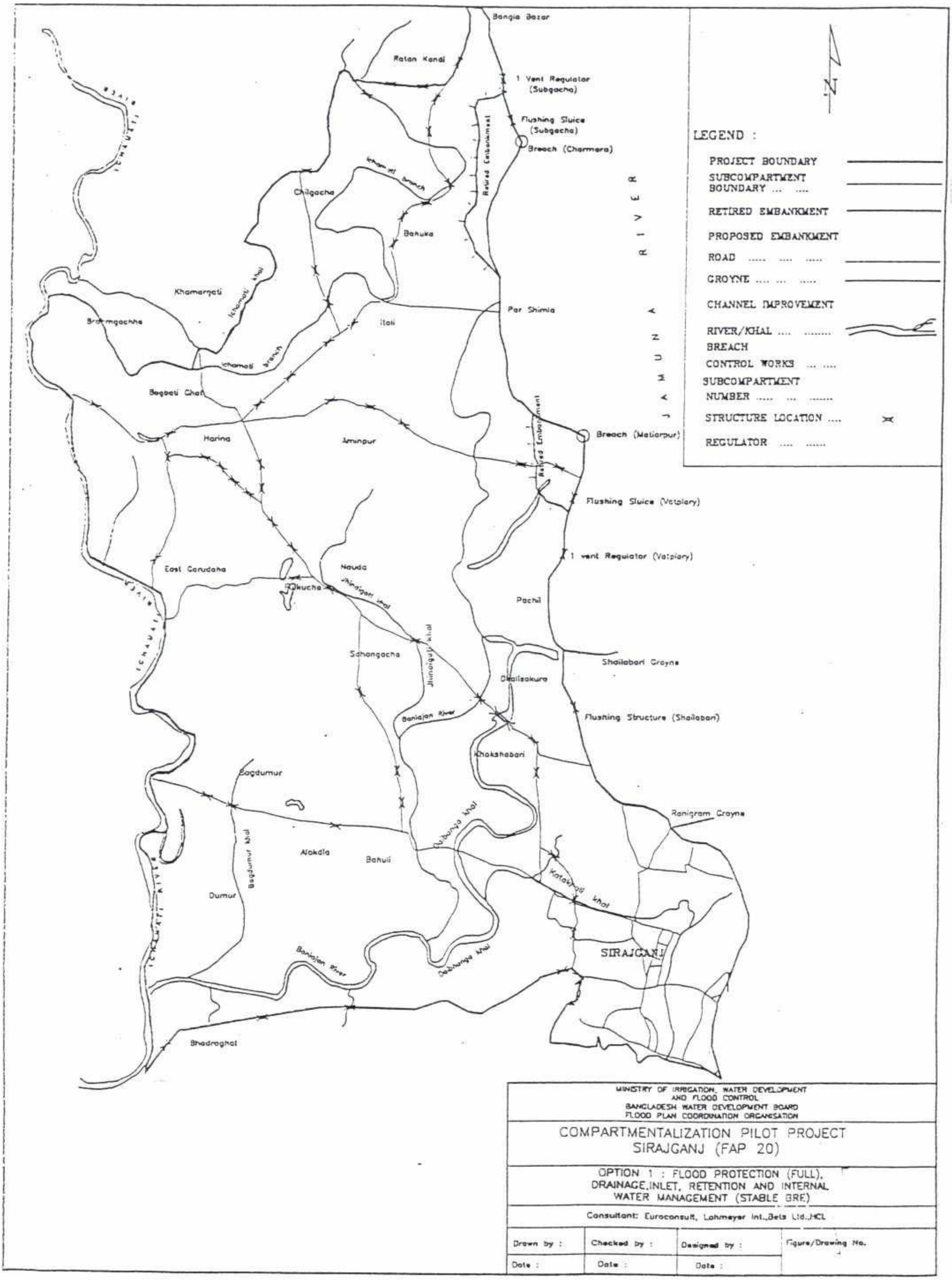
4.1.6 Groundwater Resources

Groundwater availability. Bangladesh is known for its ample supply of good quality groundwater. This resource formed the basis for irrigation developments in the country over the past decade. There is possibility that groundwater recharge will be inadequate due to flood control and drainage works.

Regional Setting. The implications of existing flood control and drainage works (FCD) and development of minor irrigation on the availablity of groundwater has been evaluated in regional studies (eg. FAP 3.1991; Steenhuis 1987). The regional data for the Sirajganj district are in the Northwest Regional Study (FAP 2.1992. 10).

> The study concluded that the aquifer system has the capability to support large scale groundwater abstraction for irrigation. Current recharge seems to be sufficient to cover current and future irrigation demands in the Sirajganj district. The model indicates that there is only minor difference between groundwater recharge under "no FCD" and "partial FCD" conditions. However, some parameters are based on crude assumptions and the model is especially sensitive to infiltration and deep percolation characteristics (for further details see Appendix 2, Groundwater).

Map 4.3: Road, Embankment and Hydraulic Structures of CPP Sirajganj



The secured availability of groundwater for irrigation does not imply that there is no impact of FCD on groundwater levels. In fact, the area of Sirajganj is considered as being affected in future by groundwater table lowering (Map G1 in Appendix 2).

During the flood season, groundwater levels are a close reflection of flood levels. With full flood control, the groundwater levels will show a reduction in level similar to that of the flood levels. During the early part of the dry season groundwater tables recede to levels in January which are nearly identical for both no FCD and full FCD. This trend of effects of floods on groundwater levels is shown in Appendix 2. During the pre-monsoon period, which is in fact the main irrigation season, there is no marked difference between both scenario's, and hence, the impact of FCD measures on irrigation is minor.

Sirajganj CPP. Records of groundwater table depth in the CPP area (Map 4.4) are available from the following institutions:
- Department of Public Health Engineering, Sirajganj
- Ground Water Circles (BWDB)
- BADC, Sirajganj

and the record data are summarized in Appendix 2 (Tables G1 to G2). At present, only an initial evaluation is possible based on the analysis of parts of data sets. In-depth analyses are part of the proposed "Environmental Monitoring Programme"(see Chapter8).

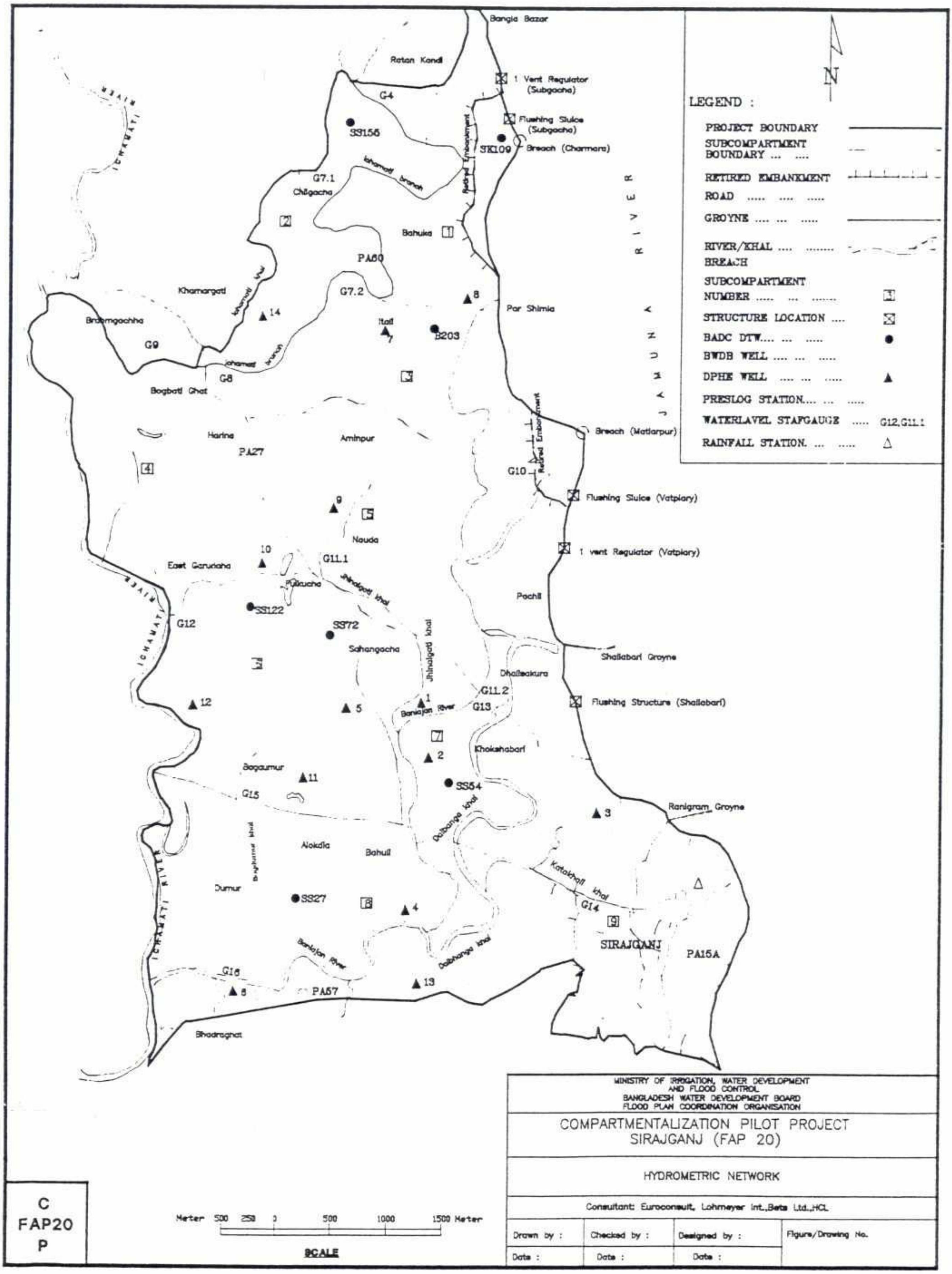
The data show that - at present - sufficient groundwater is available to cover all urban and rural needs during all seasons (see Section 4.4). In general, water tables are in the range of 5 to 8 m below surface which is in the reach of suction lift pumps (STW, handlift pumps). As expected, seasonal fluctuations are high; a general trend of decline in the groundwater depth was observed in most wells, but in few others a rise was observed. Further monitoring is required to verify any long-term decline of groundwater levels.

4.1.7 Water Quality Status

Water Pollution as a Major Hazard. Regional data on water quality show a high degree of microbiological (organic) pollution in many surface waters and in some groundwaters (FAP 2. 1992.14). The most urgent concern is the impact of domestic waste contamination of surface water. Consequently, water-borne diseases are common (see Section 4.5). The reasons for this are: the prevalence of sanitary latrines and general hygienic standards are low in both rural and urban areas, and the wastewater treatment and municipal garbage disposal facilities are virtually non-existent in the Sirajganj town (see Section 4.7).

Chemical Pollution. Pollution in the CPP area may be caused by agrochemicals, chemicals for health control measures or by industrial discharges, including small scale or cottage industries. There are a number of handloom factories in villages Ratni and Kalidasgati in SC 8. These establishments discharge organic dyeing chemical into ditches within homesteads. They may contaminate soil and water resources.

Map 4.4: Locations of BADC, BWDB & DPHE Groundwater Observation Wells



Existing regional data do not suggest a serious and widespread problem. Sector-specific or local preventive measures (eg. the use of cleaner process technologies) may be adequate. It is proposed to conduct an environmental pollution survey to identify important pollution sources in the CPP area (see Chapter 8).

Natural Hazards. In some areas in the central and northern part of Bangladesh, natural concentrations of iron, manganese and boron are high in groundwaters. They may adversely affect potable water supplies and cause health hazards when used for irrigation.

> A nationwide inventory showed that dissolved iron may be present in excess of 7 ppm in the Sirajganj area (Steenhuis 1987). These concentrations are close to the upper limit of recommended maximum concentrations of trace elements in irrigation waters, especially in sandy soils with low pH-values. Under waterlogged conditions, soil acidification is enhanced and the availabiity of essential trace elements (eg. Mb) and phosphorus is reduced.

Pesticide Residues. Pesticide residue and fertilizer contamination by agrochemicals are a matter of widespread speculation. Unfortunately, only very few data exist, and the low agrochemical use in the country - compared to India - may suggest the marginality of the problem (see Section 4.4.2). However, the notoriously low standards of production, handling and application of agrochemicals and storage or disposal of containers suggest high risks of exposures to pesticides, risks of soil and water contamination and subsequent bioaccumulation. Indeed, hot-spot investigations indicate the presence of harmful chemicals in the environment.

> In the CPP Tangail area, DDT, Dieldrin and endosulfans were detected in milk and fish tissue samples. The levels are below the mortal limit, but are well within the carcinogenic limit (FAP 16/19.1992). Another study in the Northwest Region reported the presence of dieldrin in surface waters at 0.64 ng/l, whilst DDT was detected at 1.5 ng/l (FAP 2.1992.14).

Some harmful organochlorine insecticides such as dieldrin and DDT (also used for malaria control) are now banned in Bangladesh, although they may still be marketed at some places. Large scale aerial spraying is no longer practiced in the country. A regional survey showed that the following pesticides were frequently in use:

> Sumithion, Dieldrin, Furadon, Basudin, Nogos, Diazinon, Malathion, and Aldrin (FAP 2.1992.14).

Many insecticides which are in use in Bangladesh are nearly immobile (high retention) and some are persistent in the environment (low degradation). They are rarely selective and some have a high mammalian and fish toxicity, eg. most of the organo-chlorine, organo-phosphorus and carbamates. Site specific data for the CPP are not available (see also Section 4.4.2).

Nitrogen Enrichment. It is claimed that the increased use of fertilizers in modern agriculture leads to eutrophication of surface waters and contamination in groundwaters. Flood control works are aimed at intensified cropping pattern and HYVs which require high fertilizer rates to achieve high yields. Therefore there is potential that FCD works contribute to water pollution.

Unwanted eutrophication of water bodies may be either caused by natural processes of decaying organic matter, by domestic wastes, animal/cattle feedlots or inefficient fertilizer uses and high soil erosion on croplands. It is difficult to separate these factors in the floodplain environment of Bangladesh.

Urea, which is the preferred N-fertilizer, releases ammonium to the soil where it is transformed to plant available nitrate. Nitrogen tends to be very mobile and can easily reach the groundwater. However, fertilizer application rates in Bangladesh are low compared with international standards and thers is no evidence of widespread misuse. Field experience suggest that present fertilizer rates are frequently too low to adequately compensate for nutrient extraction of crops (see also Section 4.4.2). Also groundwater and surface water analysis in the region and neighbouring areas show very low concentrations of nitrates, nitrites and ammonium:

- Northwest Region: nitrogen levels below 0.4 mg/l in tubewells, rivers and beels (FAP 2.1992.14); ammonium levels are below 1.3 mg/l.
- Tangail CPP area: average <0.5 mg/l NO3 (FAP 16/19. 1992).
- Jamalpur Project: below 0.4 mg/l NO3, except near the Fertilizer Factory disposal site.(FAP 3.1.1993).
- Gumti Phase II Project: NO3-N ranges between 0.3 (detection limit) to 10.8 mg/l in groundwaters. Highest concentrations were found in shallow tubewells. Some nitrate at concentrations of 3-7 mg/l have penetrated the aquifers to depth of 50-80 m, whereas no nitrogen was detected in deep tubewells (Gumti, 1993).

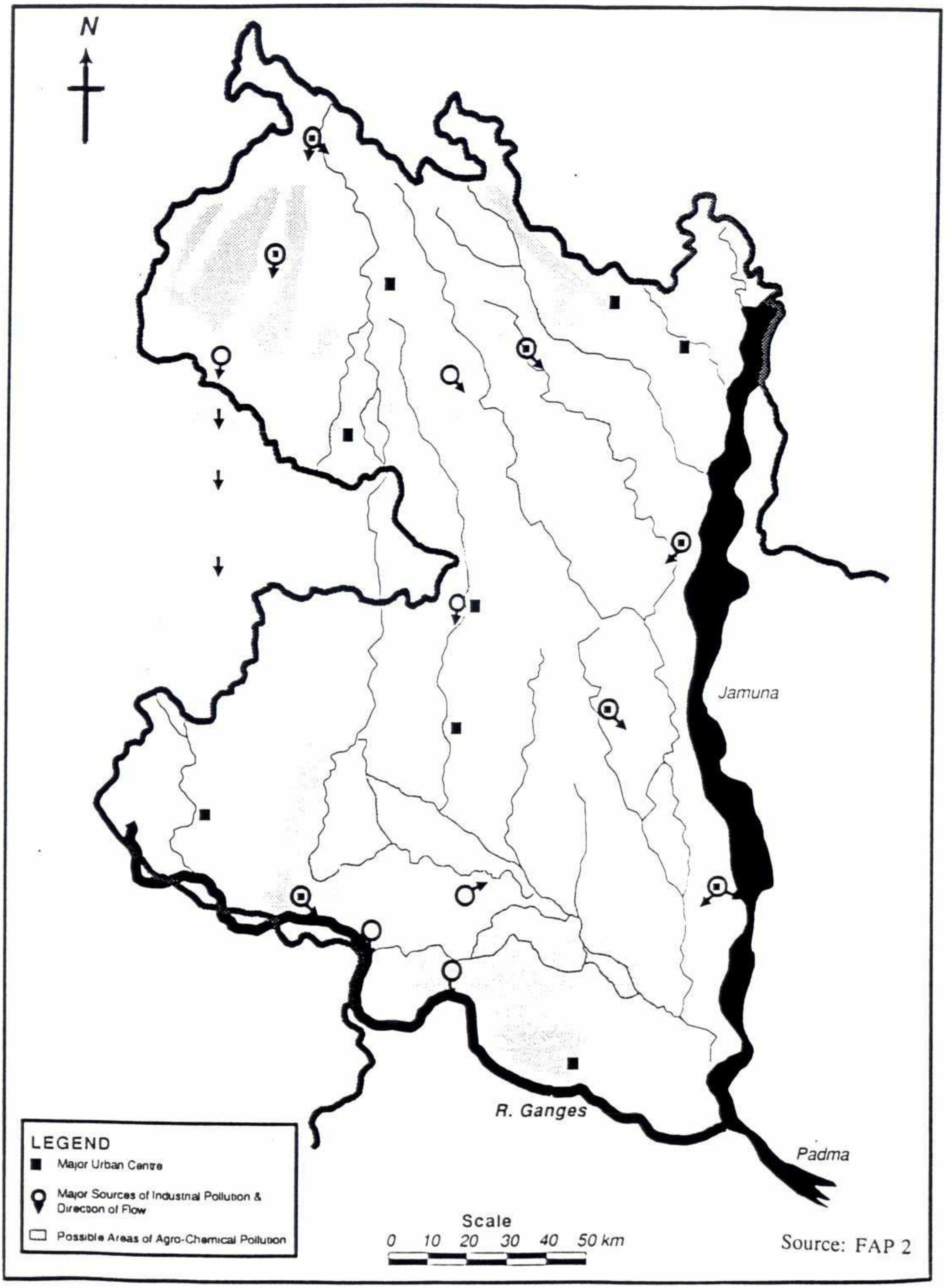
It can be concluded that there is no evidence of nitrate contamination of groundwater or surface waters. Low nitrate levels in groundwater suggest that plant growth may even be limited by nitrogen availability, and crops certainly respond to nitrogen fertilizers (FAP 2.1992.14).

Summary on Regional Water Pollution Status

Map 4.5 provides a regional overview of some of the potentially important sources of water pollution. All the available regional data on water quality are presented in Appendix 5 (Tables W1-W6) and can be summerized as follows:

- Jamuna River water is soft and poorly buffered, with a pH range of 7.7 to 8.2. Nitrate and phosphate are adequate to support phytoplankton growth. Heavy silt loads during all seasons prevent the penetration of light which is essetnial for growth of phytoplankton. Consequently, nitrate and phosphate are in higher concentration in the permanent rivers than in any other surface waters, since there is no plant activity which could remove them from solution. Ammonium levels are comparatively low.

Map 4.5: Potential Source Areas of Water Pollution in NWR (Source FAP 2)



Source: FAP 2

Oxygen levels in the main rivers are high, ranging from 8-9 mg/l. They are normally associated with a high photosynthetic activity, but in its absence it appears that the high turbulence is sufficient to reach oxygen saturation.

- Seasonal rivers, eg. the Ichamati River degenerates into a series of static pools during the dry season. In this period, they are like permanent standing waters such as beels. They have a pH in the range of 7-8, dissolved oxygen levels of 5.5 to 8 mg/l, and virtually no dissolved nitrate or ammonium nitrogen, nor phosphate.

  The bacterial quality is generally low. Most water bodies are contaminated with faecal bacteria. Flushed beels (inundated by overflow during the flood season) tend to show higher coliform counts than unflushed beels.

- Groundwater has a low pH range, associated with low dissolved oxygen and comparatively high BOD and COD values. The levels of plant nutrients and most other dissolved chemicals except iron and manganese are low.

Summarizing, there is an insufficient data base to assess local problems of water quality in rural and urban areas of the CPP. A monitoring survey should assess the existing status in various habitats. Subsequently, adequate mitigating measures can be proposed to improve public health and preserve wetland habitats in an integrated floodwater management project.

4.2 Land Resources

4.2.1 Physiographic Features

The CPP Sirajganj area is part of the Bangali floodplain in the Northwest Region. In the east, it is bounded by the braided Jamuna River.The characteristic topographical feature of the area is its flatness, although micro- elevations exert a major influence on the soil moisture regime. Elevations vary from 9.2 m to 15.2 m above sea level. As a consequence of the very low gradients, the rivers and channels (khals) within the floodplain are generally meandered and braided, and capacity for rapidly passing substantial flood peaks is very limited. This favours, in combination with river flooding and heavy local rainfall, seasonal waterlogging and local drainage congestion.

4.2.2 Agro-climatic Features

The CPP Sirajganj area lies in the subtropics just north of the Tropic of Cancer. It has a monsoonal climate with four seasons: wet summer monsoon (June to September), unstable post-monsoon (October to November), dry and mild winter (December to February), and unstable and hot pre-monsoon (April to May).

Climatic Features.

Rainfall ranges from 1,500 mm to 3,000 m in the Northwest Region. The median rainfall at Sirajganj totals 1542 mm/a. The divergence from the mean annual rainfall of 1,779 mm is high, although this is a typical feature of subtropical regions with a high rainfall variability; the standard deviation is 364 mm, the coefficient of variation is 21%. Over 85% of the annual rainfall occurs during heavy thunderstorms within a period of six month between May and October, although scattered showers occur in all months. Storm rainfalls can be very heavy and the highest 10-day rainfall is as high as 451 mm in 1 out of 5 years. There is a trend of increasing rainfall over the past decades; the mean precipitation increased to 1792 mm/a (FAO 1988); however, wet periods had also been recorded earlier in the century.

The average humidity is above 70%, except during the sunny and relatively cool dry season from November to February. The transition from the monsoon to the dry seasons in October to November is fairly smooth, with declining temperatures, humidity and storm frequency. The early pre-monsoon period in April-May is associated with thunderstorms and squalls and can be very hot. This is also the peak season for cyclones and the Northwest Region can be affected by associated heavy storms.

The potential evapotranspiration (PET) at Sirajganj totals 1,239 mm/a and the open water evaporation amounts to EO = 1,186 mm/a. Estimates for Sirajganj are probably not very accurate and PET at Sirajganj may total some 1,600 mm/a as proposed by hydrological studies for Bogra station (FAP 2.1992.10).

Further climatological parameters for the Sirajganj station are shown in Annex 4, Agriculture.

<u>Agro-ecological Regions</u>.

There are three agroclimatic periods: kharif 1 (pre-monsoon), kharif 2 (monsoon) and rabi seasons (November to February). The kharif 1 season is vulnerable to excessive early rainfall, whereas the kharif 2 season is vulnerable to flooding hazards, either too early, too high, too rapidly rising or prolonged floods. The rabi season depends on the residual soil moisture unless irrigated. Mild temperatures and the absence of flood hazards offer a great potential for future crop diversification.

Based on the characteristics of the three periods, Bangladesh is divided into thirty agroecological regions. Sirajganj is in the Karatoya-Bangali Floodplain i.e. subregion 4b and is characterized as follows:

- mean annual temperature of 25.5°C
- the mean length of the pre-kharif transition period is around 51 days from 18th march to 9th May
- the mean length of the reference kharif (K100) growing period is some 210 days, from 9th May to 9th December
- the length of the humid period (kharif 2) season is about 141 days, from 24th May to 15th October
- the mean length of the reference rabi growing season is around 135 days, from 24th October to 1st March
- the mean date when minimum temperature begin to fall below 20°C (time limit for aman flowering) is 4th November

- the mean length of the cool winter period is 85 days with minima of < 15°C
- there are usually about 3 days with summer maximum temperatures above 40°C. (UNDP/FAO 1988).

4.2.3 Soils

Major Soil Fertility Issues

It is claimed that the fertility of the land decreased after the natural flood from the Jamuna River ceased since 1963. The annual deposition of silt was almost entirely stopped and also the nitrogen fixation on the floodplains during the flood season was reduced. On the other hand, highland trees might benefit from the absence of floods and high groundwater levels during the flood season (FAP 2.1992.14) and (FAP 12.1991).

The lack of local data does not permit the verification or rejection of these hypotheses. It seems that the contribution of silted deposits to soil fertility is overestimated and the nitrogen-supply of algae in floodwaters is minor compared to nitrogen needs in intensive cropping systems. However, there are further flood control induced impacts which are related to changes in soil water dynamics and subsequent changes in physical or bio-chemical properties of soils. A survey on the soil fertility status and trends is recommended which should investigate the impact of flood and drainage control on the soil-water balance and its implications on soil biology and fertility for crop production (see Chapter 8).

Predominant Soils

This section describes the predominant soils and their properties in the Sirajganj region of the Region 4 (Karatoya-Bangali Floodplain) and draws on the Land Resources Appraisal by UNDP/FAO 1988. This, in turn, uses data from a reconnaissance soil survey of the Pabna region in 1967. A document on regional soil physical and chemical properties for the Thana of Sirajganj is in preparation and includes recommendations for agriculture.

It must be considered that soil conditions have changed during the past decades. The crop intensification under irrigated paddy resulted in changes in water and nutrient dynamics. Also the inundation regime altered after the construction of the BRE in the mid 60s (reduction in flood occurrence, depth and length) and subsequent alterations in wetland ecology and nutrient deposition exerted an influence on the soil's fertility status (see Appendix Ecology). Also, changes in soil phases (pH-values) and cation exchange capacity by intensified weathering can be expected due to improved aeration status. Soils in the Sirajganj area have a moderate overall fertility. Some have shortages in nutrients, especially nitrogen and micronutrients. This is likely to be attributed to low returns of organic residues to fields (use for fuel, fodder), low residue contents of modern rice varieties and increased nutrient uptakes under intensified crop rotations. Leaching losses of essential elements such as Ca, K, Mg, Na, Cu, Mn and Zn are important in permeable soils unless nutrients are replaced by organic or inorganic fertilizers or green manure (see Mian et al.1991).

It is proposed to analyse the water and nutrient balance of CPP soils at selected sites to assess the existing conditions and to monitor effects of flood control and drainage impacts, especially the supply of nutrients during the flooding season. Recommendations to maintain soil fertility under intensive cropping systems (flooded and non-flooded conditions) can be based on these findings. Similarily, this applies to current impairments caused by nutrient depletion and contamination by agro- chemical which are commonly attributed to modern agriculture.

Land Types and Soils in the Sirajganj area

The area have smooth, wide floodplain ridges and almost level basins. Relief is more irregular with linear ridges, depressions and cut-off channels in belts adjoining the rivers, and near the active Jamuna floodplain.

Most of the Sirajganj area is classified as highland or medium highland, although parts of medium lowland exist in the CPP. The hydrological land types are described in terms of inundation depth during the peak rainfall period of the wet (kharif) season and corresponding approximately with peak discharges of the river systems.

The following inundation classes were determined for the Sirajganj Region, using the UNDP/FAO 1988 land types and corresponding F-classes of the MPO. The percentage proportions of the various lands and inundation classes are shown in Table 4.3 for the Sirajganj Region and the CPP.

Table 4.3: Land Types in the Region and the CPP Area

Inundation	Land type	F- type	Region	CPP
not flooded	H 0 Highland	-	31%	11%
0- 30 cm	MH1 Medium Highland 1	F0	45%	13 %
30- 90 cm	MH2 Medium Highland 2	F1	ND	31 %
90-180 cm	ML Medium Lowland	F2	9%	23 %
180-360 cm	L Lowland	F3	1%	2 %
> 360 cm	VL Very Lowland	F4	0%	-
Homesteads and water		-	14%	20 %

Source: UNDP/FAO 1988. Report 5. Vol.II/4:159
F0 to F4 after Master Plan Organisation (MPO)
CPP, GIS map interpretation 1993; see also Table 4.6

Grey silt loams and silty clay loams predominate on ridges and grey or dark grey silty clays predominate in basins. Significant proportions of shallow soils overlying sand may also occur in the Siragjanj area; erratically, silty and sandy alluvium from the active Jamuna floodplain can occur, including recent Jamuna spill deposits. The soil types which occur in the Sirajganj region are shown in Table 4.4.

Table 4.4: Areas & Proportions of Soil Types in Sirajganj

	subregion	CPP

total area in ha	56,200	12,500
- non-calcareous alluvium soils		
sandy	2%	5 %
loamy	4%	10 %
- non-calcareous grey floodplain soils	80%	65 %
- river	4 %	4 %
- urban	1 %	6 %
- homestead and water bodies	9 %	10 %

Source: UNDP/FAO 1988. Report 5. Volume II/4:163.
CPP estimates

The majority of cultivated land has non-calcareous grey floodplain soils. They are classified as Eutric Fluvisols. Soils with strong signs of waterlogging are classified as Chromi-Eutric Gleysols (FAO Soil Map Classification 1985).

Associated soils are Dystric Fluvisols, Areni-Eutric or Chromi-Eutric Gleysols. Patches of Cambic Arenosols may occur on sandy highland ridges.

For the CPP area, the following soil associations were classified : 37, 34, 44a, 33 and 42a, see Soil Map in Annex 4, Agriculture (SRDI 1967).

Soil Properties

Seasonally flooded or temporarily waterlogged soils are predominant with a weak cambic B horizon which either is grey or has grey ped faces (cutans). Seasonal flooding since 1963 (BRE-construction) is mainly caused by local rainfall, and ranges from shallow to moderately deep, except during BRE breaches. The Ap-horizon is grey or olive grey, with yellow-brown mottles along root channels and ped surfaces. Puddled soils have a compact ploughpan at the base. The loamy or clayey subsoils have a favourable strong prismatic or blocky structure. The subsoil grades into the substratum at variable depth, but usually at around 40-60 cm.

The ridge soils are highly permeable, especially when they overlye sand, and they have a relatively low moisture holding capacity. Most other soils have slow permeability, especially when they are puddled for transplanted aman cultivation, and they have a high moisture holding capacity, remaining moist long into the dry season. In basins, heavy clays have a low available moisture capacity, and they become very hard when dry.

Organic matter contents are generally low (< 1.5% OM) in the topsoil of ridge soils but are somewhat higher (upt to 2.5% OM) in basin soils. Topsoil reactions (pH) varies from favourable slightly acid to unfavourable very strong acid conditions; however this varies in paddy soils depending on seasonal redox potential changes. Subsoils are slightly acid to slightly alkaline, but the upper part of the subsoil in basin soils often is medium acid and some heavy soils have strongly acid subsoils.

Soil Constraints

There are several soil constraints related to intensive crop production (UNDP/FAO 1988):

- uncertain flood regimes; risks of intensive crop damage if the BRE is breached (frequently since 1984)
- the ploughpan developed in soils used for transplanted aman restricts root development in following rabi crops and pre-monsoon kharif crops; this is most serious on the relatively higher, fine sandy loams and silt loams which are more intensively puddled to reduce infiltration to retain water
- ridge soils usually are sensitive to seasonal drought because they are highly permeable and retain less moisture
- irregular relief and complex soil pattern hampers medium or large scale developments, eg. irrigation
- deep flooding and heavy, waterlogged soils in basins restrict their use for other crops than paddy; in Sirajganj, impeded drainage is likely to be restricted to some 21% of the total area
- excessive seepage losses from irrigation channels may cause waterlogging on adjoining basin land
- extensive exploitation of groundwater for irrigation could lower the dry-season water table in some areas below the operational level of existing wells; it could also reduce dry-season flows in small rivers or water level in beels and reduce the capillary uptake of moisture by crops in the dry season
- vertical or lateral leaching of agro-chemicals from ridge soils can lead to crop damage in basin sites, and eventually to the contamination of domestic water supplies and contribute to eutrophication of water bodies
- reduction in organic matter in irrigated soils need to be addressed; the reduction is caused by reduced return of organic matter to soils and the intensified cropping pattern; manure and compost should be used, but it should be well decomposed before being mixed into the soil; however, the use of manure in paddy soils which stay wet for much of the year need special water management to allow decay of organic matter
- local waterlogging caused by local rainfall requires adequate surface drainage systems
- nutrient deficiencies including trace elements are reported for the CPP area; organic matter contents are low.

(Source: UNDP/FAO 1988.Report 5.Vol.II:166; Report 5, Vol.I:29 cont.)

4.3 Eco-Biological Resources

This section draws on ecological surveys in the Northwest Region (FAP 2.1992.14) and the Tangail CPP case study (FAP 16/19.1992). Amendments will be made during a special ecological survey for Sirajganj CPP during the flood and dry seasons in 1993/94 (details in Chapter 8).

4.3.1 Floodplain Ecosystems

The Sirajganj CPP is located in the Middle Bangali floodplains along the Jamuna River (Map 2.1). This area shows a continued elimanation of floodplain habitats that were once common, but that now are highly specialized for crop production and at risk of biological imbalances. Further flood control and drainage will cumulatively contribute to the continued loss of the few important habitats that remain to support species diversity. The CPP should aim at identification of key areas which should receive protection under a multi-purpose environmental management plan, eg. conservation of wetlands marshes or homestead thickets on highlands.

General Description of Biological Trends

Due to the immense population pressure in the floodplains adjacent to the Jamuna River, nearly all terrestrial habitats have a high primary value as permanent agricultural land. Since many centuries, most areas are extensively used for cultivation of field crops, especially paddy. Attempts to mitigate flood hazards on croplands resulted in the construction of large embankments along major rivers. Also the construction of embankment roads contributed to permanent changes in flood regime and pattern which altered the floodplain ecosystem. Alternating wet and dry cycles are less pronounced and terrestrial succession communities are now predominant. This resulted in further encroachments into lowlying wetlands which were previously unsuitable for permanent cropping. Modern irrigation developments tend to accelerate the process especially the low lying lands.

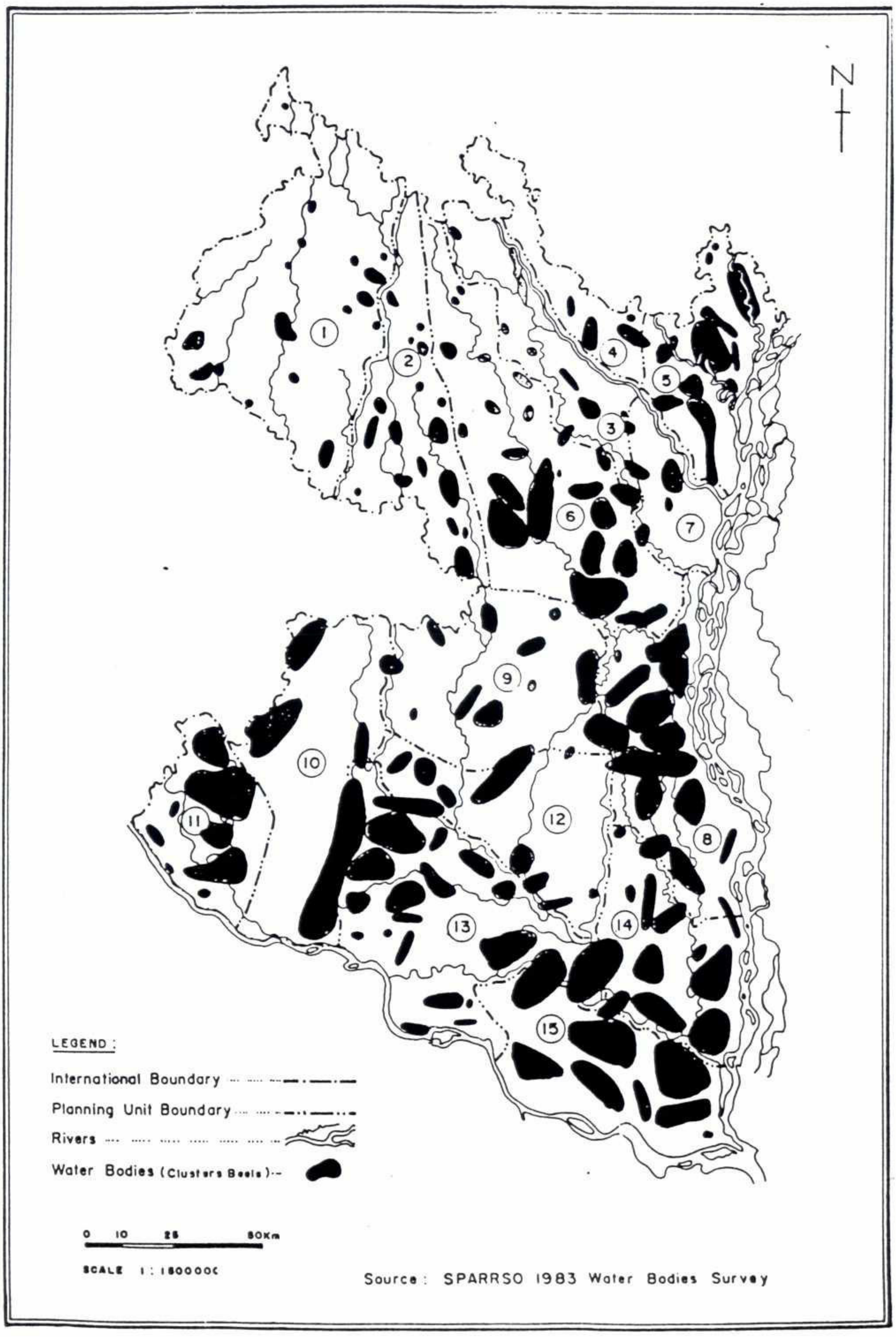
The present status of permanent beels in the region (see also Map 4.6) are as follows:

CPP area	55 ha	= 0.46 % of 12.057 ha
Middle Bengali Basin	1,180 ha	= 0.52 % of 225,000 ha

(Source: FAP 2.1992.2; CPP 1993; post-monsoon season)

Recently, refuges for wildlife are also being endangered by cropland or settlement conversions. In Sirajganj CPP the process of transformation of landscape and ecosystems has been more complete than in many other regions and the natural system and its floral and faunal associations have basically disappeared. Habitats for almost all terrestrial wildlife that cannot easily adapt to the human environment have already gone. The indigenous tree species and forest areas have all been replaced by homestead and horticulture species. There are, nevertheless few vital sites showing the semi-natural floral and faunal diversity. These are homestead plantations or thickets and few remaining permanent wetlands. Secondary source data indicate the ecological importance of these habitats for a large variety of species including endangered aquatic and terrestrial species.

Map 4.6: Water Bodies, Rivers and Planning Units in NWR



Description of major habitats

The major habitats are well defined by the flooding regime to which a location is subject. There are three distinctive terrestrial zones in the NWR, each with its peculiar habitat.

1 Lowland zone: river banks and channels (khals)

Plant species abundance is low, with a dominant community of semi-prostrate or small species able to tolerate exposure to fast-flowing currents. Larger plants (shrubs/trees) are absent. The resource value of the species appears to be very low (Appendix 1, Table E.1).

Animal species abundance is much higher, and there is a fairly rich bird fauna, inevitably including a large proportion of fish-eating species. The reptilian fauna is also represented (Appendix 1, Table E.2)

2 Floodplain proper (seasonal flooded lands)

- beels (permanent or seasonal aquatic habitats)
  These water bodies are generally isolated in the dry season. They may be subdivided into those which are flushed by flood annually and those which usually receive only rainfall runoff. The former are subject to external recruitment of both aquatic plants and animal species. The beels serve as dry-season reproductive area for beel fish e.g. taki, shing, koi, etc. (see Annex 5). Today, most of them are under very intensive fishing pressure.

  Many beels contain virtually no aquatic macrophytes. In those which do, the species diversity is high, unless water hyacinth invades the water, in which case all other species are eliminated because sunlight is unable to penetrate the water hyacinth blanket (Appendix 1, Table E.3). The water hyacinth is, in spite of apparent problems in unflushed water bodies (and borrow pits), resourcefully used in local fishing, agriculture and craft industries.

  The main vertebrate fauna consists of birds, but water-loving reptiles are frequent, although they tend to be less common in those beels which are almost completely reclaimed for agricultural use in the dry season (Appendix 1, Table E.4).

- crop land
  Agricultural fields themselves provide the least species abundance of all the habitats. Extraneous plants are weeded out, whilst the monocultures themselves provide little shelter for animals. The small border and field margins (banks, pathways, fallow) are much more diverse, and provide the only habitat for potential pest control agents (Appendix 1, Tables E5-E6).

- inundated homesteads
  Few homesteads are situated below the elevation of peak floods and become inundated for short periods during the flood season (but most homesteads are on highlands)

Species abundance is usually far below those of highland homesteads. Most of the animal species recorded can be regarded as commensals - ie. species which live in close association with human. Species variety is low and most areas can be considered as extremely impoverished (Appendix 1, Tables E7 to E8).

- embankments

  Species abundance is often higher compared with surrounding floodplains. Animal species are especially prominent, and the embankments clearly form important linear habitats for a wide variety of terrestrial animals. The high frequency of small mammals, including pests stored in grains such as mice, and the cool microhabitat provided by hollows in the embankments, attract reptiles including occasional venomous snakes (Appendix 1, Tables E9-E10).

  Major river embankment provide essential refuges for people and wildlife during high floods. Where villages have been destroyed by floods and bank erosion, displaced families often set up their houses on embankments. These embankments are vulnerable to degradation and bank erosion.

3 Highlands (rarely inundated land)

- highland homesteads

  In terms of species abundance, they stand far above all other habitats. They provide a wide range of micro-habitats in which many plants and animals can survive. They provide the greatest opportunity for species conservation, since almost all species found in the floodland are also present.

  The wide variety of fauna provides a remarkable range of resources for humans. Their uses range from medicinal through religious to utilitarian,eg. multipurpose trees for food, construction or cottage industry materials (Appendix 1, Tables E11-E14).

  Few small clusters of bamboo or tree thickets (woodlands) offer some degree of shelter for the shyer animals.

4.3.2 Biological Imbalances

There are few data available on the diversity and role of aquatic weeds, animal pests and major tree or crop pests and the role of their predators in that specific environment of the CPP area. The key aspect to assess biological imbalances would be the recognition that the linkages between various aquatic and terrestrial habitats, and species of all kinds must be understood. At this stage, the assessment is based on conceptional understanding of ecological processes and the subjective view of farmers and agricultural extension workers.

Biological imbalances are likely to occur on cropland and in urban areas. The imbalances are either caused or enhanced by human interventions into predator habitats and the provision favourable conditions for potential pests.

On croplands, imbalances are often caused by monoculture and intensified cropping pattern, and may be aggravated by the indiscriminate use of biocides which usually destroy both target and non-target species. A dramatic reduction in biodiversity, in turn, favours the uncontrolled and explosive growth of pests.

For example, cropping intensity increased as a result of flood control projects and the application of modern agricultural techniques including irrigation. The dominance of rice in the cropping system was strengthened and resulted in a loss of macro- fauna and soil-fauna diversification.

In addition, the reduction in flood depths and duration converted formerly alternating dry and wet cycles into terrestrial habitats and contributed to a reduction in biodiversity. Prolonged flooding of agricultural land is known to assist in efficient control of vertebrate (eg. rats, mice) and insect pests. In urban areas, flushing of khals and drains assists to control pest related health hazards.
Not surprisingly, regional ecological studies showed that plant and macro-fauna species abundance and number of individuals are very low in croplands in comparison with homesteads and refuge woodlands. But also embankments can play an important role in providing habitat for species which are important in pest control. The high proportion of insect-eating birds and reptiles in the fauna of embankments indicates their role in natural pest management (FAP 2. 1992.14).

Agricultural pests and diseases

The major agricultural pest recorded in the region is rice hispa (Pamri)(FAP 16/19. 1992).

Also stem borer, green leafhopper, case worm, leaf roller, mealy bug and ear-cutting caterpillar are important rice pests. Important rice diseases are sheat rot, blast, stem rot, sheat blight, bacterial blight and tungro.

The main granivorous wildlife which cause damage are *Munia spp.* and rats which are increasing with the extension of embankment roadsides and their associated grass verges and near villages. In Tangail, it is estimated that pest wildlife destroy up to 12% of the total crop production (FAP 16/19.1992). There are no figures for Sirajganj available.

Biological balances for controls. The following predator, scavanger and insectivorous species would be of special importance to control agricultural pests: birds (owls, scavangers, crows, mynas), fish, frogs, spiders, reptiles, snakes, soil invertebrates and a variety of beneficial insects and even some mollusks. Favourable habitats for pest predators are village homesteads, roadside and embankment plantations, semi-aquatic habitats around beels and river banks and field borders, although some are also the refuge for pests (eg.embankments for munia). Such habitats are under continuous stress in the Sirajganj CPP and the wildlife is sensitive to changes caused by changes in the water regime.

Similarly, the high frequency of insect-eating reptiles and birds reveals the value of such habitats for the control of mosquitos and flies in and around rural villages.

4.4 Resource Uses and Competition for Development

4.4.1 Water Resources Use

The major usage for ground water resources of the Sirajganj, CPP is for drinking, domestic and irrigation purposes whereas those for surface water are in the field of fisheries, livestock, navigation and others.

A total number of 5430 hand operated tubewells are there within the Sirajganj Thana for providing drinking and domestic water requirements of the whole area (Source: DPHE,Sirajganj). These tubewells have an averae water lifting capacity of 1.35 m3/hr. In addition, there is a water treatment plant at Sirajganj town with a water supply capacity of 204m3/hr. (Source: Sirajganj Pourashava).

Number of tubewells and irrigated area in the Sirajganj, CPP area are as follows:

SC #	Number of Tubewells used for irrigation				Area Irrigated, ha
	STW	DTW	LLP	MOT	
1	96	6	0	2	494
2	89	9	0	0	538
3	77	17	0	0	452
4	170	14	3	0	748
5	144	21	3	0	803
6	120	18	12	0	686
7	63	11	0	2	424
8	229	8	5	7	931
9	25	3	0	0	159
Total	1013	107	23	11	5235

Source: Land Use Survey, CPP Sirajganj, January - April 1993.

A total number of 1013 STWs, 107 DTWs, 23 LLPs and 11 MOTs are in use for irrigating 5235 hectares of cultivated land. Sub-compartment number 8 is on the top for using ground water resources for agricultural production. Fisheries uses approximately 7445 ha of water area for the production of capture & culture fishes. Out of these total area 22 ha are permanent beels whereas the rest are seasonal water bodies. Use of surface water resource in the livestock sector is limited in the CPP area.

Water/area used for fisheries

Permanent Waterbody	Beel	22 ha
Seasonal Waterbody	Beel	33 ha
	Floodplain	7200 ha
	Borrowpit	40 ha
	River & khals	150 ha
	Total	7445 ha

Source: Fisheries Reconnaissance Survey, CPP, March, 1993.

Before few decades all the rivers and khals of the Sirajganj, CPP were accessible to country boats in all seasons and these water ways played a major role for carrying goods and passengers into the remote villages of Sirajganj Thana. Ratankandi, Bhatpiary, Chongacha, Bagbati, Bohuli and Rahmatganj are the main village trade centres which had much importance int he earlier times along these navigational routes. But the present situation is that these rivers and khals remain accessible to navigation for only few months in the year.

4.4.2 Land Resources Use

The land use pattern in the CPP Sirajganj is dictated by croplands, although settlements and the urban area of Sirajganj constitutes a large and continuously increasing percentage of the land. The water bodies, including rivers and beels are confined to just 2% of the total area and there is a continued decline of wetlands over the past years. Land use pattern of the Sirajganj CPP is shown in Table 4.5.

Table 4.5: Land Use in the Sirajganj CPP Area

- total gross area, TGA		12,057 ha		100 %
- urban area		685 ha		6 % of TGA
	residential areas		51 % *	350 ha
	commercial areas		10 % *	69 ha
	public services		12 % *	82 ha
	roads		12 % *	82 ha
	railway		14 % *	96 ha
- rural homesteads		1,527 ha		13 % of TGA
	housing		40 %	610 ha ^
	trees/groves		43 %	650 ha ^
	gardens		15 %	230 ha ^
	ponds		2 %	37 ha ^
- net cultivable area		9,579 ha		79 % of TGA
	cropland		94 %	8,909 ha
	field borders		2 %	191 ha
	plantations		3 %	288 ha
	rural roads		2 %	191 ha
- water bodies(excluding		266 ha		2 % of TGA
homestead ponds)	beels		20%	56 ha
	rivers		56%	150 ha
	ponds		23%	61 ha

Sources: CPP survey 1993; NCA subareas are estimates
^ estimates, based on data from CPP Tangail
* estimates based on UDD Master Plan figures

The land use in the Sirajganj CPP is, as in other floodplains in Bangladesh, dictated by the flooding pattern. The flood depth phases are used to designate land types of net cultivatable areas (NCA). The breakdown by land types shows that most land is highland or medium highland (<90 cm flooded). About 10 % of the area is only flooded during exceptional high floods (see Table 4.6).

Table 4.6: Distribution of NCA Land Types in the Region and CPP Area

Flood depth		NW Region	PU 8	Thana	CPP
Gross area	(ha)	3.5 M	225,431	31,610	12,057
NCA	(ha)		191,642	22,751	9,579
FO	0- 30 cm	1.3 M ha	35 %	33 %	30 %
F1	30- 90 cm	0.8 M ha	47 %	42 %	39 %
F2	90-180 cm	0.2 M ha	14 %	18 %	28 %
F3	180-360 cm	0.1 M ha	4 %	7 %	3 %
F4-5	>360 cm	<0.1 M ha	-	-	-

Source: FAP 2.1992.4; CPP-data from CPP surveys. Data are generated through GIS by intersecting a 1:5 year water level surface. NCA is the net cropping area; the actual area under crops changes annually and seasonally depending on flood depth and inundation period.

NW-Region is the Northwest Region of FAP 2; PU 8 - Planning Unit 8 of FAP 2. Thana is that of Sirajganj. CPP- Sirajganj.

Agricultural Land Use

NW-Regional setting. Rice predominates the farming system in the floodplains by 119% (the total crop intensity is 158%). Other crops of importance are wheat, jute, oilseeds (eg. sesamum, safflower), sugarcane, pulses (eg. mungbeans, pigeon peas, chickpeas, lentils and vetches) and vegetables. Minor crops are grown locally that tend to be defined by marketing facilities and soil/climate conditions (eg. millet, tobacco).

In lowlands of the Middle Bangali Basin (PU 8), exclusively rice is grown (F3 land), whereas on F2 land also oilseeds, pulses and jute are grown. Wheat, potato, pulses, sugarcane, tobacco, spices, jute and vegetables are exclusively grown on F0 and F1 land. The cropping intensity in the rabi season is highest on F0/F1 highland at 167%; it declines to 126% in F2 land and to 108% in F3 lowland, respectively.

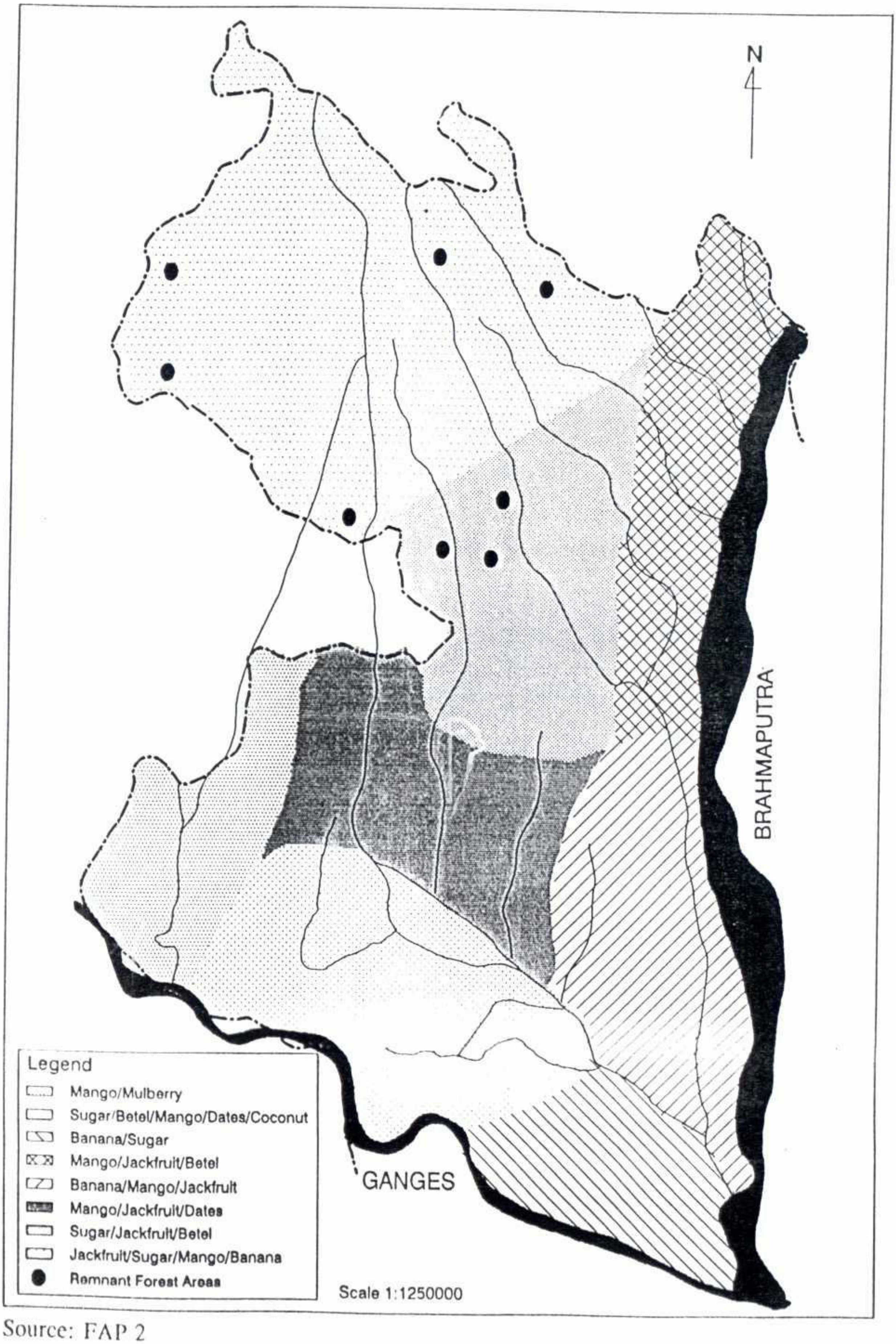
Village groves and homesteads support the widest variety of species of tree crops. Mango, banana, jackfruit and coconut orchards are widespread (Map 4.7).

CPP-Sirajganj

Crop production in the CPP Sirajganj is high and rice is the main staple crop. The typical cropping pattern being practiced in the CPP area is shown in Annex 4, Agriculture.

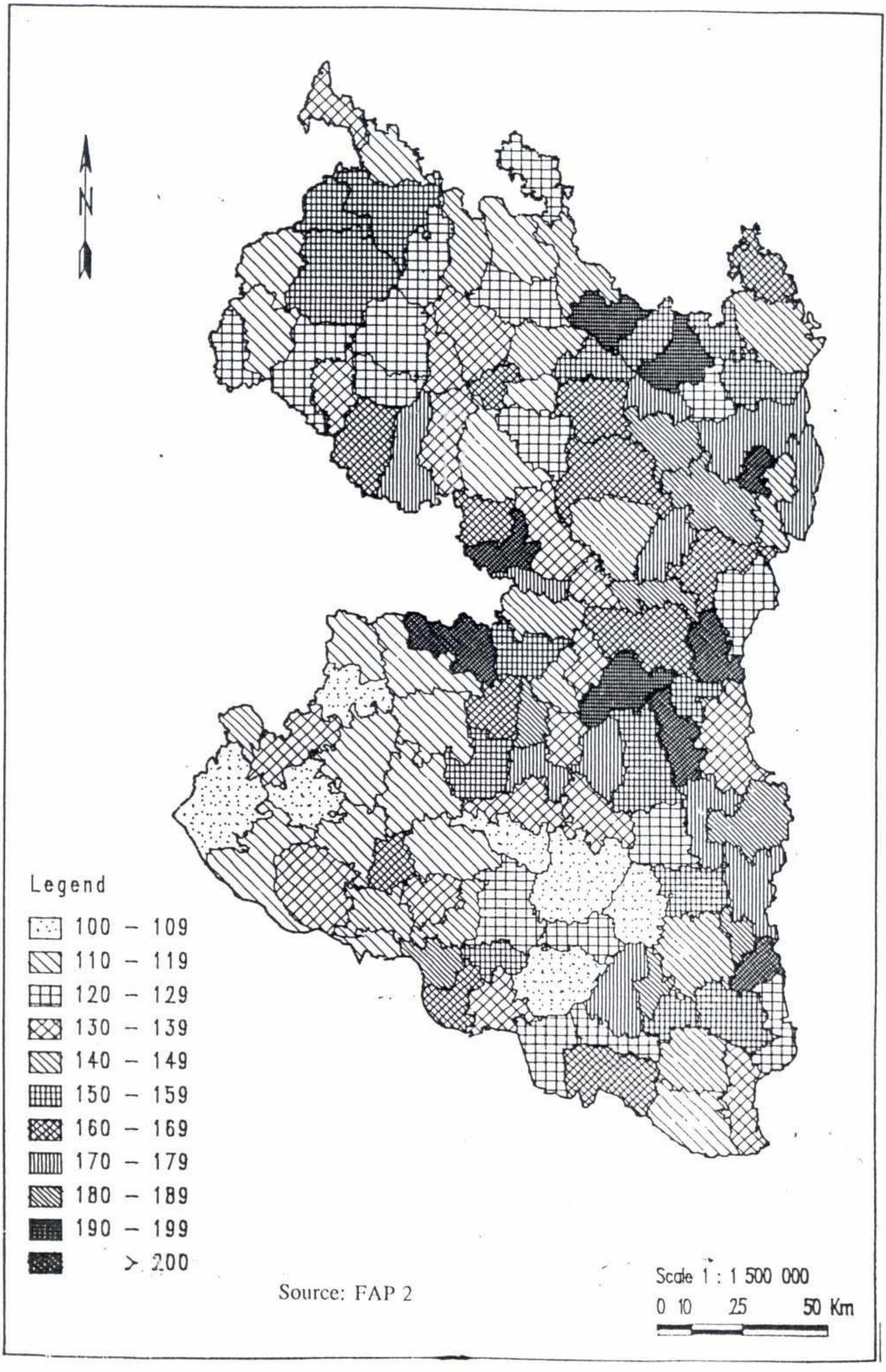
The cropping intensity of 184% in the CPP area is amongst the highest in the region (Map 4.8). The predominance of rice is less pronounced, ie. about 89 % of the NCA compared with above 100 % in the region (see Table 4.7).

Map 4.7: Generalised Vegetation Types (Tree Crops) in the NWR



Source: FAP 2

Map 4.8: Cropping Intensity in the NWR



Source: FAP 2

Table 4.7: Data on Cropping Pattern and Intensity in the Region and CPP

Area	gross area ha	NCA ha	cropping intensity	year
Northwest Region	3.4 M	2.5 M	158 %	1987
Planning Unit 8	222,431	191,683	158 %	1987
Sirajgang Thana	18,976	13,658	176 %	1987
CPP Sirajganj	12,057	9,579	184 %	1993

CPP area: single cropping on 11 % of the area
double cropping on 84 % of the area
triple cropping on 2 % of the area
89 % of the NCA is under rice, other crops 95%

Sources: CPP surveys 1992-93; FAP 2.Vol.2.1992

Irrigation coverage in the CPP area is about 54 % in 1993 (Household Survey). This is above the average of the Planning Unit 8 (Map 4.9) which was about 38% in 1989. In the central part of the NW Region, the irrigation coverage was in the range of some 50-70% (1989). In the PU 8, only HYV of Boro was irrigated on some 81,000 ha in 1989 (FAP 2.1992.2).

Use of Agro-chemicals

Fertilizers are applied to all the more productive crops, especially the HYVs, T.Aman and sugarcane. Small quantities are applied to irrigated wheat and occasionally to broadcast aus and aman. The blends of nitrogen, phosphate and potash applied are mostly in line with recommendations by the Agricultural Extension Services. If mixtures are applied, farmers tend to apply higher doses in nitrogen or only urea.

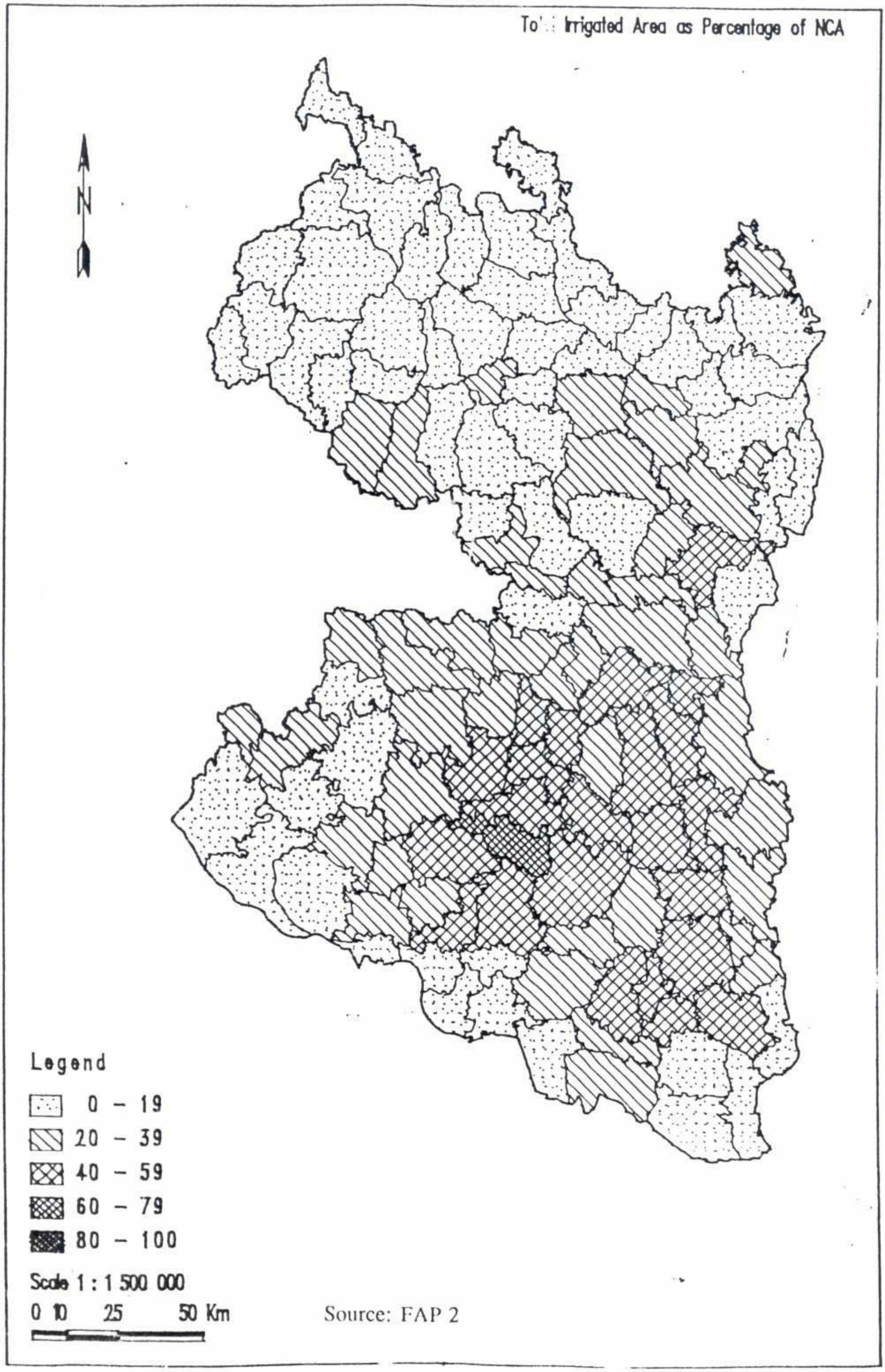
It is common to apply gypsum in fertilizer mixes to combat sulphur deficiencies which is widespread in Bangladesh. Also zinc sulphate, at rates of 10-15 kg/ha are recommended. Approximate doses of nitrogen, phosphate and potash applied to the major crops in the CPP areas are shown in Table 4.8.

Table 4.8: Recommended use of Fertilizers in the CPP

Crop	Urea	TSP	MP	Gypsum	Zn
HYV Boro	237	91	45	58	4
T.Aman HYV	120	66	25	25	2
T.Aman	66	53	26	5	0
Wheat	92	71	37	4	0
Sugarcane	106	74	45	7	0
Jute	61	52	29	0	0
Mustard	90	97	42	-	-
Potato	102	121	54	-	-

Source: FAP 2.1992.12; Agricultural Survey CPP.1992-93.

Map 4.9: Irrigation Coverage in the NWR



Source: FAP 2

Fertilizers are exclusively sold by private dealers; previously, the BADC was responsible for distribution and there was a Primary Distribution Point at Sirajganj.

Specific data for CPP Sirajganj will be evaluated at a later stage. It is estimated that fertilizer application rates are below nutrient depletion rates of most crops.

Pesticides, usually insecticides, are applied to HYVs of rice, mainly boro and T.aman. In the Sirajganj CPP area, pest attacks occur in decreasing pecentages of affected crops to Garlic, Mix Aus-Aman, T.Aus (LV), Khesary, Onion, Wheat, Mustard, T.Aman (HYV). It seems that especially high valuable rabi crops, such as vegetables and wheat are affected (often >30% of the area). Most new rice varieties are affected in the range of 10 to 17% of the area (Household survey, preliminary data 1993).

Granular formulations are most common. Integrated pest management practices are not used, although few farmers provide perches for insect-eating birds in rice fields to encourage access in otherwise treeless fields.

Until 1974, pesticides were procured by the government and supplied to farmers free of cost. In 1979, subsidy was abolished and pesticide use fell off dramatically. Since then, a gradual increase of pesticide use is recognized. In 1985, some 3,000 t were used and in 1992 already 7,000 t were used, mainly on rice crops (Ramaswany 1992). All pesticides were sold by some 20,000 private pesticide dealers. Their sales doubled between 1985 and 1990. An unknown quantity is imported from India, especially along the North West Region borders.

Pesticides are especially applied to HYV of T.Aman, Boro, T.Aman (LV) and Potato. Application rates are below 1 kg/ha. The total pesticide use in the CPP is estimated to around 1 to 2 t/a. A special survey should be made on the use of pesticides and the associated occupational and environmental risks.

The increased use of agrochemical in intensive agriculture associated with FCD/I developments is documented from two projects:

	Bhedra Beel		Bhitabari Damash		
	pre	post	pre	post	
pesticide	10	45	10	55	% of NCA
fertilizers	25	65	30	90	% of NCA

(Source: FAP 2 1992.4:2-19; year and period are not given)

Currently, the indiscriminate use of locally produced chlorinated hydrocarbons and carbamates poses most harm to the water, because the soil environment favours the migration of pesticides. The rate of natural degradation may be low at low pH-values and low cation exchange capacities, and thereby favouring a long persistance of compound organic chemicals in the environment.

Livestock

The situation of livestock in the CPP area and Sirajganj Thana is shown in Table 4.9, including figures about the common grazing land (ha), its production (t/a) and the calculated demand (t/a) for the specific number of local livestock.

Table 4.9: Livestock in the Sirajganj Area

area	bullock	cows	poultry	Grazing land	prod.	demand
CPP	5,896	18,124	108,935	14	33	141
Thana	10,941	33,460	173,935	50	106	266

Source: CPP.1993; Sirajganj Livestock Officer; DAE

Livestock are kept in most rural households in small numbers. Bullocks are kept mainly for draft power and transportation, and cows for milk. Smallstock, such as goat, chicken, ducks and sheep, are kept as a source of protein and for cash income. Cow dung is a major source of fuel in poorer rural households.

Livestock holdings per rural household range between 0.2 and 2 animal units. Smallstock holdings range from 2 to 6 per household (preliminary data). There is a shortage of draft animals in the CPP Sirajganj area. Availability of draft power is just 1.9/ha which is lower than the national average of 2.6/ha. The general health condition of livestock in the CPP Sirajganj is poor due to mostly common shortages of feed and fodder, lack of grazing land and cattle diseases.

The loss of natural fodder from low-lying depressions due to the encroachment of crop production into wetlands causes serious deficiencies in livestock feed. Livestock is now mainly fed on crop residues and by-products. Occasionally, crop weeds, grasses from field margins and embankments and water-hyacinth are used as fodder. Feed deficiencies are most severe in the pre-monsoon period and again in the months of August-October, when aman crops remain on flooded fields.

Potential grazing land in the CPP Sirajganj area is limited and there is no programme to enhance fodder production.

Homestead Forestry

The status of homestead forestry in the Sirajganj CPP area is poor even to Bangladesh standards. It accounts only about 2% of the total area and the elimination might continue with increasing housing and cropland encroachment and the over- use for fuel and timber consumption.

Nevertheless, the homestead forests show the highest diversity in floral and faunal species in the area and they provide shelter for a number of threatened species and potential pest predators (see Appendix 1). They have an over-riding importance not only for the biological conservation but also for providing shelter and material for humans. Given the multiple-importance of homestead forests, it is remarkable that the development of homestead forests (social forstry) received only recently some attention. Also the assessment of impacts of flood control works on homestead forests received - in general - only little attention in previous studies.

The CPP area has some 2,212 ha of homestead land and this is occupied by urban and rural settlements, roads, ponds and homestead vegetation. Homestead vegetation comprises forests, plantations, homestead groves and kitchen gardens. A preliminary list of important trees, shrubs and herbs found in the CPP Sirajganj area is given in Appendix 1, Table E.15.

Forest. The Sirajganj CPP area has no public forests. Forests - in a wider sense - in the CPP are localized clusters of bamboo or tree thickets. All these forests are privately owned land. They are currently used for timber, fuelwood and other multi-purpose trees.

Plantations usually exist along roads. Fast growing exotic tree species such as mahagony, eucalyptus and epil-epil have been planted. Older trees such as babla, koroi and paia grow along the old Sirajganj-Bogra road. The verges of unpaved roads between or within villages are generally planted with multipurpose tress and shrubs. Roadside plantations are often damaged by straying cattle and smallstock. Few embankments have dense covers of grass (eg. vetiver grass) which is generally used as a source of fodder material.
There are, however, in the CPP area some planned efforts to establish grass covers or any other means of erosion control on river and road embankments. Recently, PROSHIKA has planted 83,820 trees within the homestead areas of subcompartments 4, 7 and 8 and 8,030 trees along 15 km of road in subcompartment 1 (Appendix 1, Table E16). Mahagony, Sissoo, Raintree and Eucalyptus are the main species.

Homestead plantations and gardens occupy about 55% of the rural homestead area. Some 15% are used for vegetable gardening. About 40 % of the households have small pieces of land ranging from 0.02 to 0.3 ha in extent.

> The homestead plantations are - in the elevated areas - dominated by bamboo (about 50% of the area), mango, jackfruit, betelnut, citrus and bananas. Debdaru is dominant in the adjacent lower areas. Timber, such as teak can be locally of importance.
>
> Among the vegetable species brinjal, cabage, sweetgourd, cucumber and chili are important cash crops wideliy grown in the lower lying palan areas.

Forestry Programmes. For forest plantations, the Department of Forestry (DOF) has taken up woodlot and agro-forestry programmes. However, there is no programme in the CPP area. In addition there are Thana afforestation and nursery development projects. Thana nurseries and nurseries of the DOF raise seedlings for public sale and for institutional and strip planting along roadside, railway lines and embankments.

4.4.3 Competition over Land Resources

Land is a scarce resource in the context of the Bangladesh environment. The rapid population increase over the past century resulted in a population density well above 1,000 people per km2. Consequently, the entire land is intensively used for agriculture, rural settlements, infrastrucuture and urban developments.

Most of the land is occupied by croplands. In the past, croplands expanded on the expense of waterbodies and fallow land and forests. This process is now almost completed. The trend of development shows that agricultural land will be - at slow rates - lost to urban developments and rural settlements because of the immense population pressure.

Land use competition

Competition occurs between various rural land uses and between urban and rural land uses. The region of Sirajganj is characterized by:

- the urban area of Sirajganj is constantly expanding on the expenses of agricultural land. The rapid growth of population (about 3%) and new industrial or commercial activities and infrastructure services occupy land especially at the eastern border, but also the southern and northern wards are expanding. The town occupies already some 1,100 ha gross area, including agricultural land within the Pourashava. This is about 9% of the total CPP area. It is expected that the town will expand by some 40% within the next 20 years. In 2010, the town will probably occupy some 1,500 ha gross area.
- rural settlements are rapidly expanding. They occupy already about 610 ha, ie. 5% of the land. Due to outmigration (in towns) the process will be less intensive than the town development.
- brickfields, usually associated with town development, occupy some 20 ha in Sirajganj CPP. Often, borrow pits leave infertile sandy layers exposed and this land is usually unsuitable for intensive cropping or fish ponds
- forests areas are already extinct and converted to homestead plantations; few plantations thickets exist as refuge for indigenous plant and wildlife species
- permanent waterbodies (beels) are continuously converted to seasonal waterbodies and eventually into terraced paddy fields. This process is virtually complete and only a few permanent privately owned beels are left (55 ha).
- some minor khals are also converted to terraced cropland and pressure on remaining khal sections will continue
- road infrastructure occupies already about 2 % of the total area. Because almost all roads are built on embankments, road construction is also combined with a loss of fertile topsoil in borrow pits.

Improved access facilities between villages and between rural areas and the town have still a high priority because they facilitate marketing of crops, migration, better access to public facilities and possible private or business links between local resource user groups and urban groups. Construction of new embankment roads may be continued on the expenses of further croplands.

4.4.4 Use of Energy and Non-Renewable Resources

Fuel consumption. The main source of fuel for cooking in the rural settlements are cow dung, dried leaves, sticks (jute or from multiple-purpose trees or bushes) and crop residues. In the urban areas some 30% of the households use kerosine whereas the rest depend solely on firewood for their fuel needs. Village people use kerosine only for lightning.

Fuel efficient tress such as neem and tetul are not extensively grown in the CPP area. Few plantations have been exploited by brick field owner in the southern part of the CPP. Currently, there are no programmes to encourage the development of such biomass fuel resources in the area.

Fossil energy resource. The use of non-renewable energy resources in the CPP area is low even compared to Bangladesh standards. Electricity consumption in rural households is very low and most energy is used for irrigation pumps. Approximately 700 households in the Sirajganj town use electricity as light energy source.

Building Materials. The continued use of fertile soils for construction purposes is enhanced by new road and river embankment developments and by the continuously growing demand for housing. Despite the lack of precise figures, it is estimated that probably 2-4 % of the total CPP area is directly effected. This, in fact, means a direct annual loss of propably some 500 ha of the countries fertile topsoil only in CPP Sirajganj. The long- term impact of this kind of land degradation need to be addressed in future, although existing economic analysis models might suggest that this is a minor issue.

During embankment construction, the fertile topsoil is rarely stockpiled to be used for revegetation. This waste of scarce resources occurs even at some construction sites under the responsibility of national institutions.

4.5 Public Health

4.5.1 Major Health Issues

The major human health considerations in the Sirajganj area are water-related diseases and nutrition. Originally, flood control and drainage projects are aimed at improved agricultural production and reducing harm to life and habitation or infrastructure. However, there is possibility that risks will increase for some water-related and vector-borne diseases, such as malaria and kala- azar, through the change of flood pattern and habitat conditions for a number of existing or potential disease vectors and water-related diseases.

This section provides a brief review of public health issues relevant for the CPP. It is evident that some communicable and non-communicable diseases need further attention during planning and operation of water development projects. Although most of these diseases will be less directly influenced by flood control and drainage works, they are still integrally linked to the hydrological and drainage changes which FCD brings about.

There is also an increased risk in few vector-borne and water-washed diseases. The most important health problems, however, are generated mainly by the poor socio- economic status of the population. Proper sanitation and good water and environmental management should be an integrated part of water development plans (see Section 4.5.3). The CPP should, in addition to agricultural and other production oriented goals in water management, aim at "The Need for Clean Water".

4.5.2 Important Water-related Diseases

Some decades ago, the country was hit by frequent outbreaks of epidemics of cholera, malaria and other diseases. This has caused high mortality. Recent achievements in public health services, but also environmental changes and a more secure nutrition were factors of a decreasing mortality rate.

The vigilance of health services in the CPP area is relatively favourable because of the vicinity of the district headquarter town of Sirajganj. The following services are provided within the Thana:

General Hospital Sirajganj, Eye Hospital Sirajganj, Child & Maternity Hospital Sirajganj, TB-Clinic Sirajganj, Rural Health Centre Khoksabari, Union Health Subcentres (total number six; three in CPP area).

Nevertheless, public health and nutrition are still in a poor state in the district. Most acute are problems of safe drinking water, sanitation and the lack of safe waste disposal.

Common diseases have a high rate of occurence and have a definite pattern associated with the flood and rainy season period. The known vector hazards include endemic diseases such as malaria, kala-azar and filariasis. Most important, however, are water-related diseases such as diarrhoea, bacillary dysentery, cholera, hepatitis and typhoid and parasitic diseases (FAP 2.1992.15; FAP 16.1992; FAP 16/19.1992). All are related to polluted sources of drinking water and to oral-faecal contact. The water-washed diseases include skin and eye infections such as scabies, yaws, leprosy, typhus, trachoma and conjunctivitis. The most important parasitic diseases are helminthic infections and there is little knowledge about such diseases.

Figure P1(Appendix 3) shows the prevalence of diarrhoeal diseases in the Sirajganj Thana during the year 1992. There is an increasing trend in the incidence of diarrhoea beginning in the month of August. The trend continues throughout the wet season reaching its peak on September. The general lack of safe drinking water, contamination of some shallow tubewell water and improper sanitation may cause the increase in incidence during the monsoon season.

Other water-borne diseases such as dysentry, jaundice and typhoid fever affect about 1/3 of the rural farm households (Sirajganj Health Department). There is an increasing trend in some of these diseases over the last years in the Sirajganj area. Prevalence of stagnant and polluted water used for bathing and washing by a large number of people act as the catalytic agent for such diseases.

A case study in the Northwest Region showed that dysentry is associated with frequent use of stagnant contaminated water. The prevalence of diarrhoea is relatively high in the Lower Jamuna Basin (including Sirajganj), ie about 1/4 of the people are affected, compared to some 14% as a national average and less than 10% in the Northern Jamuna Riverine areas (FAP 2.1992.15).

Also cholera, in epidemic forms causing several deaths, was reported in 1988 and 1991 in the Sirajganj District. During the 1991 epidemic, approximately 900 cases were reported. Similar trends exist for night blindness and anaemia, two nutrient deficiency diseases. Skin diseases are found to be epidemic in the area.

Table P1 (Appendix 3) shows the reported clinical cases in the Thana of Sirajganj for the years 1989 until 1992.

Malnutrition is a general problem for the Sirajganj area and a major concern for some rural villages. The household survey established a seasonal pattern of prevalence of malnutrition which is associated with the flood season, too.

4.5.3 Communicable Vector-Borne Diseases

The construction works for flood control, drainage and irrigation (FCD/I) affects the timing, depth, and duration of flooding and soil moisture thereby potentially affects the abundance of vectors and the incidence of vector-borne diseases. The CPP is expected to lead to widespread changes in flooding and drainage, with consequent potential changes in disease vector abundance and associated vector-borne disease risks to human populations.

There are three important communicable vector-borne diseases which have association with FCD/I projects in the region: benign malaria, kala-azar and filariasis. The summary assessment in Table P2 (Appendix 3) shows that there is only limited risk change due to future FCD works, although kala-azar risks may increase, under certain local conditions (FAP 16.1992.2). Further details are given in Appendix 3 under headings: vectors, environmental factors, vector control, recommendations and an overall risk assessment.

Other vector-borne diseases such as dengue fever and Japanese encephalitis are arboviruses transmitted by mosquitos. Although firm data are lacking, it is likely that prevalence is low. No association with embankments is expected (FAP 16.1992.2).

4.5.4 Need for Integrated Water Management Planning

The critical time for planning for water control and management is the condition in the low flow season when flushing and assimulation capacity is least. While rivers with large flows may be resilient (Jamuna River), complacency in relaying on the natural cleansing capacity of the rivers would be a dangerous development approach lacking responsibility for future generations. The rather poor distribution of access to clean water, sanitary latrines, and the rising water tables and flood conditions from river and local rainfall in the monsoon, leads to a distinct seasonal pattern in increase in gastro-intestinal and parasitic infections. When overlain on the impaired health already prevailing from nutritional disorders, the amplification effect is far more serious than the effects of both added together (FAP 2.1992.4).

Under conditions of FCD there are opportunities for integrating water-related public health issues, including sanitation, water supply and waste management, into an integrated water management plan on the regional or local level.

This would suggest, however, that also stricter controls, proper and enforced legislation, community awereness and participation, and the involvement of the urban sectors are the broad front required to ensure that important thresholds are not crossed (FAP 2.1992.4).

- The agricultural sector has to move to integrated pest management and the controlled use of pesticides, fertilizers and irrigation water
- Rural villagers and urban people have to adopt sewage recycling systems and safe liquid and solid waste disposal facilities.

The implications for planning are that agricultural and non-agricultural water supplies, sources and extraction technologies must be given more attention in FCD planning designs and specific monitoring programmes. Possible urban and rural health control programmes may be:

- sinking of tubewells at high elevations, ie above the average high flood level so that contamination during the flood season is reduced
- construction of latrines which meet minimum hygienic standards
- flood prepardness plans and the provision of medical supplies in emergency cases. District health institutions should maintain buffer medicine stocks. Such plans could include inputs from NGOs, cooperative groups and CPP water user groups
- construction of flood shelters at key locations; they should also be provided with adequate tube wells, latrines and proper sanitation
- promotion of cultivation of dry season vegetables and medicinal plants
- chlorination (or other adequate purification methods which avoid the harm of chlorination) of ponds which provide drinking water
- health education and awareness programmes
- use of flushing methods in khals or ponds to control vector habitats
- the general use of flushing for water-washed diseases must be carefully analysed because floods may contribute either to the spread of diseases or to the dilution of contaminated water. In the case of dilution, the natural degradation of organic constituents in a river or beel system must be assessed. River flushing should not be seen as a substitute for a properly planned and operated solid waste or sewerage disposal system.

4.6 Other Issues of Quality of Life Values

4.6.1 Cultural Heritage Sites

There are no previous archeological surveys within the CPP Sirajganj area. The FAP 2 study (FAP 2.1992.4) identified one site of archeological and historic interest in the CPP area, ie. the Sirajganj Ghat Temple which is a Hindu heritage site.

Other culturally interesting sites are all located within the town of Sirajganj such as former residental houses of Hindu families and hindu or muslim graveyards. All these sites are not impacted by planned activities of the CPP. The BRE embankment and other bank erosion control works along the Jamuna provide efficient protection from floods.

The planning procedure of CPP ensures that important sites of local heritage will not be affected. Local people will be consulted through water user groups before sites are selected for construction of embankments or regulators.

4.6.2 Socio-economic Welfare

Socio-economic issues are not part of this Annex because they are covered by other CPP Annexes, such as 1, 4, 5 and 8.

4.7 Sirajganj Town

Sirajganj town is the district headquarters. The total area of the town is some 1100ha and its estimated present population is about 132,000.

A household survey in 1989 (UDD 1991) showed that most income in Sirajganj town was generated in services and business: 33% from services, 31% from business, 19% from a combination of these, 13% from daily labour and 5% in agriculture (732 urban households were interviewed).

Water-related Infrastructure

Water supply and waste disposal facilities are poor even to Bangladesh standards. In Sirajganj town, only 6% of households have pipe water from the municipal piplines and about 75% have access to private or public tubewells (Table 4.10). In total 682 numbers of public urban tubewells are installed. They have an capacity of some 1.35 m3/hr. The daily abstraction during 10 hr of operation is estimated to some 9,200 m3. A water treatment plant delivers additionally some 1,400 m3/d through 726 numbers of water supply connections in the town (Map 4.10). The per capita daily domestic demand is calcaulated as 180 l/d. This would require the total supply of some 23,000 m3/d.

Table 4.10: Drinking Water Supply by Households (%) in Sirajganj Town

Dug well	6 %
Pond (private)	2 %
Tubewell (own)	75 %
Tubewell (neighbour)	10 %
Tap water	6 %
River/khal	1 %

Source: UDD (1991) survey in 1989

Data from DPHE show that some 2,267 numbers of latrines are there at present in the Sirajganj Pourashava (Table 4.11) and they cover only about 22% of the total needs for human waste water disposal and sanitation facilities of the town.

Table 4.11: Latrines in the Town of Sirajganj

	Number
Sanitary latrines	1,000
Bucket latrines	590
Water sealed latrines	525
Pit + cummunity latrines	152

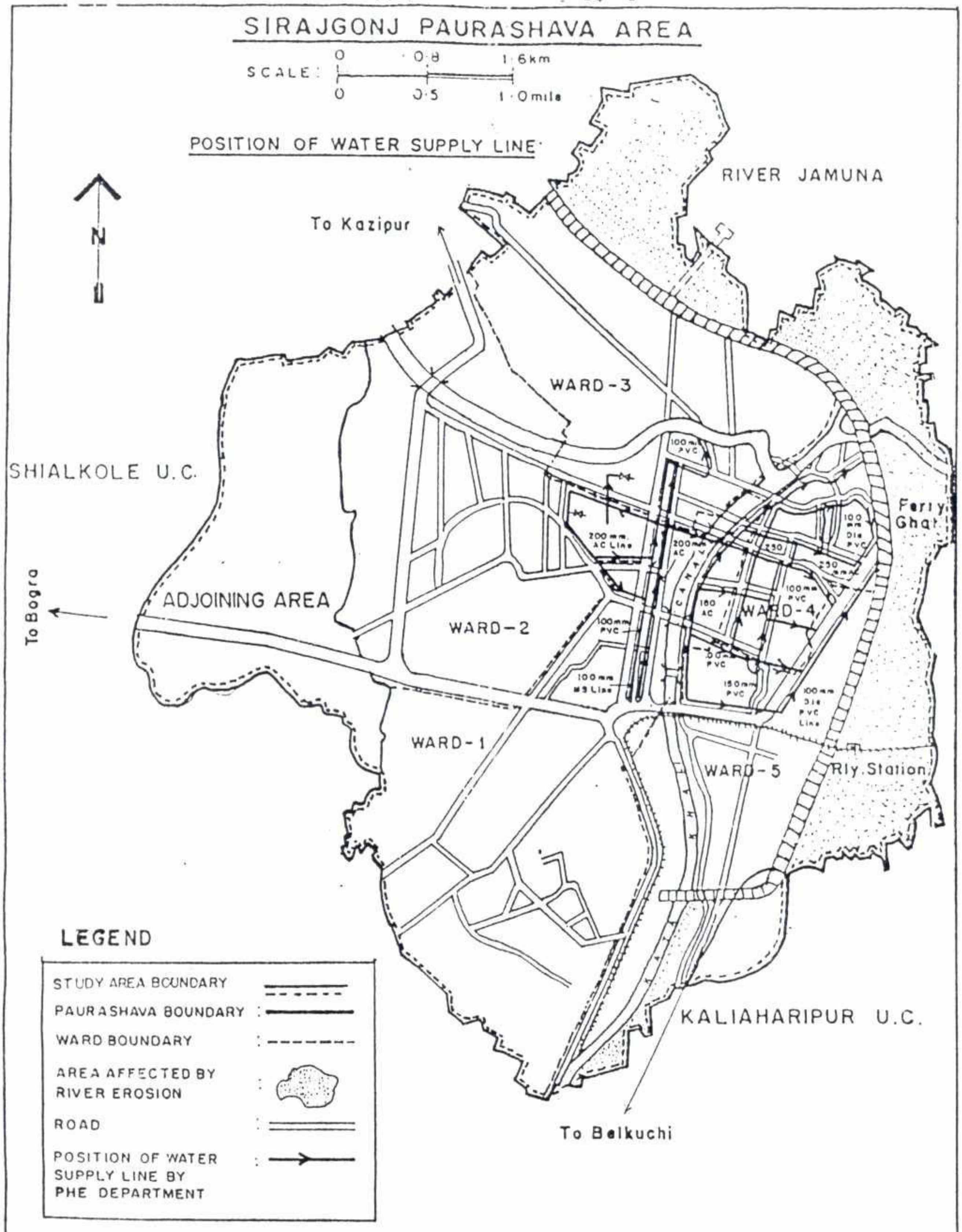
Source: DPHE, CPP urvey 1993

Specific drainage facilities like storm or house sewer and drainage systems for industrial waste disposal are absent. Natural systems such as channels and rivers are being used for all kind of waste disposals from the town. This is especially the Katakhali khal and some ponds through 8.4 km pacca drains and 14 km kutcha drains.

Drainage Congestion

Haphazard development within the Pourashava area has disrupted the natural water courses and this has become one of the major constraints for proper drainage within the town. As a result, Katakhali khal suffers water congestion and drainage problem in almost all seasons of the year. This khal also suffers back water flow from the Ichamati river during flood period and this causes inundation of most of the areas of ward-3 and ward-5 of Sirajganj town. Rain water and seepage water congestion in the low lying areas, ponds, ditches and borrowpits during the monsoon and post monsoon period is very common. This problem is more acute near the stadium area in ward-4 and in ward-5. The whole area of ward-3 and ward-5 of Sirajganj Pourashava is flood prone. BRE serves as an effective barrier against flooding of Sirajganj town. But unless it is properly maintained and the Katakhali khal is opened and re-excavated at its south end there will be the problems of drainage and flood damage.

Map 4.10: Position of Water Supply Line in the Sirajganj Town



Source : Public Health Engineering Department, Shirajgonj zila (October, 1989)

Land Uses

Land use survey results of the Sirajganj Pourashava and some of its adjoining mouzas namely Sialkol, Chawk Sialkol, Raghunathpur, Fulbari and Bera as conducted in October 1989 are summarized in Table 4.12 and land use pattern is shown in the Map 4.11. Agricultural land constitutes the major portion of the survey area and accounts 47.28% of the total land. Residential area is next to agricultural land use and covers 25.57%. Most of the commercial and industrial lands (5.16%) are in ward-1. Recreational areas are in the east central part of the town and accounts only 0.17%.

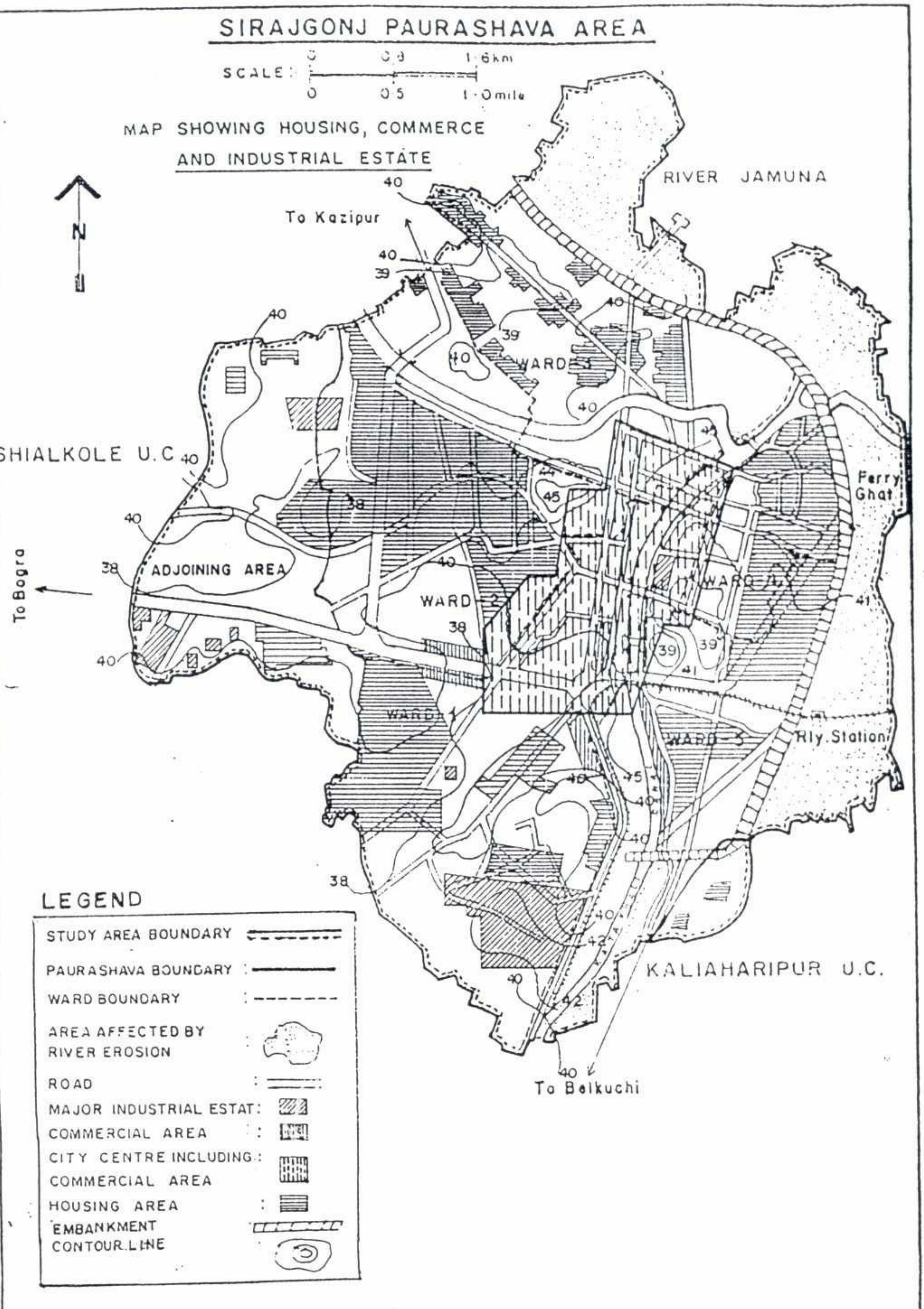
Table 4.12: Existing Land Use Pattern of Sirajganj Pourashava and its Adjoining Areas (October 1989)

Type of Land Use	Pourashava Area, ha	Adjoining Area, ha	Total Study Area, ha	% of Total Area
Commerce & Industry	71.93	6.60	78.53	5.16
Education	23.80	0.55	24.35	1.60
Health	5.94	-	5.94	0.40
Administrative	24.13	0.49	24.62	1.62
Recreation	2.63	-	2.63	0.17
Socio-culture	10.63	-	10.63	0.70
Urban Services	5.84	3.03	8.87	0.58
Residential Area	351.79	36.65	388.44	25.57
Roads	83.64	12.63	96.27	6.33
Railway	95.88	-	95.88	6.31
Water Bodies	63.07	1.47	64.54	4.24
Agriculture	422.21	296.15	718.36	47.28

Source: Land Use/Master Plan, Sirajganj Pourashava, May 1991.

The population of the Sirajganj town and its adjoining villages is forecasted to be 297,303 by the year 2001 and this will require an additional residential land of 175 hectare (Source: Land Use/Master Plan, Sirajganj Pourashava, May 1991). The eastern and middle parts of the town has already become congested. However western part of the town still provides some scopes for localizing new sub-centres and neighbourhood centres for the extension of Sirajganj Pourashava area.

Map 4.11: Land Use Pattern of the Sirajganj Town



Source : Field Survey (October, 1989)

5 SUMMARY OF MAJOR ISSUES OF ENVIRONMENTAL CONCERN

5.1 Perception of the People

A field survey was conducted within the Sirajganj CPP in March 1993 on people's views regarding their current water related problems and possible solutions. The extracts of the survey results are summarized in Appendix 6 for nine subcompartmetns.

Flood from the Jamuna and Ichamati Rivers and water congestion in the khals, stagnant pools, ditches and low lying areas have been reveived as the common environmetnal problems from all sub-compartments of CPP. People are very much concerned regarding any flood risk from BRE breaches and from the Ichamati River. It is believed by the majority of the people that stable BRE with water regulatory sluices, embankment along the left bank of the Ichamati River, re-excavation of khals and canals, and drainage improvement by increasing the number of culverts along the existing roads could be the best solution for these problems.

But some people in SC 1 apprehended that stabilization of the BRE is not possible due to river erosion. They suggested that all village roads should be upgraded as embankments to stand against flood hazards. People from SC 1 and 3 suggested the construction of a series of groynes accross the BRE to stop river erosion. Problems like sand deposition on agricultural land and siltation of river and khal beds have been noticed in SCs 2,3,5,6 and 7. They were complaining about a gradual reduct on in soil fertility of croplands in some areas and they were forced to change cropping pattern from paddy to sugarcane. Further land deterioration might even hamper sugarcane cultivation.

Drought and dry wells in the winter season are amongst the major issues in SCs 1,4,5,7, and 8. Many people believe that complete flood protection by the BRE has created these environmental problems. Other important issues were the destruction of homestead vegetation for firewood, high mortality of livestock and poultry due to lack of fodder and vaccination, extensive fish diseases, diarrhoea and other water borne diseases, and lack of drinking water, municipal drainage, sewerage, sanitation and health care facilities in the different SCs.

People living in Siragjanj town are more concerned about environmental issues, especially related to public health, than rural villagers.

5.2 Sensitive Environmental Resources and their Impairments

Sensitive resources which require further attention in environmental impact analysis for the CPP include:

- Permanent swamps (beels). Seasonal or intermittently flooded wetlands have various values for fauna and flora and human uses (common goods); wetlands are very sensitive to changes in flooding pattern; they are impaired by cropland (paddy) encroachment

- Fauna and flora which depends on these wetland habitats, including freshwater capture fisheries; impairments are - in addition to habitat destruction - caused by overuse, pollution and biological imbalances (aquatic weeds, pests/diseases and animal imbalances)
- Biological balances between various species are valuable for pest controls; impairments are caused by habitat destruction (wetlands, homestead forests, trees or bushes in open croplands) or modern agricultural practices such as indiscriminate use of agrochemicals, irrigation, cropping pattern, tillage and cultivation practics
- Homestead forests and plantations. They provide the highest number of wildlife species and a number of common goods; they suffer from continuous overexploitation and conversion to rural settlements
- Groundwater resources. They are under continuous stress of human uses (namely irrigation), reduced recharge due to flood protection and human-made chemical or biological impairments such as organic-faecal, agrochemical pollution or toxic emissions from urban industrial or cottage industry sources
- Surface water resources. They are impaired by changes in flood pattern and organic pollution
- Soil resources. Soil fertility provides the basis for agricultural production; soils are impaired by changes in inundation occurence and length, and by modern agriculture practices and reduced recycling of biomass production
- Livestock. Changes in land use pattern and the overexploitation of homestead vegetation contributed to the decline in livestock production
- Biomass energy. There is severe shortage due to overexploitation of homestead plantation or other resources, underutilization of potential land and changes in cropping pattern.

Public health. Some diseases are affected by changes in flood pattern, channel and land drainage improvements; communicable diseases such as vector-borne and water-based diseases are a major hazard in the region; some vector-borne diseases have potential for epidemics, others are caused by very poor sanitation standards in rural and urban areas.

The current state of these sensitive resources is tentatively assessed in the EIA-matrix (Section 6.3). The impairments or hazards are of serious concern include:
- extinction of wetland resources
- reduction in beel and floodland capture fish habitat
- terrestrial and aquatic biological imbalances
- organic water pollution
- water-related communicable diseases
- shortage in availability of biomass energy
- shortage in fodder for livestock.

There is also likely an increasing trend of
- reduced groundwater availability
- chemical water pollution
- soil fertility degradation
- diminishing of wildlife species.

5.3 Environmental Risks in the CPP Area

Environmental risks are related to natural hazards and to risks arising from CPP activities or general trends outside the direct control of the CPP. All hazards and risks are important in the context of compartmentalization developments and need to be adequately addressed in the environmental management plan.

Natural hazards in the CPP area are related to agro-ecological and hydrological or physiographic features. They make the CPP area vulnerable to seasonal river floods, river bank erosion and land losses, siltation of beels, sedimentation of khal, waterlogging, sand deposition during BRE-breaches, heavy rainfall and winds during thunderstorms, droughts and pests. Almost all subcompartments are affected (see Section 5.1), although the nature, extent, duration and frequency of risks and damages largely depends on land levels and BRE-breaches. The key problems related to floods in various subcompartments are already assessed in Section 4.1.4. The types of loss or damage can be categorized by direct or indirect and tangible and non-monetary factors:

Type	Tangible	Non-monetary
Direct:	House damage	Loss of life
	Crop damage	Malnutrition
	Loss of land	Resettlement
	Livestock loss	Epidemics
	Smallstock loss	Waterlogging
Indirect	Loss of income	Change in habitat
	Transport disruption	Household disruption
	Loss in business/trade	Educational & health Services disruption

Modified after FAP 16.1992d:5-92

Human-made hazards are related to organic and solid waste pollution of water resources due to poor hygienic standards, the lack of adequate waste treatment or disposal facilities.

The overexploitation of natural resources such as water, fauna and flora is related to irrigation developments and the scarcity of biomass for fodder, fuel, timber, food or other uses as common goods.

Technical hazards arise from the indiscriminate use of agro-chemicals and chemical pollution from cottage industry and other urban commercial activities or industry.

Management related risks are associated with poor maintenance and operation (O & M) of water control structures such as embankments and regulators. Technical risks include dam leakages and regulator blockages beyond the control of normal O & M.

6 POTENTIALLY SIGNIFICANT IMPACTS FROM FLOOD CONTROL AND DRAINAGE WORKS

6.1 Existing Status: Impacts from the BRE

The CPP Sirajganj borders the Brahmaputra Right Embankment (see also Sections 4.1.4 and 4.1.5). Since 1963, the BRE has changed the hydrological conditions in the floodplains along the Jamuna River. The most important changes are associated with agriculture, livestock, fisheries, nutrition, social impacts and other environmental impacts. The findings of a survey at the Kazipur reach, just north of the CPP Sirajganj area are summarized here (FAP 12.1991). Due to similar flood and land use conditions, they apply especially for the northern part of the CPP Sirajganj which is also seriously affected by BRE-breaches.

- Land Use. The situation did not change significantly regarding net cultivated area. The area of permanent beels decreased from 63 ha to 14 ha.
- Agriculture. As projected, the BRE did successfully change the previous crop cultivation and cropping pattern of B.Aus/Jute-B.aman-minor rabi crops into a B.Aus/Jute-T.Aman pattern or, in recent years with increased irrigation, into HYV Boro-HYV T.Aman pattern. This change in cropping pattern (and associated irrigation and input developments) caused an increase in total rice production from some 5,000 to 8,000 t/a. Minor rabi crops are now more diversified, although area coverage especially in pulses and oilseeds decreased. Cropping intensity remained unchanged (177 versus 176 %).
  The re-emerged risk of annual flooding due to breaches has seriously reduced the scope for monsoon season crop intensification in the breach-affected areas, eg. the northern parts of the CPP Sirajganj area.
  The increase in paddy production, especially irrigated Boro, has increased rat infestation.
- Livestock. The number of goat and cattle has declined since 1984 due to abrupt and severe inundation caused by embankment breaches/flooding and shortage of straw for fodder from HYV paddy production in the monsoon. HYVs, although they produce more straw, are reluctantly accepted by the cattle due to their high lignin content. Rabi crops (especially pulses) were intensively grown in the pre-breach period and provided good sources of feed. Cropping pattern changes removed local T.Aman which provided good quality straw and after the early harvest the lands were fallow and were used used for grazing. Small earthen bunds which divided plots supported growth of winter grasses (*Cynadon ssp. and Auxonopus ssp.*).
- Fisheries. A marked decline in open water capture fisheries was caused by:
  * the blockage of fish migration routes from and to the Jamuna river, beels and floodplains
  * reduction of aquatic habitats (khals, beels, floodplains) suitable for fish spawning and breeding
  * reduction of wild spawning collection in the river
  * annual flooding due to breaches, limiting the scope for pond culture fisheries.

A marked decline in catches is especially observed in floodlands (from 22,000 t in 1983 to 5,000 t in 1988), but also beel fisheries declined.

- Nutrition. People's nutritional status, especially that of woman and children, has deteriorated, due to decline in fish and pulse production and the high rate of population increase (2.4% in 1981). Overall, food scarcity seemed less frequent after the BRE, as cultivation of more than one crop was secured. However, with frequent BRE-breaches, the intensity of paddy production has declined and the Kazipur area remains a deficit area.
- Overall Environmental Evaluation. The BRE succeeded in protecting the area from Jamuna flooding until 1984, but the situation worsened when severe bank erosion caused frequent breaches of the embankment leading to a series of retired embankments and further losses of agricultural land. The increased sand deposition in breach-affected areas deteriorated the lands which is only suitable for sugarcane production. Frequent breaches increased the extent of wetland and seasonal waterbodies since 1984, although permanent waterbodies decreased.

The FAP 12 study concludes that there were no significant impacts on the fauna (except fisheries) caused by the BRE because the decline of migratory bird communities and their habitat was almost complete in 1963 (pre-BRE) and any further deterioration was a function of human population increase rather than the BRE. The same would apply to other macro-fauna such as mammals, reptiles, amphibians etc. For example, homestead forests are destroyed inside and outside the BRE impact areas. However, the study admits that the lack of historical data does not permit detailed impact analysis. Similar trends are attributed to the status of flora.

Summarizing, the negative impacts of the existing BRE are: decrease in soil fertility and change of soil physical characteristics, decline in capture fisheries, failure to achieve institutional effectiveness and encourage public participation and the deterioration of social attitudes. An overall scoring of physical, biological and human environmental impacts is shown in (FAP 12.1991).

6.2 Conceptual Impact Analysis

At this planning stage only a conceptual assessment of likely impacts is possible. The following additional data would be required for a full assessment including the quantification of impacts:

- detailed hydrological data on flood pattern and regime for CPP options 1, 2A and 2B for three hydrological scenarious: low flood (1:2 year), average design flood (1:5 year) and high flood (1988 conditions) and for each subcompartment
- detailed assessment of cropland damages for three hydrological scenarious (as above) for each subcompartment
- the hydrological cycles and associated flood hazards need to be assessed in detail, except for BRE-breaches which are in any case disastrous. However, the specific relation between drainage congestion and minor river floods (Ichamati, or controlled Jamuna inflow) is not well established for the Sirajganj CPP. Existing assessments of

river flood damages are only tentative (Section 4.1.4). Further hydrological studies are required to evaluate whether drainage improvement and flood proofing of homesteads would be efficient (and probably sufficient) to reduce flood risks to such a degree that additional benefits of main regulators (river in- and outflow), internal regulators and especially embankments would only be minimal. Such an alternative concept would have the benefit of minimum interference in hydrological cycles and associated environmental impacts would be minimal.

- predictions of changes in agricultural land use (cropping calendar) and the likelyhood of crop damages by floods with these new cropping patern
- design criteria for structures (sill level, discharge capacity)
- regulator operational rules, because much will depend on "how the regulators will be operated"
- assessment of institutional (or water users group) aspects, ie. the likelyhood that the operation will follow these operational rules, taking into consideration the conflicting interests amongst various farmers and between farmers and fisheries interests or other environmental aspects such as conservation of key wetlands and public health aspects (see Section 6.3).

The CPP aims to introduce a controlled water regime, to create a terrestrial environment on higher ground, and to divert water quicker through the river network (rivers and khals). Further, flood hazards from BRE-breaches should be contained within compartments to allow a safe release towards the Ichamati River and its tributaries. These physical diversions modify the physical-chemical, biological status and human resource uses and eventually the quality of life values inside and outside of projects.

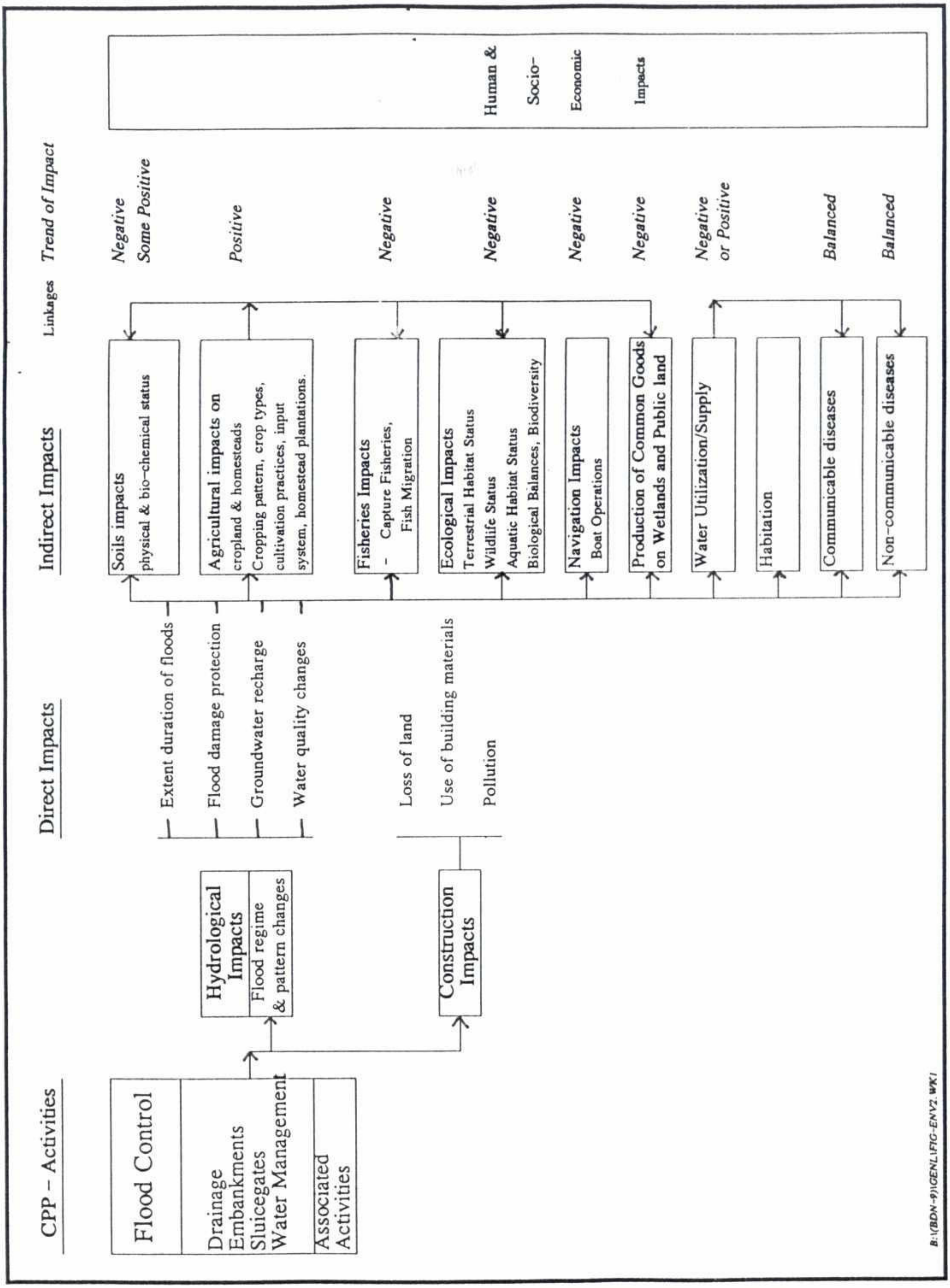
FCD is a source of <u>hydrological change</u>. It causes direct effects on river regime and flood pattern and subsequent changes in surface water and groundwater, soil, fauna and flora resources status (see Figure 6.1). Potential higher order impacts are the following effects:

- direct interference into wetland status (seasonal and permanent beels, seasonal floodplains)
- intervention in water resources which are important for users such as fisheries, navigation and water supply
- changes in terrestrial habitats and land use pattern due to changes in flooding pattern.

<u>Direct Impacts</u>. In CPP Sirajganj, the following hydrological elements are likely to be affected:

- seasonal flood pattern through embankments, regulators and re-excavation of khals or new canals
- changes in flood volumes, ie. retention time of both rainfloods and monsoon river floods from either the Ichamati and Jamuna Rivers, through controlling inflow and outflow in various subcompartments
- bank erosion through control works.

Figure 6.1: Impact Network for CPP Activities



The following environmental elements will be directly affected:

- wetlands such as khals and beels; their future water supply will depend on the construction of inlets and outlets, the operation of these regulators and the implementation of wetland conservation measures
- distribution of land types, ie. F0 to F3 lands (Note: the magnitude and duration of changes will be analysed in detail at a later stage)
- waterlogging on floodplains status will be significantly modified, depending on land elevation, soil drainage conditions and drainage improvements in khals
- drainage congestion in khals will be reduced, depending on re-excavation and other structural works
- flood damage by BRE-breaches: area, extent and duration will be signifcantly modified
- groundwater availability through a decreased recharge during the flood season
- homestead settlements and plantation through improved protection from floods (extent, duration)
- soil moisture status will be changed through reduced extent and duration of inundation.

Indirect Impacts. Higher order impacts are related to increased agricultural production through likely changes in cropping patterns and the adoption of new agricultural technologies, including irrigation which seeks to mitigate drought in the dry season. Effects are likely becoming effective in the medium term because compartmentalization will only provide a more secure environment for agricultural development and will not directly interfere by a development programme. There are several environmental effects at risk which are related to soil fertility and water quality (see Section 5.3).

- cropping pattern is likely to shift to HYV Aman, to HYVs of Boro, from single to double and triple crop patterns, and a diversified system in the dry season
- crop types and varieties will change with subsequent changes in cultivation practices with long-term effects on mechanical soil properties and soil nutrient status
- increase in cropping intensity
- increased use of fertilizers
- increased application of pesticides
- probably an increase in irrigated area.

Further indirect impacts occur on fauna and flora which depend on wetland habitats:

- pre-monsoon wetland habitat will be reduced (Note: the extent cannot be determined at this planning stage)
- monsoon wetland habitat will slightly be reduced; however, there are still planning and operational options to facilitate controlled flooding which can establish a flood pattern and extent close to the natural flood regime.
- post monsoon wetland habitat will significantly be reduced by improved land drainage.
  Mitigation: select key wetland sites to implement a wetland conservation programme, see Chapter 8)

Other indirect impacts are related to human uses of natural resources:

- water resources: likely impacts on communicable diseases, water supply systems, sewage systems. Likely impacts on public health is already assessed in Section 4.5. Groundwater contributes to water supplyand likely changes in water tables can lead to water supply shortages. Changes in water quality can occur due to modifications in flood pattern and increasing levels of water pollution; both will have impacts on domestic water supply and personal hygiene (potable water, washing, bathing etc.). Seasonal navigation within khals and from khals into the Ichamati can be hampered by sluices.
- wetlands provide a variety of common goods such as aquatic and semiaquatic plants and fish. Depending on continued reductions in wetland habitats, a further decline is likely to occur for such common good uses; mitigation can compensate for such losses in key wetland areas
- bioresources from highlands such as homestead plantations and embankment plantations are under continuous stress from overexploitation. Some of these resources are regarded as common goods for food, fodder, timber and biomass fuel. The CPP will increase embankment areas and is likely to improve growth conditions of terrestrial habitats.

6.3 Preliminary Project Impact Matrix

Table 6.1 shows a summary of rapid environmental appraisal of CPP development options 1, 2A and 2B. All options are verbally assessed in the following paragrapahs.

The environmental impact matrix is presented for the preferred option 2B in Table 6.2. The matrix provides information on important environmental elements:

- top priority issue from the planner's point of view and from the perception of the affected people
- status quo: a tentative assessment of the current state of the resource is shown. The ranking is subjective and indicates an increasing degree of impairments or severity of an environmental problem
- without project: a qualitatative prediction of the development of the resource is shown; the rating indicates a positive (+) or negative (-) change or unchanged (o) conditions.
- with project and without/with mitigation: a qualitatative prediction of the development of the resource is shown
- subjective scoring: the assessment is performed on predicted negative or positive impacts. The following criteria are used: sustainability, reversibility, sensitivity, magnitude and rate of impacts. Details of the procedure are given in the EIA case study for Tangail CPP (FAP 16/19.1992). The scoring was done within a 11 point scale from -5 to +5.
- mitigation possible and costly: self explanatory
- recommendation: self explanatory.

All analyses are preliminary and much depends on conceptional model predictions at this planning stage (see Sections 1.2 and 1.3). Further limitations to project assessment are discussed in Section 6.6.

The rather unique approach of CPP of stepwise planning and implementation leaves sufficient space for future amendments or even corrective measures before final implementation and operation starts. On many areas information specific to the CPP area was not available, such as present environmental pollution, soil fertility, terrestrial and aquatic habitat status, urban health situation and the fate of organic pollutants during floods. Further baseline surveys and monitoring are proposed (Chapter 8).

Figure S1 (Summary) shows the holistic environmental appraisal of CPP option 2A with or without mitigating measures. The impact valuation assumes that there are beneficial or adverse project impacts. The appraisal shows that the predicted effects can be compensated or reduced if mitigating measures and associated programmes are implemented within the framework of an environmental management plan. A further assumption is that the environmental planning and design criteria are observed and good water management practices are applied during operation. This would require:

02

Table 6.1: Rapid Environmental Appraisal for the Development Options of CPP Sirajganj

Environmental Elements	OPTION-1	OPTION-2A	OPTION-2B
Containment of BRE-Breach Flood	+1	+4	+4
Regular Flooding of Croplands	+3	+2	+1
Drainage Improvement	+3	+2	+2
Groundwater Availability	-1	-2	-2
Soil Fertility Maintenance	-1	-2	-2
Surface Water Quality	?	?	?
Groundwater Quality	?	-1	-1
Aquatic Habitat Status	0	-2	-3
Wildlife Threat	-1	-2	-3
Terrestrial Habitat Status	+1	+2	+2
Biological Imbalances	-1	-2	-3
Capture Fisheries	-1	-2	-3
Culture Fisheries	0	0	0
Crop Diversification	+1	+1	+1
Crop Intensification	-1	-2	-2
Crop Production	+1	+2	+2
Homestead Plantation	0	0	0
Embankment Plantation	0	0	0
Biomass Energy Availability	0	-1	-2
Fodder Production	0	-1	-2
Communicable Diseases			
Water-based	0	0	0
Vector-borne	0	0	0
Non-Communicable Diseases			
Occupational Risks	-1	-2	-2
Water Pollution/Sanitation	0	0	0
Construction Impacts			
Land Aquisition/Losses	-1	-2	-4
Building Materials	-1	-3	-4
Pollution/Spillages	-2	-3	-4
External Impacts of Contained Rivers	0	-3	-5
Overall Index	Minor Impacts	Medium Impacts	Major Impacts

Scoring system = +5 to -5

Table 6.2: Preliminary EIA Matrix of the CPP Sirajganj (Option 2A)

ENVIRONMENTAL ELEMENTS	Priority Issue of CPP		Current Status 1 to 10	Without Project	EXTRA IMPACTS OF CPP With Project (Option 2A)		Subjective Score	Enhancement or Mitigation		Recommendation
	Planner	People			Without Mitigation	With Mitigation		Possible	Costly	
Regular flooding of cropland	Yes	Yes	7	0			+2	desired goal of CPP		Monitoring of flood extent & land use changes
F0				+	+					
F1				+	-					
F2				-	-					
F3				-	-					
Beel				-		0				
Cumulative off-site effects of contained rivers				0	-	-	-2			
Flood-free land for homestead			3	0	+		+2			
Loss of land to river bank erosion			8	0	0		0			
Containment of floods in event of BRE-breach	Yes		8	0	+ off-site - local		+2			
River flood damage			7				+2			
Homesteads				0	+					
Cropland				0	+					
Infrastructure				0	+					
Rain flood damage to cropland			5	0	+		+2			
Drainage network conditions	Yes	Yes	7	-	+		+4			
Groundwater availability	Yes		2					partly by controlled flooding	low	Groundwater level monitoring
Flood season drawdown				-	-	0	-1.5			
Dry season drawdown				-	0					
Irrigation supply				0	0					
Domestic water supply				-	-	0				
Water quality	Yes						-1.0			Water quality monitoring; Best management practices; Sanitation
River/khal water			3	-	-	0		Yes		
Ground water			3	-	-	0		Yes		
Beel water			6	-	-	0		Yes		
Soil quality							-1.5			Monitoring of soil fertility; Best management practices
Physical status			3	-	-	0		Yes	moderate	
Bio-chemical fertility			4	-	-	0		Yes	moderate	
Soil contamination			2	-	-	0		Yes	moderate	
Aquatic habitat status	Yes		7				-1			Wetland conservation plan for key areas
Pre-monsoon				-	-	0		Yes	moderate	
Monsoon				-	-	0		Yes	moderate	
Post-monsoon				-	-	0		Yes	moderate	
Terrestrial habitat status			5				+1	desired goal of CPP		
Pre-monsoon				0	+					
Monsoon				0	+					
Post-monsoon				0	+					
Wildlife			7				-1	Yes	moderate	Ecological survey; Enhancement of threatened aquatic habitats in key areas
Endangered species				-	-	0				
Threatened species				-	-	0				
Presently common species				-	-	0				
Biological imbalances	Yes		6	-	-	0		Yes	moderate	IPM-programme
Capture fisheries	Yes	Yes					-2			Enhancement proposals for selected beels (Fisheries Project)
River			5	0	0	0				
Beel			8	-	-	0		Yes		
Flood plain			9	-	-	-		Yes		
Culture fisheries			6	0	0	+	+2.5	Yes		
Crop production	Yes	Yes	3	0	+		+3	desired goal of CPP		Introduction of more non-rice crop
Crop diversification			2	0	+					
Cropping pattern & intensity			4	0	+					
Homestead plantation			5	0	0	+	+2.5M	Yes		Homestead and embankment plantation
Embankment plantation			9	0	0	+	+2.5M	Yes	moderate	
Biomass energy production		Yes	8	-	0	+	+2.5M	Yes	moderate	
Fodder production			8	-	0	+	+2.5M	Yes	moderate	

ENVIRONMENTAL ELEMENTS	Priority Issue of CPP		Current Status 1 to 10	Without Project	EXTRA IMPACTS OF CPP With Project (Option 2A)		Subjective Score	Enhancement or Mitigation		Recommendation
	Planner	People			Without Mitigation	With Mitigation		Possible	Costly	
Public health							+1 M	Yes		Public health survey; Environmental manipulation & management; Sanitation facilities
Communicable disease										
Water based/washed			7							
Community vulnerability				-	-	0			moderate	
Environmental receptivity				-	0	+				
Vigilance of health service				0	0	+			moderate	
Communicable disease										Co-operation with health services and flushing of rivers
Vector - borne disease			4				0			
Community vulnerability				-	-					
Environmental receptivity				-	0	+				
Vigilance of health service				0	0	+				
Non-communicable disease							+1.5M			Safety precautions during construction; Integrated sanitation and waste management
Occupational risks			3	-	-	+		Yes	high	
Urban water pollution			6	-	-	+		Yes	high	
Rural water pollution	Yes		8	-	-	+		Yes	moderate	
Waste disposal facilities	Yes									Integrated sanitation and waste management
Urban			6	-	0		+1M	Yes		
Rural			5	-	0	+	+1M	Yes		
Water supply facilities		Yes						Yes	moderate	Urban and rural area water supply facilities
Urban			6	-	0					
Rural			8	-	0					
Navigation										Design and operation of sluices
Major river			2	0	0	0				
Beel/khal			7	-	-	+	+1M	Yes		

Notes:
- Priority issue = Only the most important issues are addressed here.
- Current status = Existing state of the environment; Subjective rating, 1 = excellent/no impairment, 10=impared/extinct
- Impact rating = + positive change; 0 unchanged; - negative change
- Subjective score = The system follows EIA-guidelines by FAP-16, +5 to -5, criteria are sustainability, sensitivity, magnitude and reversibility type of change; scoring is without mitigation measures unless mentioned as M=Mitigation.

- the active participation of target groups to ensure proper operation and maintenance
- efficient institutional co-operation
- the committment at all levels to maintain a wetland ecosystem to the benefit of future generations and for the production of common goods in addition to short-term production oriented development targets.

Rapid Assessment of CPP Options

The CPP proposes three technical options (Section 2.2). These are evaluated in qualitative terms as compared to the without project case.

Without project case

Overall, existing impairments wi'l continue to deteriorate the situation of shortage and overexploitation of natural resources. Environmental insecurity related to natural hazards and risks arising from previous interferences in the floodplain ecosystem will remain or will increase.

- Risks of untimely flooding of cropland will further continue and flood damages will increase in all subcomportamtns, mainly caused by BRE-breaches.
- Impacts on land types: see agricultural report
- Drainage congestion will further increase due to continued human-made obstructions

and natrual sedimentation within khals.
- Groundwater availability will continue to decrease because of full flood protection from BRE and increasing abstractions for irrigation and domestec water supplies.
- Soil fertility will probably decline due to soil fertility impairments of modern agricultural systems.

Surface and groundwater quality will further deteriorate due to poor enforcements of environmental legislation, increased use of agro-chemicals, increased urban and rural cottage industry pollution. Microbiological pollution will increase due to increased population and poor sanitary and hygienic standards and the lack of sewage and waste disposal systems.

Aquatic habitats will further decline due to unplanned conversion of wetlands to croplands in the absence of regional land use plans.

Habitats of aquatic species will further decline. Fauna will be threatened by increased uses in agro-chemicals. Terrestrial fauna and flora will further be impaired by a reduction in crop diversity index.

Capture fisheries will further decline in wetland habitats such as floodlands, beels and minor rivers/khals (see Annex 5, Fisheries).

Homestead products and the availability of other common goods will probably become increasingly scarce with growing demands. Existing development programmes are either insufficient to meet future demands. Underutilization of some natural resources (eg. homestead and embankment plantations) is likekly to continue.

Public health hazards will probably remain unchanged, although the risks of epidemics can increase with low nutritional status, increase in water pollution and decrease in access to safe potable water.

Seasonal and country boat navigation will further decline because of increased khal sedimentation.

Option 1: Compartmentalization but without Ichamati embankment

The hydrological regime and flooding pattern from the Ichamati River (without BRE breaches) is under investigation. Assuming that damaging floods from the Ichamati are rare and that maintaining normal floods is a desirable target, this option has the advantage of "minimum interference in hydrological cycles". However, if it proofs that Ichamati floods (ie. spills over the river bank) are at risk for croplands even in normal years, then an embankment would reduce flood risks to agricultural production.

In case of prolonged BRE breaches, option 1 has the disadvantage of irregular and probably disastrous flooding of croplands especially in subcompartments 4 and 5 and 8.

The ecological advantage of option 1 would be the preservation of seasonal wetlands along the Ichamati River (subcompartments 4, 6 and 8). The area extent of such seasonal aquatic habitats must be determined by hydrological calculations. It is estimated that around 2,000 ha can benefit, especially monsoon and post-monsoon wetland habitats, including fisheries and other wetland fauna and flora. There would be minor effects in normal years, ie. if no river bank overspill occurs. The regulators at the khals are sufficient to allow for water management similar as in options 2A and 2B.

Other subcompartments are not or marginally affected by the Ichamati embankment and other impacts would be similar as in options 2A and 2B.

Option 2A: Compartmentalization with Ichamati embankment

Alignment follows existing roads

This option permits full control of floods within all compartments. Hence, regular flooding of croplands is posible to the extent that water management groups agree on operational rules.

Drainage congestion, a major hazards from rainfloods and impeded land drainage, is mitigated for. Drainage can be improved especially in the post-monsoon season to allow early planting and crop damaged in the pre-monsoon and monsoon season by short peak of flood levels can be mitigated by rapid flow into the khals and rivers.

Flood damage to croplands is mitigated and damages to livestock and humans or infrastructure are minimized. In the case of local BRE-breaches, water will be contained for some days within the upper subcompartments (closer to the breach). Hereby, flood damages in adjacent subcompartments is avoided or minimized.

Groundwater availability will slightly decrease because less floodwater will be available, land drainage will accelerate runoff and sandier highlands with higher percolation rates are less frequently flooded. The decrease of recharge will depend on the amount of volume of floodwater which is hampered to enter the floodplains during the floodseason. Probably, an average reduction of some -10 to -40% in potential recharge will occur (see Appendix 2). The overall effect of flood protection is a steepening of the rainfall-recharge response, and probably a marked reduction of recharge occurs in high flood years. On the other hand, CPP has the potential to mitigate for overriding negative BRE- impacts which already completely disrupted the floodplain ecosystem. If properly designed and operated, the CPP can even improve the groundwater recharge compared to the existing condition. This would require the construction of several sluices with adequate design discharge to re-establish former seasonal inflow from the Jamuna River.

Impacts on soils are likely to be more pronounced with full flood protection because this would enhance modern agricultural practices. There are a number of well established negative impacts on long-term soil fertility and biological balances, unless mitigating measures are implemented such as integrated pest management, on-demand fertilization and adequate tillage practices and cropping pattern.

The area and duration of inundations would be reduced in all seasons, especially in the monsoon and post-monsoon seasons. As a result, soil moisture replenishment is likely to decrease with negative impacts especially during the dry season. On the other hand, detrimental impacts of prolonged floods and waterlogging will decrease especially on medium highlands and for rabi crops in F2 and F3 lands. In general, the aeration status of soils will be improved. Leaching of nutrients will be less but extractions from HYV will also increase. Further impacts are related to reduced supply of sediments (alluvial silt) and nutrients during the flooding season. A quantification of impact would be possible after detailed soil-water and nutrient balances are evaluated using local soil data (see "Soil Fertility Monitoring" in Chapter 8). The overall effect on soil fertility would be negative, unless mitigating measures are implemented.

Water quality will probably further decrease due to reduced opportunities of flushing of highlands and the reduction of seasonal semiaquatic environments on inundated areas which can contribute to the dilution of pathogens and accelerated of organic toxins. However, such linkages must be established or confirmed during the "Water Quality Monitoring" (see Chapter 8). Potential risks arise from increased uses of agro-chemicals and other industrial developments.

Aquatic habitats will further decline, deminishing the already vulnerable and endangered habitats. Although wetlands in the CPP Sirajganj area are only of local importance (group C according to IUCN-classifications), they are important in the provision of common goods and in maintaining biological diversity. Mitigating measures at key beel sites could compensate for these overall losses and create sanctuary habitats for multiple uses of common goods provides by permanent or seasonal beels. Especially endangerd aquatic wildlife species could benefit from such key conservation areas. However, there is risk that such sanctuaries will fail because most beels are privately owned and much depends on a management plan to the benefit of all involved.

Terrestrial wildlife depends mainly on homestead or embankment plantantions. These are under continuous stress. However, it is expected that flood protection will create a more favourable soil environment for tree growth, especially in medium highland. If associated plantation measures are implemented, a beneficial CPP impact can be realized with the increased availability of common goods in homesteads and on embankments.

Impacts on public health are likely to be balanced, although there is potential for improvements of mitigating measures and associated integrated water management and public health engineering developments would be implemented.

Health risks associated with vector-borne diseases can slightly increase (Kala-azar) or slighly decrease (malaria) or remain unchanged (filariasis) due to FCD works. In general, major changes in environmental receptivity and community vulnerability are unlikely to due to CPP works. Kala-azar can be at significant risk with embankments at some localities, however, functional relationship between vector habitats and flooding is not well established. Clinical cases are not reported from the Sirajganj area in recent years, despite flood control through the BRE.

Other water-related communicable diseases are prevalent, especially during the flood season. There is potential for environmental management and manipulation to control environmental receptivity and community vulnerability by mitigating measures such as controlled overland flow, flushing of khals or rivers and water level manipulations. Flood control would also leave options for associated public health developments, namely improved sanitation and habitation, access to safe potable water during the flood season and safe waste disposal systems.

Occupational risks, associated with polluted water and soil resources and contacts with hazardous materials can increase in both rural and urban areas due to agricultural and industrial\commercial developments. Also, risks associated with polluted drinking water can increase in some localities.

Navigation within khals and from khals to the Ichamati River will be hampered by sluices and regulators, unless sluices allow a free flow and a low sill level is maintained. Small country boat operations could benefit from CPP, if operational rules would leave khals filled with water during monsoon and post-monsoon seasons.

Option 2B: Compartmentalization with Ichamati Embankment

Alignment follows Ichamati River

This option would have negative impacts on a small stretch of land along the Ichamati River and would leave no options for beel bypasses and embankment setback. Hereby, some 1,500 ha of regularly flooded areas would become terrestrial habitats and valuable potential seasonal wetlands would be lost. Land losses to embankment construction would be high, as well as disturbances during construction by access roads etc.

Overall summary (see Table 6.1)

Option 2A is preferred in case of frequent and disastrous BRE breaches. It allows fully controlled floodwater (river and rainfloods) over the entire compartment. It provides sufficient protection from Ichamati River spills in case of BRE breaches.

Option 2B is the least favourable option because it would have the greatest adverse environmental impacts and would not leave space for mitigating measures for seasonal wetlands along the Ichamati River. Additional cropland would be lost to embankments.

Option 1 would have the least negative environmental impacts and could even improve several environmental elements, if all mitigating measures would be implemented. However, in the case of disastrous BRE breaches, the CPP area would also be prone to flood hazards from Ichamati River spills.

Essential mitigating measures for Option 2A

These include:

- providing sufficient sluice gates (free-flow types) along the Jamuna to re-establish a part of the natural floodplain ecosystem. The minimum volume of seasonal floodwater inflow should be determined as early as possible.
- provide sufficient sluice at the Ichamati River to control both river backflow and

drainage outlet from floodplains
- the design of major sluices (except BRE) should allow for country boat traffic (local operations)
- establish operational rules for envioronmental sound FCD devlopment (see Chapter 7)
- implement homestead and embankment plantation programmes within the scope of FCD works
- implement a beel conservation programmes to protect key areas
- implement an "Integrated Pest Management" programme to reduce risks associated with harmful agro-chemicals
- inititate a development programme for safe water supply in rural villages
- monitor soil fertility and groundwater availability to obtain data for environmental managemen plans for long-term land and water resource uses
- implement and initiate a Sirajganj Town development plan related to flushing of the Baral river and its tributaries.
- initiate and cooperate in a urban health programme to minimize water-related risks.

Specific recommendations are given in Chapter 7.

6.4 External and Strategic Impacts

Likely External Impacts. Impacts from outside the CPP are related to other FAP developments (Section 2.2) and especially to the BRE (Section 6.1). Upstream developments within the Ichamati River catchment are unlikely to affect the CPP area in the near future. Operation and maintenance of the BRE are outside the scope of CPP works. It is expected that BRE breaches can occur at irregular intervals even after major repairs of the existing BRE and new retirements. Further regional hydrological studies should provide the baseline data for detailed environmental impact assessments of external impacts.

Likely Strategic Impacts of CPP. The effects of CPP would extend beyond the immediate project boundaries because of hydrological effects up- and downstream sections of the Ichamati River. Further hydrological studies are required to assess the significance of impacts of CPP works, especially embankments along the eastern Ichamati bank.

Impacts outside the CPP area are likely to occur upstream of SC 2, along the western Ichamati River banks and probably in downstream Ichamati River sections. The magnitude of impacts depends on the discharge capacity of the Ichamati River because this river has to convey an additional portion of floodwater that does not enter the flood protected CPP area. The CPP do not assume full protection against beneficial monsoon floods. Therefore, a part of river floodwater will enter the CPP areas and cumulative impacts of CPP embankments would probably be small.

Cumulative Effects. With every additional compartmentalization project, the scale of response increases until effects can be seen at a regional level. Aggregated regional impacts of full compartmentalization in greater region will be subject to future analysis. Detailed regional hydrological data would be required for such an impact assessment.

6.5 Other Impacts Addressed in the Interim Report

The impact of flood control on floodplain and beel capture fisheries is covered in a separate study of CPP (Annex 5 Fisheries). Effects on crop production, diversity and intensity, and increased use of agricultural inputs and mechanization are addressed in Annex 4, Agriculture. Social impacts and institutional aspects of the CPP are already addressed in Annex 7. For the Mlti-Criteria Analysis reference is made to Chapter 8 of the Main Volume.

6.6 Limitations of Impact Analysis for CPP

6.6.1 Complexity of Impact Analysis

The CPP will affect the monsoon flood pattern regarding the time, duration and depth of floods in the Sirajganj floodplains. The physical responses of the hydrological surface and groundwater systems induce changes in habitats of both terrestrial and aquatic fauna and flora. Further, land uses and water resource uses are changing which feed into a wide network of ecological and socio- economic processes eventually affecting the quality of life values. These interactions and modifications are usually complex and they vary over time and space. Simple cause-effect relationships are only a part of understanding the impacts of FCD interventions. Complex feedback and long-term accumulative processes are involved.

In the floodplains of Sirajganj CPP, the situation is further complicated by the fact that the area is already influenced by pre-existing flood and drainage works but also through irrigation developments which are all beyond the direct control of the CPP. Therefore, it is difficult to differentiate between various levels of impacts:

- BRE-impact: existing environmental conditions in the CPP Sirajganj area are largely controlled by the BRE (Section 6.1), especially flood pattern and regime and land use pattern and systems.
- BRE-insecurity due to breaches: this impact level is introduced by a variety of human-made and natural factors which contribute to BRE-breaches. Long-term planning of the CPP assumes, similar to FAP 2 strategies, that the BRE is effectively sealed. Hence, future breaches or overtapping will rarely occur (probably with a 1:50 chance of occurence, compared to 3 out of 5 years under present conditions)
- Other regional FAP impacts (see FAP 2 proposals): these are rather minor compared to the BRE impact, although hydrological changes in the Ichamati River may be possible due to future up- and downstream developments, eg. Bangali floodway, Jamuna Bridge.
- CPP impacts: impacts imposed by CPP structural or non-structural activities as outlined in Chapter 3.
- general trend of development of natural resources (water, soil, fauna and flora) and their human uses (rural, urban).

6.6.2 The Magnitude of Impacts

The impact assessment has further methodological limitation. Although the type of impact and other parameters of the impact significance can be fairly well established once the detailed planning and design criteria of engineering works are known, it must be acknowledged that the magnitude of impacts will also depend on the operation of sluices. Theoretically, all impacts are possible:

- minimum interference, ie. leaving all gates open at all times,
- maximum impact, ie. leaving all gates closed throughout the flood season.

At this planning stage, it would be a matter of speculation to run various operation scenarios. Here, it assumed that gates are operated according to a set of operational rules and institutional arrangements which are tentatively given in the Interim Report (Chapters 3 and 4). The rules consider agricultural, fisheries, social demands and should also include environmental considerations to the long-term benefit of all users in the affected areas. Operational rules for environmentally sound development are outlined in Chapter 7. They are rather generalistic to fit to a variety of environmental conditions and amendments will be required in future.

Once the infrastructure exists, the CPP should monitor whether the rules are observed by the responsible local and regional institutions.

6.6.3 Shortcomings In Impact Quantification

Predictions, especially quantification, of the extra impacts caused by CPP activities versus the other mentioned impacts would either be arbitrary or debatable under the set of conditions outlined above. Many data sets and predictions are controversial even amongst professionals.

In the case of CPP, the following environmental components are diffucult to quantify because changes depend on a variety of factors which are not fully controlled by CPP activities:

- land type changes
- crop production, depending on cropping pattern and yield levels
- groundwater developments
- soil fertility changes
- culture fisheries developments
- habitat and wildlife changes
- public health risks

Note: Impact assessment depends on subjective predictions, even with the existence of hydrological and agricultural models which only reflects a part of the reality. The valuation of impacts adds another subjective element to the assessment procedure, ie whether the impact is significant, considering the variablity in time and space and having in mind that any change poses beneficial and detrimental effects to a wide range of recipients (humans, fauna and flora).
"One person's flood protection is another person's flood hazard"

Hence, impact assessment and decision making means always setting development priorities against the background of commonly agreed frameworks such as environmental, agricultural or fisheries policy or rural development strategies and programmes.

Such a framework must be set on the national policy level and implemented by the Department of Environment. The national conservation strategy and environmental policy guidelines are still under discussion or not yet adopted by the responsible project implementing institutions. Hence, a valuation of environmental changes (eg conversion of wetland into croplands) will remain subjective unless clear guidelines regarding agricultural, fisheries, biodiversity, pollution policy are implemented at national and regional levels.

6.6.4 The major Focus: Environmental Management

The CPP aims at implementation and a variety of structural and non-structural development options should be tested. Therefore, efforts to integrate environmental management into the CPP project should focus on:

- identification of real impacts during the implementation and operation phases: environmental monitoring
- taking direct influence in planning and design of structural and non-structural activities to ensure environmentally sound, sustainable development; this should be based on experiences from previous FCD activities in the region and on conceptual impact analysis
- developing quality criteria for planning, design and operation of structural measures
- identification of potentials to enhance the environment by additional community-based resource management projects which are linked to compartmentalization or integrated water resource development

7 RECOMMENDATIONS FOR ENVIRONMENTALLY SOUND FCD

7.1 Risk Management in the CPP

The CPP aims at reducing hazards by minimizing damages to human life, livestock croplands and buildings caused by floods and impeded drainage. Environmental criteria can already be considered during planning. The CPP has potential to reduce risks if an integrated approach of environmental management is implemented:

- reduction in potential future shortage in groundwater availability by the application of a strategy of "maximum groundwater recharge" in compartment floodwater management
- reduction in risks of overfishing of the remainng permanent beels by implementing a "fish mitigation" and "beel development" programme
- reduction in shortage of common goods, if CPP promotes "multiple purpose plantations" on embankments and in homestead areas; these areas are likely to benefit from flood protection through improved soil aeration
- reduction in water-related health risks if measures and operational rules for regular flooding (overland flow) and "flush flooding" (eg. khals, pools) are considered for CPP floodwater management
- enhancement of soil moisture status if CPP considers a "maximum area inundation" approach for the floodplains, which would also promote floodland capture fisheries; controlled seasonal flooding would also enhance pest control such as rodents
- conservation of key areas of beels can be promoted if the CPP implements a "wetland conservation" component in the water management plans. This programme can be executed in combination with an "Integrated Pest Management Programme" and "fish sanctuary plans".

However, the CPP may also introduce extra risks which are related to changes in flood pattern and subsequent changes in agriculture. These risks are:

- further reduction in wetland habitats through flood manipulation and facilitating crop production on F2 and F3 lands (reducing river inflow into a subcompartment); this, in turn, would further reduce fish and other wildlife habitats in khals, beels and floodplains
- increased use of agro-chemicals for higher yields and associated risks of water pollution and soil contamination; increased occupational risks in handling, storage and application of toxic chemicals
- intensified cropping pattern, new crops and varieties and tillage systems may be associated with risks of soil fertility degradation such as nutrient depletion and physical degradation
- increased demand for irrigation may eventually lead to overuse of groundwater resources; the need for more irrigation may be caused by changes in cropping pattern, a decrease in soil moisture replenishment during less frequent floods, and a drop in groundwater levels which reduces the capillary rise during the dry season
- failures of flood control structures (embankments, sluices) which may exacerbate flood risks (see BRE breaches, structure in the Ichamati branch).

7.2 Environmental Considerations in Planning and Operation

This section provides a series of tentative recommendations for consideration in planning, design and operation of structural targets in FCD. There are various environmental quality goals for development in the CPP area which should be integrated into the existing short-term production oriented targets (eg. agricultural and fisheries production targets in Section 3.2). They are aimed at environmentally sound development and the conservation of a floodplain ecosystem:

- reducing risks associated with natural flood hazards
- mitigating possible impairments of water, soil and biological resources which are linked to flood and drainage control works
- reducing managerial and technical risks which are involved in the manipulation of natural floods
- reducing conflicts over utilization of scarce natural resources (eg. water resources, common goods)
- reducing risks associated with water-related public health hazards
- reducing risks associated with construction

The following environmental management targets are proposed:

- groundwater development targets: allow for maximum recharge of local aquifers by deep percolation during the flooding period
- public health targets: reduce risks for communicable vector-borne diseases and improve rural/urban sanitation conditions; reduce risks of flood induced spreading of water-related diseases; reduce risks of any uncontrolled spread of polluted water (urban pollution)
- other environmental management targets: replenishment of soil moisture; development of wetland habitats in key areas for multiple uses (fisheries, migratory and resident wildlife); maintenance of soil fertility under intensive cropping systems; enhancement of habitats which compensate for wetland value losse, such as homestead and embankment plantations

Planning and design critieria for compartmentalization

Planning options to minimize environmental risks - related to controlled flooding are:

- provide sufficient inflow from minor rivers (eg. Ichamati River)
- allow for adequate inflow from the Jamuna River to re-establish part of the natural flood regime (pre- BRE-status). Free-flow sluice gates should provide inflow as early as possible within the river's hatchlings/fry peak period during June/July and at design discharge rates in the range of 5-203/s, depending on the command area. Alignments should be made in close consultation with groups of affected people. Sluices should preferable re-establish natural flow pattern of khals/rivers, eg the Jamuna was connected with the Baniajan River.
- design of structures to allow discharge rates which are close to natural flow rates in khals/rivers, tentatively:
  * small khals about 80% of a 1:5 year discharge

* major khals about 70% of a 1:5 year discharge
* minor rivers about 60% of a 1:5 year discharge

- minimize the number of regulators in order to minimize maintenance and operation needs and institutional difficulties with water management minor regulators (<5m3/s) should only be constructed on demand of the local people and after a thorough risk versus benefit assessment, taking into consideration agricultural, fisheries and other environmental aspects
- improve overland flow by providing additional culverts in existing road embankments
- improve land drainage by re-excavating of existing khals; khals should be provided with fish mitigating measures such as minimum sill levels (see Annex 5)
- excavate new canals only on demand of water user groups, or in combination with fisheries mitigating measures
- embankments should be constructed as submergible embankments to reduce interference in natural flow pattern unless the embankment is aimed to provide full protection of sensitive areas (homesteads, settlements, infrastructure)
- planning and design criteria and implementation of embankments should follow internationally accepted standards (eg. slopes, blanket/core, compaction, filters, berms).
- implement wetland conservation measures to promote aquatic habitat diversity through for example
  * beel bypass or embankment setback that beels remain freely connected to the river system
  * provide measures for beel clusters, ie interlinkages of beels with free-flow regulators or spill structures within minor khals
  * provide sufficient inflow from minor rivers to key beel areas and consult people to implement a beel conservation programme (in co-operation with the fisheries mitigation programme)
  * implement beel bunding and beel embanking approaches to maximize water volumes stores during the dry season.

All beel mitgating measures should be planned in co- operation with fisheries and to long-term benefits of the production of a variety of common goods in perennial aquatic habitats.

Construction Phase

Impacts depend on the specific nature of construction activities and the level of technology used. Only tentative guidelines can be provided at this planning stage:

- reduce requirements for access to land for temporary works (access roads, construction camp) and permanent structures (sluices, embankments)
- avoid losses of land with high suitability for crop production or valuable land for homestead plantations and wetland preservation (permanent or seasonal beels with a high biodiversity)
- minimize the extent of borrow pits to avoid further loss of cropland. Pits should be developed as fish ponds
- topsoil material should be stockpiled and lateron used for re-vegetation on the embankment

- borrow pit land aquisition policy and compensations issues need to be formulated in agreement with the water user groups
- minimize contamination of land and water sources caused by disposal of wastes, toxins and other materials used during construction
- minimize dust and noise pollution during construction operations
- minimize erosion and siltation around the construction sites
- prevent communicable disease risks associated with construction camps.

Criteria for Environmentally Sound Operation and Maintenance

Environmentally sound flood control and drainage means:

- minimum interference into natural flood pattern and regime
- minimizing damages to human life, livestock and settlements
- avoiding disastrous cropland .

The following tentative critieria for regulators/sluices operations should be observed:

- maximize groundwater recharge, ie. controlling natural floods to a minimum interference level regarding flood duration and extent
  objective: ensure long-term groundwater availability to various domestic and agricultural users
- maximize soil moisture replenishment, ie controlling natural floods (extent, level, duration) to a minimum interference level
  objective: increase post-monsoon soil moisture availability to croplands and natural vegetation
- provide flushing options for health controls:
  * avoid stagnant waters in post monsoon period
  * flushing of rivers/khals in or near settlements once or twice a year
- flood all beels as long as natural flood levels permit
  objective: conservation of biological resources and biological balances
- flood as much floodplain areas (even for short periods) to re-establish the natural floodplain ecosystem status
  objective: health controls, pest controls, supply of natural soil nutrients, preservation of wetland fauna and flora sucessions.

Embankment Maintenance. All flood control embankments should be cultivated with suitable trees and grasses (eg. Durba, Sungrass, Hoglapata, Vetiver species) for slope protection against soil erosion and to provide common goods such as fodder, fuel, handicraft material. Sucessful implementation of a social forestry programme on FCD embankments could provide sustainable O & M by generating resources and incentives to maintain embankments (for details see Chapter 8).

8 FUTURE WORK PROGRAMME

8.1 Participation in Project Planning

Environmental issues should be addressed at all planning stages. Some important issues are already covered by the CPP's agronomist, fisheries and social development studies specialist. The following additional issues, important to environmentally sound planning, should be followed up from an early project planning stage:

- site of structures: the natural flow pattern should be maintained if possible
- design of structures: design discharge should be similar to the natural discharge capacity of khals or rivers
- number of structures: should be minimized to reduce managerial problems during the operation
- ensure that all precautions are taken that environmental pollution will be minimized during construction. Construction management should include sanitation and service facilities, public health and safety, contractor's site installations, services and pollution control, operations and disturbances, rehabilitation and reclamation provisions (for details see Chapter 7). These issues will be dealt with in depth at detail design stage, once the final proposed construction programme has been formulated.

8.2 Special Surveys

Special surveys are aimed at obtaining baseline data to fill gaps of local knowledge of important environmental issues for Environmental Impact Assessments. Some surveys should also provide information for the Environmental Management Plan.

Special surveys are tailor-made and they concentrate on important issues which are identified as critical issues in regional FAP studies, or they up-date information on the local environmental setting, eg. in ecological transect surveys.

Five special surveys are proposed for the Sirajganj CPP. They cover ecological and wetland conservation issues, environmental pollution, development of agroforestry resources, and public health issues. Some surveys cover also the CPP Tangail in order to develop the Environmental Management Plan for Tangail. A narrative summary of the proposesed special surveys follows. Further details are shown in a special document: Outline of the Environmental Field Programme 1993- 1995 (see Figure 8.1).

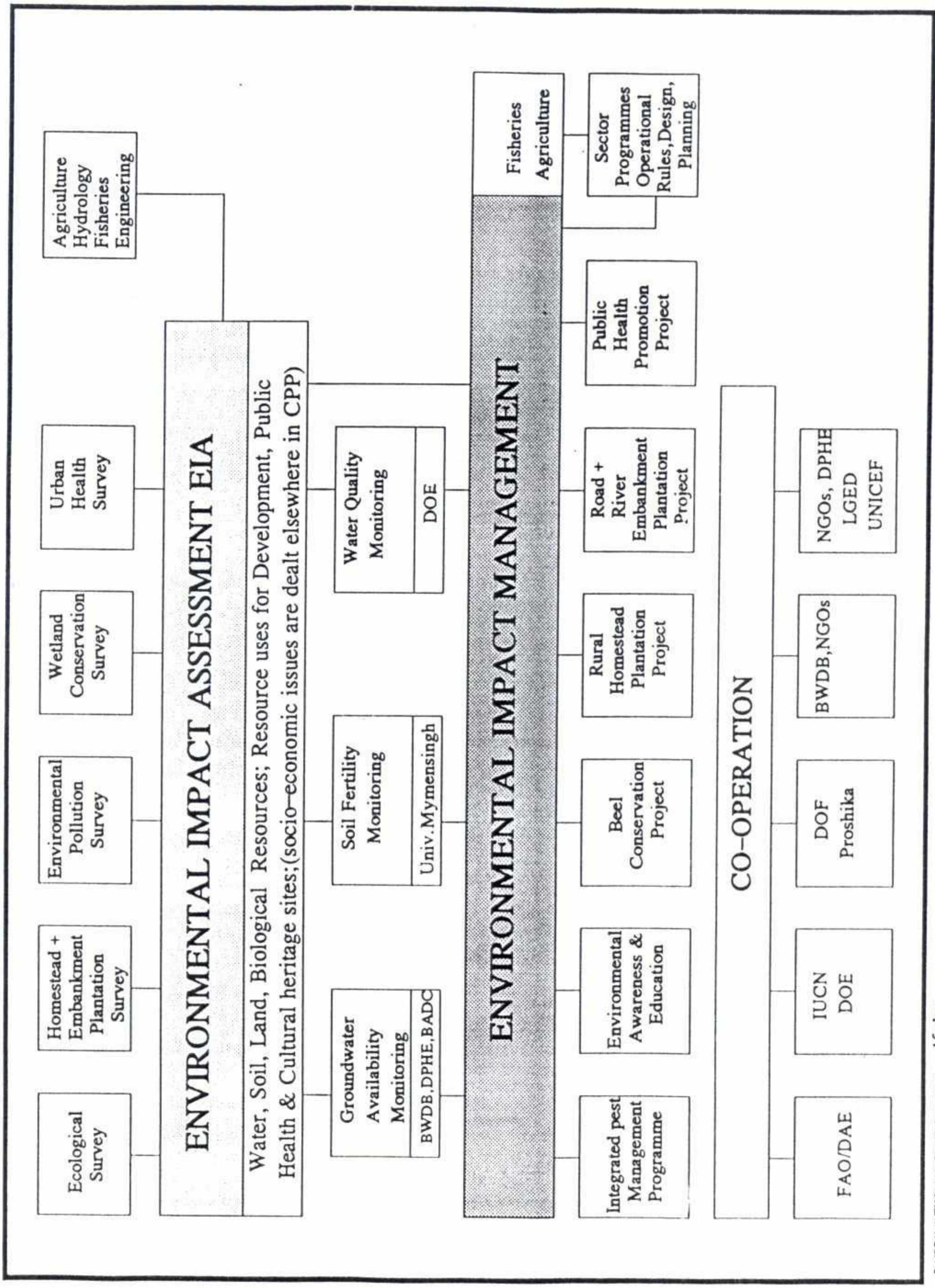
Total resources needed:

- 8 months local senior specialist; 13 months junior professionals
- cost estimates for equipment approximate US $ 10,000.

S1 Ecological Survey

Area	CPP Sirajganj
Objective	inventory of biological resources of major terrestrial and aquatic habitats
Methodology	field surveys in wet and dry seasons
Resources	local specialists 7 months (1+6)
Schedule	August 1993 to June 1994

Figure 8.1: Outline of Environmental Field Programme 1993-1995



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S2 Homestead and Embankment Plantation Survey

Tangail	4 sites
Sirajganj	3 sites
Objective	identification of key sites for plantation programmes and outline of planning, design, implementation
Methodogoly	field surveys, technical proposal
Resources	biologists 4 months (2+2)
Schedule	November 1993 to April 1994

S3 Environmental Pollution Survey

Tangail and Sirajganj:	urban and rural areas
Objective	identification of types and sources of urban/rural water & soil pollution
Methodology	Field surveys, chemical analysis
Resources	CPP Environmentalist 3 month Cost estimates: 9,000 US $
Schedule	August 1993 to August 1994

S4 Wetland Conservation Survey

Tangail	2 key sites
Sirajganj	2 key sites
Objective	identifying key conservation areas; outline of a multiple beel use programme and implementation proposals
Methodology	field survey, technical proposal
Resources	CPP-staff + local specialists 3 months
Schedule	start during flood season 1994

S5 Urban Health Survey

Tangail and Sirajganj towns

Objective	identification of major hazards/risk related to polluted water
Scope	inventory and mitigation measures
Resources	health engineer 1 month Cost estimates: US $ 1,000
Schedule	start in January 1994

8.3 Environmental Monitoring

Scoping of important issues. Considering the complexity and interlinkages of environmental effects in the areas under study, it is impossible to obtain data for all components at the desirable degree of detail within a project's lifetime. Hence, an important step is the identification of important environmental components, ie. such elements which deserve further special attention because they are either sensitive elements in the ecological system or they are under severe stress from the project. In any case, there must be a direct cause- effect relation between the project's activities and the likely impacted environmental elements such as water, soil and biological resources and public health.

Monitoring surveys are aimed at either "problem assessment-" or "management practice monitoring". Problem assessment monitoring determines and evaluates the extent to which potentially harmfull substances are in the water or soil and to which extent the project influences such pollutions (beneficial/detrimental). Management practice monitoring address longer term environmental management and determine to which extent the natural resources are deteriorating, eg. soil fertility or groundwater availability. The major goal is to test on hypothesis or suspecions whether significant problems occur in the area and - if so - to develop an inventory which is of use in formulation of mitigation programmes. This monitoring also aims to assess the degree of impact by the project's activities in order to verify the quantification of impact analyis.

Total Resources:
- 11 months local senior specialist; 9 months junior professionals
- cost estimate for analysis and equipment US $ 12,500

M1 Groundwater Availability Survey

Tangail	12 groundwater observation sites
Sirajganj	15 groundwater observation sites
Objective	management practice monitoring
Scope	groundwater fluctuations over time; model for groundwater recharge assessment
Methodology	data collation and analysis, modelling
Resources	CPP Environmentalist 3 months Cost estimates: 1,000 US $
Schedule	Start in 1993

M2 Soil Fertility Monitoring

Tangail	four sites
Sirajganj	three sites
Objective	evaluation of physical and chemical soil properties and their changes due to FCD
Resources	soil specialists 12 months (3+9) Cost estimate: US $ 6,500 Cooperation Mymensingh Agricultural Univ.; BARI
Schedule	Start in early 1994

M3 Water Quality Monitoring

Tangail	to be defined from S3
Sirajganj	to be defined from S3
Objective	concentration and spread of plluted water due to FCD works and industrial discharges
Resources	CPP environemtalist 3 months Cost estimates: US $ 5,000
Schedule	Start in January 1994

Project Management: Environmental Monitoring and Evaluation

There will be short- and long-term environmental impacts due to the CPP. Many impacts will not hamper the natural resource base within the remaining two years of project lifetime because changes are gradually. However, many effects have far reaching consequences which should be evaluated before the concept of compartmentalization can be considered as environmentally sound. Special attention should be paid for short term and irreversible impacts. Short-term production oriented fisheries and agricultural effects are not considered here because they are subject to special CPP studies. The following issues should be subject to monitoring:

- minimizing environmental pollution during construction
  Indicator: safe disposal of wastes;
  Means of verification: site inspections; CPP documents relevant to construction risk preventions/precautions
- loss of fertile land or ecologically important habitats to embankments or other construction works
  Indicator: loss of net cultivatable area and impairments of imporant habitats
  Means of verficition: site inspections, CPP land use figures
- design criteria of regulators should meet environmental standards (Chapter 7) to permit minimum interference in hydrological cycles
  Indicator: design discharge versus natural discharge
  Verification: CPP documents
- permanent beels should be preserved and construction of embankments or regulators should not significantly interrupt flood pattern and regime
  Indicator: loss of beel area, deterioration of beels
  Verification: land use monitoring
- Loss of seasonal beels
  Indicator: reduced F3 areas and reduced duration of inundation

Indirect or long-term changes include

- soil fertility changes
  Indicator: reduction in organic matter, nutrient availability (eg. N, P, Zn), waterlogging status
- groundwater availability changes
  Indicator: groundwater table drawdown
- environmental pollution by agrochemicals etc.
  Indicator: pesticide residues in water, soil; application of pesticides (types, rates), safe storage and handling, training and knowledge of farmers
- surface water quality index
  Indicators: DO-decrease, FC-increase, pH-increase
- groundwater quality index
  Indicators: nitrogen and nitrite contents increase
- conversion of land and diminishing of wetlands
  Indicators: loss of F3 and F2 lands and less frequent floods on highlands, ie. on F0 and F1 land types.

8.4 The EIA-Sirajganj Report by CPP

According to the objectives of the CPP, the environmental impact assessment should mainly focus on obtaining and analysing data about the real impacts of compartmentalization rather than modelling or predicting impacts in EIA-case studies (see Section 1.2). Based on monitoring findings, the CPP should provide recommendations for environmental management which specifically aim at FAP implementation (see Section 6.6.4).

The EIA Sirajganj report will focus on such environmental management aspects and be prepared at a later stage of the pilot phase, ie. when monitoring data will be available.

8.5 Mititgation and Enhancement Measures

Based on the identification of likely impacts as a result of CPP activities, there are proposals to minimise or avoid impacts that are negative. Table 8.1 shows a summary of such possible mitigation measures. In addition proposals are given for enhancing environmental elements which are presently underutilized.

At this planning stage, only few elements of the future environmental management plan can be outlined:

- mitigating further wetland losses by developing a "wetland conservation programme" (M1)
- mitigating further increases of pesticide uses by initiating an "integrated pest management" programme (M2)
- enhancing rural homestead plantations by promoting fast growing and multipurpose tree species; an agroforestry programme (M3) is proposed to be implemented on key sites which will be determined during the "homestead and embankment plantation survey" (S2)
- enhancing underutilized embankment plantations by promoting a "social forestry programme" (M4) on road and river embankments. The details of the programme should be defined during the "homestead and embankment plantation survey" (S2)
- urban health promotion programme (M5) which is aimed to improve health conditions in Sirajganj town related to river water pollution. The programme is aimed at reducing toxic industrial pollution and improving sanitation measures to reduce human-induced organic pollution of the Baral River. Further details should be elaborated during the urban health survey (S5).

Further aspects of the environmental management plan are related to

- floodproofing of rural villages/homesteads, towns and unprotected land
- an improved road network should compensate for seaonal river/khal navigation losses due to FCD works (BRE impact)
- water-related disease prevention programmes, eg provision of year-round safe drinking water and danitation facilities accompanied by health education programmes
- a fisheries mitigation programme will be provided by the CPP in a separate report
- fuelwood and fodder production are already promoted by social forestry and rural

homestead plantation programmes
- a soil resource management plan should be developed to maintain long-term agricultural production. This plan would be based on the findings of the "Soil Fertility Monitoring Programme" (MO2).

Environmental Awereness and Education

Environmental education is a permanent process in which the villagers and other affected people gain awereness of their environment and acquire knowledge, values, skills, experiences, and also the determination which will enable them to act - individually and in a group - to solve present and future environmental risks.

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Table 8.1: Summary of Mitigation Measures

Environmental Impact	Mitigation Measures	Respon-sible Institution	Relative Cost	Scheduling	Residual Impacts
Drainage congestion	Dredging of khals, rivers etc. and maintenance of structures	BWDB LGED	High	Pre-construction phase and after project implementation	Considerable if proper water management strategy avoided
Ground water table fall	Regulating flood duration to enhance recharge and restrictions for irrigation consumption	BWDB BADC	Low	After project development	None
Flood damage by sand deposition	Compartmentalization and BRE stabilization	BWDB	High	Pre-construction phase and ongoing survey for O&M	None
Deterioration of soil fertility	Increased use of organic fertilizers, manure and on-demand fertilizing of NPK including trace dements; Improve soil tillage systems and introduce IPM	DAE	Medium	After project development	None
Deteriorating of water quality	Improve flushing during flood season and provide sanitation in rural and urban areas; Reduce indiscriminate use of agro-chemicals and risks from industrial pollution	DOE BWDB DPHE DAE BSIC	Medium	Immediate and ongoing programme after project implementation	Mitigation is likely to be fully effective if properly managed
Loss of wetland habitats and bio-diversity	Establish key wetlands as refuse areas and provide interlinkages of beels with river systems	IUCN DOE NGOs	Low	Initial planning stages	High if not properly timed or planned
Increased threats to rare and endangered species	Conserve key wetland areas and promote plantations in homesteads and embankments	DOE IUCN NGOs	Medium	Initial planning stages and ongoing programmes after project development	High if not properly timed or planned
Reduction of traditional grazing areas and common goods	Promote roadside and embankment plantations by growing forage grasses and multipurpose trees	DOE BWDB NGOs	Low	After project development	None
Communicable diseases	Provide improved vigilence of health services and flush flooding of khals, rivers, beels, etc.	DOH BWDB DPHE	High	Ongoing programme after project implementation	Mitigation is likely to be fully effective if properly managed
Non-communicable diseases	Training and acoareness programme on the use of toxins	DAE DOHE DOE	Low	Initial planning stages and ongoing programme	None

An important outcome would be to support values and motivions conducive to behaviour patterns and measures that are instrumental in preserving and improving the local environment.

In the context of the CPP, the following environmental issues need to be addressed at the villagers level:
- groundwater availability
- water-related public health issues
- conservation of wetlands; wetland values as a source of common goods
- biological balances for pest control; use of integrated pest management practices
- benefits of controlled floods to replenish soil moisture and groundwater, to stimulate nutrient fixation during the time of floods, etc.
- maintaining or enhancing the soil fertility in an intensive cropping system; best management practices for the use of fertilizers
- using border or field margins and embankments for plantations
- enhancement of homestead plantations and creation of diversified terrestrial habitats for a large variety of threatened or endangered fauna and flora
- fish mitigation measures (in cooperation with the CPP's fisheries section).

A programme in nonformal environmental eduction is recommended at the village level. Indeed, there is a long tradition of self-reliance and community action in dealing with environmental issues. Subjects relevant within the context of the CPP are:
- broad introduction into the natural resources of the areas and their values for human uses such as common goods
- elements of natural conservation, especially the values of wetland resources
- collection of people's traditional wisdom to cope with environmental and health problems and incorporation of these into project planning
- explanation of hazards and risks associated with flood control and drainage works or other rural and urban developments, especially possible impacts on soils, water resources, bioresources
- explanation of changes to enhance the environment by proper flood control and drainage management
- environmental sanitation in relation to flood control, drainage and irrigation developments
- public health issues related to water-borne and water-washed diseases in urban areas
- water pollution and rural sanitation
- industrial and cottage industry pollution.

Target groups are primarily the water user groups of the CPP. However, also other formal groups or individuals should be addressed:
- water user groups of the CPP area
- other farmers, fishermen and female groups from different age groups and social strata
- interested NGO's working in the area.

The programme should make use of the experience gained by local and national NGO's in the fields of natural conservation and participatory works. Further details will be elaborated at a later stage.

References

CPP 1990. Terms of Reference (TOR).

CPP 1992. Tangail CPP Interim Report, Bangladesh Flood Action Plan, Dhaka.

BBS 1992. Statistical Yearbook of Bangladesh, 13th Edition, Bangladesh Bureau of Statistics, Dhaka

FAO 1988. Land Resources Appraisal of Bangladesh for Agricultural Development, Report 4, Hydroclimatic Resources, Rome.

FAP 2.1992.1.Northwest Regional Study. Volume 1. Bangladesh Flood Action Plan. Dhaka.

FAP 2.1992.2.Northwest Regional Study.Volume 2. Regional Data and Planning Units. Bangladesh Flood Action Plan. Dhaka.

FAP 2.1992.4.Northwest Regional Study.Volume 4.The Regional Plan - Initial Environmental Evaluation. Bangladesh Flood Action Plan. Dhaka.

FAP 2.1992.10. North West Regional Study. Vol.10. Hydrology. Bangladesh Flood Action Plan, Dhaka

FAP 2.1992.14.Northwest Regional Study.Volume 14. Ecology. Bangladesh Flood Action Plan. Dhaka.

FAP 2.1992.15.Northwest Regional Study.Volume 15.Health, Navigation and Cultural Heritage. Bangladesh Flood Action Plan. Dhaka.

FAP 3.1991. North Central Regional Study, Flood Action Plan, Dhaka.

FAP 3.1.1993. Jamalpur Priority Project Study. Annex 3 Environmental Impact Assessment. Final Feasibility Report. Bangladesh Flood Action Plan. Dhaka.

FAP 12.1991. Rapid Rural Appraisal of Brahmaputra Right Embankment Kazipur Reach. FCD/I Agricultural Study. Bangladesh Flood Action Plan. Dhaka.

FAP 16/19.1992. Environmental Impact Assessment Case Study. Compartmentalization Pilot Project. Bangladesh Flood Action Plan. Dhaka.

FAP 16.1992.2. Impacts of Flood Control and Drainage on Vector-Borne Disease Incidence in Bangladesh. Bangladesh Flood Action Plan. ISPAN. Dhaka.

Gumti.1993. Gumti Phase II Sub-Project Feasibility Study, 2nd Progress Report, FAP-5, Dhaka

IUCN.1990. Towards Sustainable Development. Vols 1-7. Ministry of Environment and Forest and NCS Secretariat. BARC, Dhaka.

Mian et.al. 1991. Water and nurtient dynamics of a paddy soil in Bangladesh. in: Z.Pflanzenernähr.Bodenk.154.93-99.Weinheim.Germany.

MPO (1986). T.R No.5. Ground Water. Master Plan Organization, Dhaka.

NCS.1992. National Conservation Strategy. 2nd.Draft. Department of Environmetn. Dhaka.

Ramaswamy,S.1992. Pest Control and Environment. Note for discussion at a seminar on Environment and Agriculture.Dhaka.

SRDI 1967. Reconnaissance Soil Survey. Pabna District. Soil Resources Development Institute. Dhaka.

Steenhuis 1987.Management, Quantity and Quality of Ground Water in Bangladesh. Research Issues. BARC, Dhaka.

UDD 1991. Landuse/Masterplan. Sirajganj Paurishava. Urban Development Directorate. Dhaka.

UNDP/FAO 1988.4. Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2. Agroecological Regions of Bangaldesh. Rome.

UNDP/FAO 1988.5-I. Land Resources Appraisal of Bangladesh for Agricultural Development. Report 5 Land Resources. Volume I Computerized Land Resources Inventory. Rome.

APPENDICES

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Appendix 1: ECOLOGY

Wetland Ecology

This Appendix discusses some important issues which are relevant for multipurpose floodplain management in which the integration of agriculture, fisheries and wetland conservation needs would play an important role. This Appendix draws heavily on regional ecological studies carried out by FAP 2, Volume 14 Ecology (1992).

First, the importance of floodplains and beels for fish is discussed and later, agricultural and soil fertility issues are considered.

Fish habitats. The network of beels and rivers in the Region constitutes an essential resource for the preservation of the integrity of the unique and highly specialized fish community of the Jamuna floodplain. Ecological studies by FAP 2 (1992:6-8 cont.) showed that most fish species (except carps) depend largely on floodplains because there is no energetic basis for the fish which live in the Jamuna River as "river fish". The river should be seen as convenient short-term refuges for extreme dry season conditions on the floodplain feeding grounds. Members of these fish species also take refuge in the beels during the same period of the year. In this respect, both rivers and beels are part of an integrated network of fish refugue and their relative importance is proportional to their residual areas at the end of the dry season. Any FAP intervention should therefore be planned to provide floodland fish with access to the rivers and beels. The preservation and management of the floodland fish stocks as a whole rests on the need to maintain access to dry season refuges and to energy sources on the floodplains during the flood season.

This favours the development of compartmentalization (centered on the major beel complexes), coupled with the preservation of the integrity of as many beels as feasible (FAP 2.Vol.14:6-9).

The present network of beels and river channels should be maintained and the fish sheltering in them should be protected by sound and effective management policies (FAP 2.Vol14:1-5).

Structures which regulate water flow between floodplains, beels, khals and main rivers must allow fish migration. Fishfriendly structures should have wide openings and a deep sill levels. The number of structures should be as high as possible.

Migration of fishes. Hatchlings needs to gain access to the feeding grounds within a very short time using up their yolk supply, since there is no food supply available to them in the major rivers. The only source of the essential high-protein foods (zooplankton) is the inundated floodplains. Any delay in their gaining access to these waters will cause substantial mortalities, an eventuality to be particularly avoided since hatchling numbers are already in very serious decline in the Region. Flood control structures designed for hatchling access facilities therefore must not delay access to the floodplains, since fish are at a very critical time in their life cycle.

Migration is critical for lateral migrants and floodplain-resident fish species during the following periods:

During May to July, adult fish move from major rivers into khals and onto the floodplains or from beels onto the floodplains

During October to November, fry and adult returns to the major rivers and beels-resident fish are trapped in the beels.

Wetlands and Agriculture. Ecological surveys by FAP 2 showed the importance in maintaining the energetic relations of the floodplain to the benefit of both fisheries and agriculture. Without the activities of the fish on the floodplains during the flood season, a large proportion of the energy stored in plant and animal remains and crop residues would be lost, because of the more inefficient glycolytic oxidation of these residues would be much more prominent, and the overall energetic efficiency of the wetland ecosystem would be greatly diminished.

At the time of flooding the land remains idle and the floodland fish take over the role of nutrient and energy recycling which is the prerogative of soil fungi and bacteria during the dry season. In this role, they are assisted by the Cyanophyceae (these blue-green algae species are the dominant phytoplankton in beels) which is able to capture atmosheric nitrogen dissolved in water and fix it in the soil in a slow-release form which is of very high value to crop production. The total nitrogen fixation by submerged phytoplankton and floating commensal (eg. ferns) is probably in the order of 35-50 kg/ha.

Remark: Unfortunately, a number of these phytoplankton species release neurotoxins which can cause fish mortalities, as well as severe reactions in humans. It is possible that some fihs mortalities reported during the dry season may be in fact due to phytotoxin, rather than to unspecified pollution by agrochemicals as is widely alleged (FAP 2.Vol.14:1-2).

Without the fish, this process would be reduced, because the fish excrete waste products from their own digestion process which provide algae with the trace nutrients which they themselves need to function (FAP 2. Vol.14:6- 9). Once the flood water receded the algae will die and become incorporated into the soil.

Recycling of biochemical residues. It is obvious that major flood interventions by FAP will alter soil biological processes by converting a semi-aquatic system, with alternating annual cycles of inundation and dry season, towards a terrestrial system with dominant aerobic processes. There is, under natural flood conditions, a seasonal rotation of biochemical degradation, because soils remain unsaturated for a considerable length of time of the year before more efficient aerobic processes commence in the dry season to converse biochemical residues. Whilst the detrimental effects of permanent waterlogging (anaerobic processes prevail) on soil chemistry and physics are accepted, also a complete change to a terrestrial ecosystem would cause a reduction in recycling of biochemical residues in floodplain soils, namely nitrogen fixation and other nutrient supplies. The efficient harvesting of plant and animal by the fish during the floods is the key factor in floodplain energy recycling.

In a fully terrestrial agricultural system, this loss must be replaced by either a nitrogen-fixing cropping pattern (eg. intercropping of leguminous crops, Azolla- rice culture sytems) or an increased supply with mineral fertilizers in order to maintain soil fertility.

Furthermore, a combination of semi-aquatic and terrestrial ecosystems offers advantages to maintain a high genetic biodiversity. This in turn will assist to keep habitats of important crop pests and their predators in a fine balance. The use of agro-chemicals almost inevitably reduces species diversity and this relates to systems which depends increasingly of the use of biocides. On the other hand, a more diverse field system will support more species which are able to predate pest crops.

Enhancement of terrestrial habitats
Flood control and drainage measures potentially encourage the preservation of the floral and animal diversity in the highlands (FO to F2 lands) by reducing high water tables in the flood season. This will enhance the growth of trees which form the dominant group.

Ecological studies showed that highland habitats (namely homestead areas) have the highest floral species diversity and most common forms of dominant species have a large number of uses. The importance of these resources almost certainly exceeds in value even the fish resources of the floodplains for most villagers, since they provide shelter, food and materials for the cottage industry.

The floral diversity promotes a comparatively high animal diversity, and a very large number of the birds which are common in the highland homestead areas and feed principally on insects. These habitats therefore present a major refuge for crop pest control species.

There are various options to maintain a high biodiversity on terrestrial habitats if crop field margins, homestead forests and other nice ecosystems (eg. roadside plantations) would further be developed. A survey of the extent of different terrestrial habitats showed that an area of about 10% of the total gross Sirajganj CPP area can be used to promote tree and shrub plantations or fodder grass production at marginal or border habitats. The total terrestrial habitat area which may be used for management plans would be about 35%, considering the already existing homestead plantations.

Wetland conservation implications

The wetlands of entire Bangladesh including the Northwestern Region are under serious threat by continued encroachment of agricultural land and urban areas into wetlands. In Bangaldesh, the Jamuna floodplain fish is of outstanding importance not only in economic terms but also as a source of protein supply. In Asia, the Indus Basin has a comparable fish species complexity and relationship with a major floodplain, and the ecology of that system is now so endangered that it is nearly beyond recovery. Therefore it is essential that suitable wetlands are designated within the Region for inclusion as protected areas under Ramsar Convention to maintain the wetland values, productivity and diversity.

It is acknowledged that - under Bangladesh conditions - an approach must be found which compromises on conservation and human uses issues, such as development of crop production, fisheries and other land or water uses to satisfy human interests. Planning targets for the public goods (such as biodiversity or ecosystem's integrity) must link human development and conservation by setting policy targets and by the development of a regional management plan. This should identify such areas within a region which should be preserved for habitat conservation, based on habitat type and importance assessments.

Extra text

Although the CPP area contains larger proportions of highland and only some 24% of lowland (F2 and F3) there was originally a rich diversity of aquatic and semiaquatic habitat. Due to the encroachment of cropland into wetlands, only some 55 ha beel areas remained in 1993. This process of conversion was partly facilitated by the construction of the BRE since 1963. The existing structures are insufficient to permit adequate floodwater entering from the Jamuna onto the floodplains and many permanent wetland fell dry. The few remaining wetland habitats are increasingly under stress from human uses (a quantification of the current status is subject to a proposed wetland survey).

Table E1: River Bank Macrophytes in the NWR

Major Group	Genus	Species	Freq.	Utility		
Herbs	Amaranthus	spinosus	3	Veterinary	Fodder	Vegetable
	Centella	asiatica	3	Dysentery	Emetic	Vegetable
	Polygonum	orientalis	3			
	Centipeda	orbicularis	2			
	Eclipta	alba	2			
	Leucus	aspera	2			

Source: FAP 2

Table E2: River Channel Macro-fauna in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Bandicota	indica	3	Grain
	Herpestes	auropunctatus	3	Snakes, small animals
	Platanista	gangetica	3	Fish
	Lutra	lutra	2	Fish
Birds	Amaurornis	phoenicurus	3	Small animals, insects
	Anastomus	oscitans	3	Small animals
	Ardeola	alba	3	Fish, frogs
	Bubuleus	ibis	3	Fish, frogs
	Charadrius	dubius	3	Insects, worms
	Columba	livia	3	Grain etc
	Egretta	intermedia	3	Fish, frogs
	Gallinego	henura	3	Omnivore
	Halcyon	smyrnensis	3	Fish
	Nettapus	coromandelianus	3	Omnivore
	Passer	domesticus	3	Grain etc
	Phalacrocorax	niger	3	Fish
	Ploceus	philippinus	3	Grain
	Sterna	aurantia	3	Fish
	Streptopelia	chnensis	3	Grain
	Tringa	hypoleucos	3	Insects
	Alchdo	atthis	2	Fish
	Ciconia	episcopus	2	Fish, small animals
	Haliaster	indus	2	Fish
	Orthotomus	sutorius	2	Insects
	Tadorna	ferruginea	2	Omnivore
	Turdoides	striatus	2	Insect larvae, etc
	Vanellus	indicus	2	Insects, worms
	Ceryle	rudis	1	Fish
Reptiles	Varanus	bengalensis	4	Small animals
	Enhydris	enhydris	3	Fish, frogs
	Trionyx	sp	3	Onmivore
	Xenochrophis	piscator	3	Fish, frogs
	Bungarus	caeruleus	2	Small animals
	Chitra	indica	2	Omnivore
	Cyclemys	dentata	2	Plants
	Naja	naja	2	Small animals
	Pelochelys	bibroni	2	Omnivore
	Ptyas	mucosus	2	Small animals
	Typhtops	porrectus	2	Worms
	Vipera	russelli	2	Small animals
	Varanus	sp	1	Small animals
Amphibia	Rana	sp	3	Insects

Source: FAP 2

Table E3: Beel Aquatic Macrophytes in the NWR

GENUS	SPECIES	FREQ	UTILITY		
Ceratophyllum	dumersum	5			
Cryptocoryne	retrospiralis	4			
Hydrilla	verticillata	4	Fodder	Compost	
Hygroryza	aristata	4	Fodder	Compost	
Ipomoea	aquatica	4	Vegetable	Fodder	
Trapa	natans	4	Food (seeds)		
Hydrocharis	dubia	3	Fishing habitat	Water cooling	Compost
Polygonum	sp	3			
Sagittaria	sagittifolia	3			
Schoenoplectus	articulatus	3	Fodder	Compost	
Schoenoplectus	grossus	3	Fodder	Compost	

Note: Aquatic Macrophytes only occur in a Minority of Beels.

Source: FAP 2

Table E4: Beel Macro-fauna in the NWR

TYPE	GENUS	SPECIES	FREQ	FOOD
Mammal	Lutra	Lutra	2	Fish
Birds	Amaurornis	phoeniculrus	4	Small animals, insects
	Dendrocygna	javanica	4	Omnivore
	Alcedo	atthis	3	Fish
	Ardeola	alba	3	Fish, frogs
	Ardeola	grayii	3	Fish, frogs
	Bubuleus	ibis	3	Fish, frogs
	Egretta	intermedia	3	Fish, frogs
	Gallinego	henura	3	Insects, fish, frogs
	Haliaster	indus	3	Fish, frogs
	Nettapus	coromandelianus	3	Omnivore
	Phalacrocorax	niger	3	Fish
	Accipiter	badius	2	Scavenger
	Milvus	migrans	2	Scavenger
	Sterna	aurantia	2	Fish
	Tadorna	ferrugiea	2	Omnivore
	Ciconia	episcopus	1	Small animals
	Leptoptilos	dubius	1	Invertebrates, fish
Reptiles	Atretium	schistosum	3	Fish
	Cyclemys	dentata	3	Plants
	Enhydris	enhydris	3	Fish, frogs
	Xeonochrophis	piscator	3	Fish, frogs
Amphibia	Rana	sp	4	Insects

Source: FAP 2

Table E5: Agricultural Land Macrophytes in the NWR

HABITAT	TYPE	GENUS	SPECIES	FREQ	UTILITY		
Ricefield	Herb	Oryza	sp	5	Cereal crop	Thatching	Fodder
Ricefield margins	Shrubs	Haliotropium	indicum	2	Veterinary	Eye diseases	Compost
		Lantana	camara	2	Fuel		
	Herbs	Centella	asiatica	4	Dysentery	Emetic	Vegetable
		Cynodon	dactylon	4	Antiseptic	Cultural	Grazing
		Gnaphalium	affine	4	Compost		
		Gnaphalium	alba	4	Compost		
		Echinochloa	colonum	3	Fodder		
		Echinochloa	crussgalli	3	Fodder		
		Ipomoea	aquatica	3	Vegetable	Fodder	
		Ludwigia	adsecndens	3			
		Polygonum	hydropiper	3	Antihaemorrhagic		
		Polygonum	plibegium	3			
		Amaranthus	spinosus	2	Veterinary	Vegetable	Fuel
		Argemone	mexicana	2	Antiseptic?		
		Fimbristylis	sp	2			
		Hygrophila	auriculata	2	Veterinary use	Fodder	
		Leonurus	sibericus	2			
Wheatfield	Herbs	Triticum	aestivum	5	Grain crop	Thatching	Fodder
		Amaranthus	spinosus	2	Compost		
		Gomphrena	globosa	2	Compost		
Wheatfield margins	Shrub	Heliotropium	indicum	2	Veterinary	Eye medicine	Compost
	Herbs	Gnaphalium	affine	3			
		Gnaphalium	alba	3			
		Phylla	nudiflora	3	Grazing		
		Centella	asiatica	2	Dysentery	Emetic	Vegetable
		Ranunculus	sceleratus	2			
		Rumex	maritimus	2			
		Vernonia	patula	2			
		Echinochloa	colonum	4	Fodder		
		Setaria	barbata	4	Fodder		
		Amaranthus	spinosus	3	Veterinary	Vegetable	Fodder
		Argemone	mexicana	3	Veterinary	Fodder	
		Cynodon	dactylon	3	Antiseptic	Religious (M/H)	Fodder
		Gomphrena	globosa	3	Grazing		
		Polycarpon	prostratum	3	Vegetable		
		Polygonum	hydropiper	3	Antihaemorrhagic	Fuel	
		Ipomoea	aquatica	2	Vegetable	Fodder	

Source: FAP 2

Table E6: Agricultural Land Macro-fauna in the NWR

HABITAT	MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Ricefield	Birds	Dicrurus	adsimilis	3	Insects
		Bubuleus	ibis	3	Fish, frogs
		Sturnus	contra	2	Insects
		Acridotheres	tristis	2	Insects
	Reptile	Varanus	bengalensis	2	Small animals
Ricefield margins	Mammals	Bandicota	indica	3	Omnivore
		Herpestes	auropunctatus	3	Snakes, rodents
		Vulpes	bengalensis	3	Scavenger
	Reptiles	Bungarus	caeruleus	3	Small animals
		Naja	naja	3	Small animals
		Ptyas	mucosus	3	Small animals
		Varanus	bengalensis	3	Small animals
		Xenochrophis	piscator	3	Fish, frogs
		Varanus	sp	2	Small animals
Wheatfield	Birds	Dicrurus	adsimilis	3	Insects
		Sturnus	contra	2	Insects
		Upupa	epops	2	Insects on ground
	Mammals	Bandicota	bengalensis	4	Grain etc
		Bandicota	indica	4	Grain, insects
Wheatfield margins	Birds	Dicrurus	adsimilis	2	Insects
		Upupa	epops	2	Insects
	Mammal	Herpestes	auropunctatus	3	Snakes, rodents
	Reptile	Varanus	bengalensis	3	Small animals

Source: FAP 2

Table E7: Inundated Homestead Macrophytes in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	USAGE		
Tree	Azadirachta	Indica	1	General Timber	Skin Diseases	
Shrubs	Ricinus	communis	3	Rheumatism	Bank stabiliser	Fuel
	Alocasia	indica	2	Vegetable		
	Heliotropium	indicum	2	Medicinal		
Herbs	Musa	sp.	4	Fruit crop	Vegetable	Religious
	Centella	asiatica	3	Dysentery	Emetic	Vegetable
	Polygonum	hydropiper	3	Antihaemorrhagic		
	Amaranthus	spinosus	2	Veterinary	Vegetable	Fodder
	Amaranthus	viridis	2	Vegetable	Fodder	Fuel
	Gynandropsis	gynandra	2	Fuel		

Source: FAP 2

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Table E8: Inundated Homestead Macro-fauna in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Callosciurus	pygerythrus	3	Seeds, fruit, etc
	Mus	musculus	3	Grain, etc
	Herpestes	auropunctatus	2	Snakes, rodents
	Mus	booduga	2	Grain etc
Birds	Acridotheris	fuscus	4	Insects
	Acridotheris	tristis	3	Insects
	Columba	livia	3	Grain
	Corvus	splendens	3	Scavenger
	Passer	domesticus	3	Grain etc
	Sturnus	contra	3	Insects
	Dicrurus	adsimilis	2	Insects
Reptiles	Calotes	versicolor	3	Insects
	Ptyas	mucosus	3	Small animals
	Xenochrophis	piscator	3	Frogs, fish etc
	Naja	naja	1	Small animals
	Varanus	flaviscens	1	Small animals
	Vipera	russelli	1	Small animals
Amphibia	Bufo	melanostictus	3	Insects

Source: FAP 2

Table E9: Embankment Macrophytes in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	USAGE		
Trees	Acacia	nilotica	4	Construction	Cartwheels	Anvils
	Dalbergia	sissoo	3	General timber		Fuel
Shrubs	Calotropis	gigantea	3	Rheumatism	Fuel	Religious (H)
	Cassia	occidentalis	3	Excema	Fuel	
	Lantana	camara	3	Fuel		
	Ricinus	communis	3	Rheumatism	Fuel	Bank stabiliser
	Heliotropium	indicum	2	Veterinary		
Herbs	Cassia	occidentalis	4	Excema	Fuel	
	Chrysopogon	aciculatus	4	Headaches		Bank stabiliser
	Echinochloa	colonum	4	Fodder		Bank stabiliser
	Cassia	sp	3	Fuel		
	Clerodenrum	viscosum	3	Veterinary	Fuel	
	Cynodon	dactylon	3	Antiseptic	Fodder	Religious (H)
	Musa	sp.	3	Fruit crop	Vegetable	Religious
	Amaranthus	spinosus	2	Veterinary	Vegetable	Fuel
	Aponogeton	natans	2	Fuel		
	Leonurus	sp	2	Fuel		
	Polycarpon	prostratum	2	Vegetable		
	Solanum	nigrum	2	Fuel		
	Cuscuta	reflexa	1	Antihelminthic		
	Musa	paradisiaca				

Source: FAP 2

Table E10: Embankment Macro-fauna in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Bandicota	bengalensis	3	Grain etc
	Bandicota	indica	3	Grain etc
	Callosciurus	pygerythrus	3	Fruit, seeds
	Herpestes	auropunctatus	2	Snakes, small animals
	Pteropus	giganteus	2	Fruit
	Vulpis	bengalensis	2	Scavenger
Birds	Acridotheris	tristis	4	Insects
	Acridotheris	fuscus	3	Insects
	Alcedo	atthis	3	Fish
	Bubuleus	ibis	3	Fish, frogs
	Copsychus	saularis	3	Insects
	Corvus	splendens	3	Scavenger
	Lonchura	malabarica	3	Grain
	Passer	domesticus	3	Grain etc
	Ploceus	philippinus	3	Grain
	Psittacula	krameri	3	Fruit, grain
	Streptopelia	decaocta	3	Grain
	Sturnus	contra	3	Insects
	Upupa	epops	3	Insect larvae
	Acridotheres	ginginianus	2	Insects
	Athene	brama	2	Small animals
	Bubo	zeylonensis	2	Small animals
	Centropus	sinensis	2	Insects, fruit
	Clamator	jacobrinus	2	Insects
	Corvus	macrorhynchos	2	Scavenger
	Dicrurus	adsimilis	2	Insects
	Dinopium	benghalense	2	Insect larvae, worms
	Eudynamys	scolopacea	2	Fruit
	Gyps	bengalensis	2	scavenger
	Halcyon	smyrnensis	2	Fish
	Milvus	migrans	2	Scavenger
	Nectarinia	zeylonica	2	Nectar
	Oriolus	xanthornus	2	Fruit, larvae, nectar
	Orthotomus	sutorius	2	Nectar, insect grubs
	Pycnonotus	cafer	2	Insects, fruit
	Streptopelia	chinensis	2	Grain
	Accipiter	badius	1	Fish, small animals
Reptiles	Calotes	versicolor	3	Insects
	Enhydris	enhydris	3	Small animals
	Ptyas	mucosus	3	Small animals
	Varanus	bengalensis	3	Small animals
Reptile	Varanus	sp	2	Small animals
Reptile	Vipera	russelli	2	Small animals
Amphibia	Bufo	melanostictus	2	Insects

Source: FAP 2

Table E11: Flood Protected Homesteads Macrophytes in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	USAGE		
Trees	Acacia	nilotica	2	Construction	Cartwheels	Anvils
	Moringa	oleifera	2	Vegetable crop	Fodder	Fuel
Shrubs	Ipomoea	fistulosa	4	Fuel	Narcotic	
	Carica	papaya	3	Indigestion	Fruit crop	Meat tenderiser
	Datura	fastuosa	2	Medicinal	Fuel	
	Ricinus	communis	2	Rheumatism	Fuel	Bank stabiliser
Herbs	Musa	sapientum	4	Fruit crop	Vegetable	Religious (M/H)
	Centella	asiatica	3	Dysentery	Emetic	Vegetable
	Polygonum	hydropiper	3	Antihaemorrhagic		
	Argemone	mexicana	2	Medicinal		

Source: FAP 2

Table E12: Flood Protected Homesteads Macro-fauna in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Callosciurus	pygerythrus	4	Fruit, seeds
	Herpestes	auropunctatus	3	Snakes, small animals
Birds	Acridotheres	tristis	3	Insects
	Centropus	sinensis	3	Fruit
	Corvus	splendens	3	Scavenger
	Passer	domesticus	3	Grain etc
	Sturnus	contra	3	Insects
	Orthotomus	sutoria	2	Insects
Reptiles	Mabuya	carinata	4	Insects
	Callotes	versicolor	3	Insects
	Ptyas	mucosus	3	Small animals
	Xenochrophis	piscator	3	Frogs, fish
	Varanus	bengalensis	2	Small animals
Amphibia	Bufo	melanosticta	3	Insects
	Rana	sp	3	Insects

Source: FAP 2

Table E13: Highland Homesteads Macrophytes in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	UTILITY		
Trees	Citrus	grandis	4	Fruit crop	Fuel	
	Ficus	heterophylla	4	Fruit	Fuel	
	Mangifera	indica	4	Fruit crop	Fodder	General timber
	Phoenix	sylvestris	4	Fruit crop	Crafts (domestic)	Construction
	Albizia	procera	3	General timber	Construction	Boatbuilding
	Areca	catechu	3	Cash fruit crop	Fish traps	Construction
	Artocarpus	heterophyllus	3	Fruit crop	General timber	Cultural
	Azadirachta	indica	3	General timber	Antiseptic	Fuel
	Bombax	ceiba	3	Construction	Fibre	Fuel
	Borassus	flabellifer	3	Construction	Fruit crop	Crafts (domestic)
	Cocos	nucifera	3	Fruit/drink	Construction	Crafts/fibre
	Zizyphus	mauritiana	3	Fruit crop	Fodder	Fuel
	Acacia	nilotica	2	Construction	Cartwheels	Anvil
	Anthocephalus	chinensis	2	General timber	Fuel	Decorations
	Apanamixis	polystachya	2	General timber	Fuel	Construction
	Cassia	fistula	2	General timber	Fuel	
	Dalbergia	sissoo	2	General timber	Fuel	
	Ficus	comosa	2	General timber	Fuel	Medicinal
	Moringa	oleifera	2	Fruit/veg crop	Gastric medicine	Fodder
	Polyalthia	longifolia	2	General timber	Ornamental	
	Spondias	pinnata	2	Fruit	Fuel	
	Syzygium	sp	2	Fruit crop	General timber	Fuel
	Tamarindus	indica	2	Fruit crop	Fuel	
	Aegle	marmelos	1	Fruit crop (palm)	G-I tract medicine	General timber
	Annona	reticulata	1	Fruit crop	General timber	Fuel
	Averrhoa	carambola	1	Fruit	Jaundice	Fuel
	Butea	superba	1	Fuel	Decorative	
	Cerbera	odollam	1	timber	fuel	
	Diospyros	peregrina	1	Construction	Boatbuilding	Commercial crafts
	Ficus	benghlensis	1	General timber	Wet season fodder	Fuel
Shrubs	Calotropis	gigantea	3	Rheumatism	Fuel	Religious (H)
	Heliotropium	indicum	3	Veterinary	Eye medicine	
	Hibiscus	rosasinensis	3	Ornamental	Religious	Fuel
	Abroma	augusta	2	Gynaecological	Dysentery	Fuel
	Carica	papaya	2	Fruit crop	Gastic medicine	Meat tenderiser
	Datura	fastuosa	2	Medicinal	Fuel	
	Ficus	hispida	2	Fruit	Fuel	
	Ipomoea	fistulosa	2	Fuel	Narcotic	
	Ricinus	comunis	2	Rheumatism	Bank stabiliser	Fuel
	Acalypha	welkesiana	1	cultural		
Herbs	Bambusa	sp	5	Construction	Crafts (domestic)	Crafts (commercial)
	Calotropis	gigantea	5	rheumatism	Fuel	
	Clerodendrum	viscosum	4	Rheumatism	Veterinary	Fuel
	Aloe	barbadensis	4	Vegetable		
	Amaranthus	viridis	4	Vegetable	Fodder	
	Ananas	sativus	3	Fruit crop		
	Centella	asiatica	4	Dysentery	Emetic	Vegetable
	Chrysopogon	aciculatus	4	Fodder	Antihaemorrhagic	
	Cleome	viscosa	4	Emergency fuel		
	Enhydra	fluctuans	2	Fuel		
	Musa	sapientum	4	Fruit/veg crop	Craft (domestic)	Religious (H)
	Amaranthus	spinosus	3	Veterinary	Vegetable	Fodder
	Aponogeton	natans	3	Fuel		
	Argemone	mexicana	3	Medicinal		
	Cassia	occidentalis	3	Excema	Fodder	Fuel
	Clerodendrum	viscosum	3	Veterinary	Fuel	
	Colocasia	esculenta	3	Skin diseases	Vegetable crop	
	Cynodon	dactylon	3	Antiseptic	Fodder	Religious (H)
	Ipomoea	aquatica	3	Vegetable	Fodder	
	Alocasia	indica	2	Rheumatism	Vegetable	Emergency food
	Leonurus	sibericus	2	Fuel		
	Polycarpon	prostratum	2	Vegetable		
	Polygonum	hydropiper	2	Antihaemorrhagic	Fuel	
	Portulaca	oleracea	2	Anti-vomiting	Vegetable	
	Rumex	maritimus	2			
	Solanum	nigrum	2			
	Buettneria	pilosa	1	Bone fractures		
	Malva	verticillata	1	Medicinal		

Source: FAP 2

Table E14: Highland Homesteads Macro-fauna in the NWR

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Mus	booduga	4	Grain etc
	Mus	musculus	4	Grain etc
	Callosciurus	pygerythrus	3	Fruit, seeds, grain
	Pteropus	giganteus	3	Fruit
	Vulpes	bengalensis	3	Scavenger
	Bandicota	bengalensis	2	Grain
	Herpestes	auropunctatus	2	Snakes, small animals
	Lutra	lutra	1	Fish
Birds	Acridotheres	tristis	4	Insects
	Columba	livea	4	Grain
	Passer	domesticus	4	Grain etc
	Ardeola	alba	3	Fish, frogs
	Athene	brama	3	Small animals
	Bubuleus	ibis	3	Fish, frogs
	Copsychus	malabaricus	3	Insects
	Copsychus	saularis	3	Insects
	Corvus	splendens	3	Scavenger
	Cypsiurus	parvus	3	Insects
	Dicrurus	adsimilis	3	Insects
	Egretta	intermedia	3	Fish, frogs
	Halcyon	smyrnensis	3	Fish
	Lonchura	malabarica	3	Grain
	Ploceus	philippinus	3	Grain
	Streptopelia	decaocta	3	Grain
	Sturnus	contra	3	Insects
	Bubo	sp	2	Small animals
	Bubo	zeylonensis	2	Small animals
	Centropus	sinensis	2	Fruit
	Corvus	macrorhynchOs	2	Scavenger
	Dendrocitta	vagabunda	2	Insects, eggs
	Dinopium	benghalense	2	Insects
	Eudynamys	scolopacea	2	Omnivore
	Haliaster	indus	2	Scavenger
	Icthyophaga	icthyaetus	2	Fish
	Milvus	migrans	2	Scavenger
	Oriolus	xanthornus	2	Insects etc
	Orthotomus	sutoria	2	Insects
	Psittacula	krameri	2	Fruit, grain etc
	Pycnonotus	cafer	2	Insects,fruit
	Accipiter	badius	1	Birds, small mammals
	Gyps	bengalensis	1	Scavenger
	Megalaima	haemacephala	1	Insects
	Nectarinia	zeylonica	1	Nectar
Reptiles	Hemidactylus	brooki	4	Insects in houses
	Calotes	versicolor	3	Insects
	Enhydris	enhydris	3	Small animals, frogs
	Mabuya	carinata	3	Insects
	Ptyas	mucosus	3	Small animals
	Xenochrophis	piscator	3	Fish, frogs
	Varanus	bengalensis	2	Small animals
	Varanus	sp	2	Small animals
	Vipera	russelli	2	Small animals
	Bungarus	caeruleus	1	Small animals, gekkos
	Naja	naja	1	Small animals
Amphibia	Bufo	melanosticta	4	Insects etc
	Rana	tigrina	2	Insects

Source: FAP 2

Table E15: Preliminary List of Trees, Shrubs and Herbs in the CPP Area

Local Names	English Names	Scientific Names	Abundance	Main Location
Am	Mango	Mangifera indica	High	Homestead
Ata	Bullock heart	Annona squamosa	High	Homestead
Bel	Wood apple	Aegle marmelos	High	Homestead
Boroy	Plum	Zizyphus jujuba	Moderate	Roadside,M/land
Gua	Betelnut	Areca catechu	Moderate	Homestead,Rds.
Jalpai	Olive	Olea europaea	Low	Homestead
Jam	Blackberry	Eugenia spp.	High	Homestead
Jambura	Grapefruit	Citrus grandis	High	Homestead
Kadbel	Custardapple	Feronia elephantum	Low	Homestead
Kala	Banana	Musa spp.	High	Homestead,Rds.
Kanthal	Jackfruit	Artocarpus heterophyllus	Moderate	Homestead,Rds.
Khejur	Datepalm	Phoenix sylvestris	Low	Homestead,Rds.
Labu	Lemon	Citrus spp.	High	Homestead
Lichu	Lichi	Lichi chinensis	Low	Homestead
Narikel	Coconut	Cocos nucifera	Low	Homestead
Pepe	Papaya	Carica papaya	Moderate	Homestead
Peara	Guava	Psidium guajava	Moderate	Homestead
Tal	Palms	Borassus flabellifer	Low	Homestead,Rds.
Debdaru	-	Polyalthia longifolia	High	Homestead
Eucalyp	Eucalyptus	Ecualyptus spp.	Low	Homestead,M/land
Dumur	Fig	Ficus glomerala	Moderate	Homestead/K.landd
Kalmegh	-	Andrographis panineulata	Low	Homestead
Neem	Nim tree	Melia azadirachta	Moderate	Homestead/M/land
Pitraj	-	Agoora rohituca	Moderate	Homestead
Sajna	Round drum	Moringa oligera	Moderate	Homestead/M.land
Aswtha	Banyan tree	Ficus religiosa	Moderate	Roadside
Bot	-	Ficus spp.	Low	Roadside
Krishnachura	-	Delonix regia	Moderate	Roadside
Raintree	-	Samanea saman	Moderate	Roadside
Bet	Cane	Calamus spp.	Moderate	Homestead.Mrg.land
Kash	-	Saccharum spontaneum	High	Roadside
Dholkalmi	-	Ipomea spp.	Moderate	Homestead.Mrg.land
Jarul	-	Lagestroemia speciosa	High	Homestead,Rds.
Kadom	Cadamba	Anthocephalus chinensis	High	Homestead,Rds.
Koroi	-	Albizia spp.	Moderate	Homestead,Rds.
Mehogini	Mahogany	Swietenia mahogany	Moderate	Homestead,M/land
Shegun	Teak	Tectona grandis	Low	Homestead
Bansh	Bamboo	Bambusa spp.	High	Homestead
Bandarlathi	-	Cassia fistula	Moderate	Homestead,Rds.
Gub	Mongosteen	Diospyros spp.	Moderate	Homestead,Rds.
Hijal	-	Lisea angustifolia	Moderate	Homestead,Rds.
Jiga	-	Lannea grandis	High	Homestead,Rds.
Shaora	Silk cotton	Strebulus asper	Moderate	Homestead,Rds.
Shimul	Tamarind	Salmalia malabaricum	Moderate	Homestead,Rds.
Tetul	-	Tamarindus indica	High	Homestead

Source: CPP Field Survey

Table E16: Plantation Programme in CPP Sirajganj by NGOs

Name of NGO	Type of plantation	Period	Species of Plants	Total number of plants	Name of Union Parishad
PROSHIKA	Homestead	1985-1992	Mehagoni, Sissoo, Raintree & Eucalyptus	83,820	Bohuli, Bagbati, Ratankandi, Khokshabari and Songacha (Total 38 villages)
	Roadside	July 91-June 92	Mehagoni, Sissoo, Raintree & Eucalyptus and Segun	2,700	Supgacha (7 kms)
		July 92 - June 93	Mehagoni, Sissoo, Raintree, Eucalyptus and Segun	4,030	Supgacha (6 kms)
		July 93 - June 94	Mango & Olive	2,000	Brahmagacha (2 kms)

Source: PROHSIKA, Sirajganj

Appendix 2: GROUNDWATER

The aquifer system in the NW-Region comprises Quarternary to Recent sediments. Holocene deposits of the Jamuna River floodplain form the southeastern part, including the Sirajganj area. Generally, four main aquifers are recognized in central Bangladesh: upper semiconfided clay or silty clay layer, intermediate fine sand aquifer, lower semiconfined clay layer and main medium to coarse sand aquifer. The intermediate and lower semiconfined clay layers may be absent in the Sirajganj area, and the maximum silty clay thickness ranges from 10 to 20 m (MPO 1986).

The main aquifer has a excellent transmissivity (MPO 1986; Fig.2 in Steenhuis). The piezometric surface (water level) is around 10 m in the Sirajganj area (MPO 1986; Fig.2, Steenhuis). It's recharge is predominantly derived from deep percolation of rain, flood water and irrigation water return flow. Lateral contribution from rivers comprise only a small percentage (<0.1%) of total potential recharge. The potential recharge is sensitive especially to infiltration and deep percolation characteristics of the soil and substratum and to the extent and depth of flooding and rainfall.

FAP 2 groundwater models (FAP 2.1992.10; based on MPO models) suggest that the hydraulic resistence of the upper clay layers is lower than expected. On the other hand, the formation of ploughpans in paddy fields may hamper deep percolation. Unfortunately, there are neither lysometric measurements, nor data on the cropland's soil moisture balance nor a beel water balance available for verifications. Estimates and recharge models are still based on tentative assumptions.

The FAP 2 model uses synthesised flood hydrographs to simulate three scenarious for all thanas over a period of 17 years to predict the impact of FCD on potential groundwater recharge: no flood control (FCD), partial FCD and full FCD. Historical rainfall data from 1972 to 1988 were used. The difference between no FCD and full FCD is high (>30% reduction) for thanas which have large proportions of F1 land, which under full FCD is assumed to be fully protected from flooding. The difference is minor (<5%) if partial protection is practiced. For Sirajganj Thana, the following data were modelled

- no FCD 1,194 mm recharge
- partial FCD 1,142 mm recharge
- full FCD 831 mm recharge

Note: it is unclear whether the "No FCD" scenario assumes the impacts of the BRE; a high recharge without FCD may also be attributed to a high lateral recharge from the Jamuna river. Thanas at some distance to the river have markedly lower recharge rates, eg. Kamarkanda and Raiganj have rates below 800 mm/a with "No FCD". However, the area of lateral movement is limited to less than 2000 m distance from the river bed. This was supported by isotope studies (quoted in MPO 1985).

On the other hand, the local influence of permeability rates is unknown. Most highland soils have considerably higher permeability rates than lowland soils and thereby contribute to groundwater recharge. These highland soils are not or less freqently flooded under the "Full FCD" scenario.

In general, the existing models use several simplifications and a number of parameters which are not yet verified by field tests. Further calibrations are required to verify the model outputs. The data must be provided by groundwater monitoring and baseline field surveys (see Chapter 8). Similar research issues were already addressed by Steenhuis (1987).

The groundwater development potential for irrigation was evaluated by FAP 2. The net groundwater consumption in 1989 was used as the baseline condition.

In fact, this development is not only related to groundwater resource potentials, but also to pump technology (suction or force mode units, land development, groundwater zoning restrictions, agricultural, economic and socio-economic factors and subsidy levels of various agricultural/irrigation equipment inputs which control the development of irrigated agriculture.

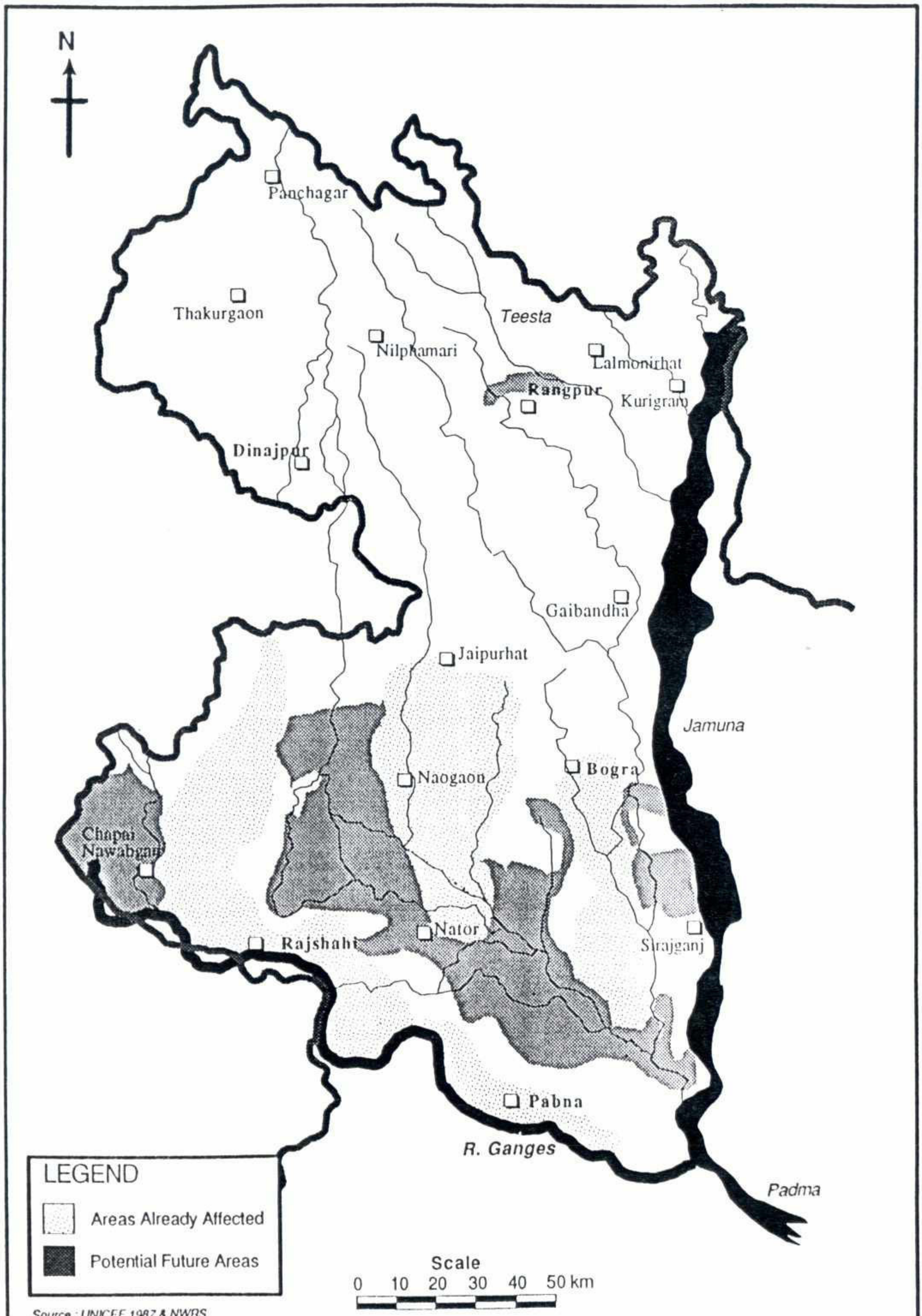
In Sirajganj Thana, some 46 M m3 of groundwater are used on 235 km2 NCA. For Sirajganj, it is estimated that groundwater is sufficient under all scenarious, full, partial and no flood control, to irrigate 100 % of the net irrigable area. Hence, there are no restrictions to irrigation development (FAP 2.1992.10:Tables 8 and 9).

The area north of Sirajganj is considered as being affected in future by lowering the seasonal water table below a critical 7.75 m. This is supported by the long-term evaluation of the development of water levels after irrigation developments in various areas over Bangladesh. A decline of water tables, caused by excessive urban supplies or irrigation abstractions, is reported from various places in Bangladesh, eg. from Chowhali, Pabna District. (Fig. 3, Steenhuis)

A major point of future concern is the increased drainage from high land (eg. F1) to low land (eg F2 or F3 land) during the monsoon season in areas with FCD structures. Typically, the permeability and substratum transmissivity of such highlands is high compared to lowlands. Hence, these areas contribute largely to the recharge of groundwater during the monsoon season. If these areas are less frequently flooded, the groundwater recharge will correspondingly decrease and needs for dry season irigation may increase due to reduced soil moisture replenishment.

Also possible impacts of groundwater fluctuations on homestead forests and beels need to be assessed. FAP 2 concludes that any negative impact on groundwater availability may be mitigated by the option of compartmentalization (FAP 2.1992.Volume 10:G1-13).

Map G1: Areas Affected by Lowering of Seasonal Water Table 7.75m (Suction Limit) in NWR



Source : UNICEF 1987 & NWRS

Table G1: Groundwater Level Data in BADC and BWDB Wells in CPP Sirajganj

			Water Depth (b.g.l.)												Annual Record		
Year	Institution	Location	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG.	AX	MIN.
1986	BADC	SS 27	5.49	5.66	5.79	5.79	5.74	5.54	4.50	3.81	3.51	3.25	3.89	4.67	4.80	5.79	3.25
	DTW #	SS 54	4.19	4.27	4.32	4.52	4.27	4.55	4.17	3.00	3.20	3.30	3.73	4.29	3.98	4.55	3.00
		SS 72	4.06	4.17	4.22	4.42	4.57	4.52	4.42	3.53	3.35	3.28	3.53	4.50	4.05	4.57	3.28
		SS 122	4.37	4.47	4.42	4.47	4.52	4.50	4.42	3.23	2.90	3.28	3.61	4.24	4.04	4.52	2.90
		B 203	4.42	4.47	4.57	4.67	4.77	4.75	4.06	3.10	3.00	3.10	3.64	4.29	4.07	4.77	3.00
		SS 155	4.06	4.14	4.19	4.42	4.47	4.45	4.73	3.78	3.45	3.28	3.71	4.29	4.08	4.73	3.28
		SK 109	3.53	3.81	4.60	4.37	4.27	3.59	1.62	1.42	1.22	1.98	2.36	2.59	2.95	4.60	1.22
1986	BWDB	PA 15/A	0.12	6.97	7.11	6.56	5.37	4.46	2.29	1.95	1.38	1.72	4.18	5.78	3.99	7.11	0.12
	WELL #	PA 27	?	?	?	?	?	?	?	?	?	?	?	?	?	0.00	0.00
		PA 57	?	?	?	?	?	?	?	?	?	?	?	?	?	0.00	0.00
		PA 60	4.64	5.09	5.54	5.82	5.43	4.77	3.34	2.17	2.40	2.66	3.09	3.73	4.06	5.82	2.17
1987	BWDB																
	DTW #	SS 27	4.27	4.50	4.62	5.49	4.95	3.81	2.44	0.96	3.00	3.20	3.48	3.83	3.71	5.49	0.96
		SS 54	4.32	4.55	4.62	4.20	4.12	3.96	2.52	0.48	2.41	2.56	2.74	3.17	3.30	4.62	0.48
		SS 72	4.09	4.12	4.32	4.27	4.12	3.96	2.64	0.38	2.49	2.79	2.92	3.05	3.26	4.32	0.38
		SS 122	4.52	4.73	4.88	4.32	4.19	4.12	2.39	0.00	2.03	2.20	2.39	2.56	3.19	4.88	0.00
		B 203	4.09	4.26	4.40	4.57	4.50	4.34	2.61	0.29	1.90	1.95	2.03	2.10	3.09	4.57	0.29
		SS 155	4.52	4.09	4.40	4.27	4.12	3.96	2.56	0.68	2.36	2.69	2.82	2.62	3.26	4.52	0.68
		SK 109	3.48	3.85	4.57	4.80	4.47	4.04	1.06	0.00	0.76	1.44	1.90	2.29	2.72	4.80	0.00
1987	BWDB	PA 15/A	6.55	6.96	7.32	6.86	6.24	5.17	3.44	1.88	2.25	3.16	4.43	5.66	4.99	7.32	1.88
	WELL #	PA 27	?	?	?	?	?	?	?	?	?	?	?	?	?	0.00	0.00
		PA 57	?	?	?	?	?	?	?	?	?	?	?	?	?	0.00	0.00
		PA 60	4.40	5.12	5.81	5.77	5.32	4.85	3.22	1.72	2.16	2.56	3.55	4.24	4.06	5.81	1.72
1988	BWDB																
	DTW #	SS 27	4.09	4.32	4.85	5.06	3.75	2.18	ND	ND	ND	1.27	1.47	1.67	2.39	5.06	0.00
		SS 54	3.73	2.01	4.24	4.48	2.87	1.49	ND	ND	ND	1.27	1.49	1.70	1.94	4.48	0.00
		SS 72	3.29	3.37	3.38	3.55	3.87	2.20	ND	ND	ND	1.24	0.52	1.77	1.93	3.87	0.00
		SS 122	2.82	3.07	3.22	3.45	2.69	1.70	ND	ND	ND	1.29	1.47	1.67	1.78	3.45	0.00
		B 203	2.41	2.67	3.28	3.51	2.10	1.29	ND	ND	ND	1.22	1.42	1.74	1.64	3.51	0.00
		SS 155	3.01	3.25	3.32	3.38	2.79	1.90	ND	ND	ND	1.24	1.49	1.77	1.85	3.38	0.00
		SK 109	3.51	3.85	4.57	4.63	4.01	3.05	1.22	0.00	0.00	1.39	1.93	2.34	2.54	4.63	0.00
																ERR	ERR
1988	BWDB	PA 15/A	6.35	6.95	6.96	6.67	5.79	4.10	2.81	2.32	1.44	3.22	4.71	5.43	4.73	6.96	1.44
	WELL #	PA 27	4.10	4.23	4.38	5.11	5.18	4.34	2.78	1.97	1.21	2.12	3.11	3.54	3.51	5.18	1.21
		PA 57	5.20	5.78	5.92	6.21	5.76	4.33	2.59	1.84	1.16	2.53	3.91	4.10	4.11	6.21	1.16
		PA 60	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Source : GW Circle II, BWDB, Dhaka, BADC, Sirajganj B:\GENL\GRD-WAT.WK1

Continuted Table G1

Year	Institution	Location	Water Depth (b.g.l.)												Annual Record		
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG.	AX	MIN.
1989	BWDB																
	DTW #	SS 27	4.37	4.82	5.34	5.43	5.40	3.95	2.87	2.35	1.70	2.96	3.69	4.13	3.92	5.43	1.70
		SS 54	3.75	4.15	4.73	5.25	4.79	4.15	2.95	2.36	1.70	2.56	3.54	3.85	3.65	5.25	1.70
		SS 72	3.73	3.92	4.37	4.73	4.97	4.04	2.79	2.23	1.60	2.49	3.62	4.24	3.56	4.97	1.60
		SS 122	3.46	4.03	4.50	4.77	4.92	3.95	2.87	2.21	1.65	2.46	2.87	3.30	3.42	4.92	1.65
		B 203	3.25	3.60	4.44	4.62	5.11	3.30	2.91	2.34	1.68	1.80	2.84	3.63	3.29	5.11	1.68
		SS 155	3.55	3.75	4.35	4.52	4.90	3.32	2.84	2.16	1.57	2.00	2.49	2.82	3.19	4.90	1.57
		SK 109	3.81	4.13	4.57	4.70	3.10	1.83	1.68	0.76	0.35	1.37	2.82	4.57	2.81	4.70	0.35
1989	BWDB	PA 15/A	6.24	6.80	7.02	7.01	5.99	4.28	3.08	3.07	2.94	3.10	4.51	5.52	4.96	7.02	2.94
	WELL #	PA 27	4.00	4.73	4.77	5.26	5.71	4.30	3.64	3.25	3.13	2.76	3.41	3.82	4.07	5.71	2.76
		PA 57	5.20	5.92	6.22	6.48	6.07	4.67	3.69	3.36	3.17	2.94	3.93	4.36	4.67	6.48	2.94
		PA 60	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
1990	BWDB																
	DTW #	SS 27	4.26	4.73	5.42	5.54	4.72	2.53	0.00	1.93	1.40	1.00	1.87	4.04	3.12	5.54	0.00
		SS 54	4.24	4.62	5.15	5.20	4.22	1.42	0.00	1.87	1.45	1.05	1.92	3.66	2.90	5.20	0.00
		SS 72	4.45	4.73	5.41	5.56	4.62	1.17	0.00	1.87	1.24	0.96	1.92	3.94	2.99	5.56	0.00
		SS 122	3.69	4.13	4.35	4.44	3.51	1.24	0.00	2.02	1.65	1.10	1.97	2.87	2.58	4.44	0.00
		B 203	3.64	3.98	4.40	4.98	4.01	0.00	0.00	1.85	0.00	0.00	1.15	2.07	2.17	4.98	0.00
		SS 155	3.22	3.88	4.24	4.44	3.53	1.86	0.00	1.93	1.42	1.03	1.90	2.95	2.53	4.44	0.00
		SK 109	4.77	4.88	5.03	4.30	4.06	0.00	0.00	0.00	0.00	2.49	2.65	2.83	2.58	5.03	0.00
1990	BWDB	PA 15/A	6.28	6.71	6.89	6.48	5.23	3.77	2.50	2.08	2.52	2.32	4.35	5.49	4.55	6.89	2.08
	WELL #	PA 27	4.21	4.93	4.75	4.81	4.92	4.04	2.91	1.69	2.06	1.61	2.83	2.91	3.47	4.93	1.61
		PA 57	4.94	5.63	5.99	6.48	5.94	4.91	3.74	3.33	3.19	2.88	3.85	4.43	4.61	6.48	2.88
		PA 60	?	?	?	?	?	?	?	?	?	?	3.34	3.64	0.58	3.64	0.00
1991	BWDB																
	DTW #	SS 27	4.80	5.92	5.43	5.09	3.63	2.06	0.63	0.89	1.50	2.97	2.42	2.92	3.19	5.92	0.63
		SS 54	4.40	5.59	5.08	5.97	3.51	1.91	0.31	0.64	1.25	2.39	2.84	3.34	3.10	5.97	0.31
		SS 72	4.68	4.72	5.43	5.33	3.84	2.27	0.34	0.69	1.32	2.30	2.75	3.26	3.08	5.43	0.34
		SS 122	3.61	4.94	4.52	4.41	2.95	1.38	0.37	1.07	1.72	2.12	2.57	3.07	2.73	4.94	0.37
		B 203	2.81	3.91	5.08	5.00	3.58	0.00	0.00	0.30	0.91	1.51	2.04	2.54	2.31	5.08	0.00
		SS 155	3.69	4.82	5.93	4.98	3.52	1.24	0.00	0.42	1.07	1.95	2.40	2.90	2.74	5.93	0.00
		SK 109	3.18	5.36	4.53	4.49	3.47	0.82	0.00	0.00	0.00	1.28	1.88	2.31	2.28	5.36	0.00
1991	BWDB	PA 15/A	6.22	6.70	6.90	6.42	5.15	3.78	2.43	2.30	2.04	3.02	4.52	5.60	4.59	6.90	2.04
	WELL #	PA 27	4.07	4.69	5.92	6.15	5.83	4.30	2.12	1.81	1.84	2.64	3.90	4.48	3.98	6.15	1.81
		PA 57	5.04	5.72	5.71	5.85	5.09	3.84	2.39	1.95	1.51	2.28	3.38	4.24	3.92	5.85	1.51
		PA 60	4.25	5.30	6.48	5.83	4.05	1.60	0.93	1.14	1.07	2.00	3.53	5.07	3.44	6.48	0.93

Source : GW Circle II, BWDB, Dhaka, BADC, Sirajganj

Continued Table G1

Year	Institution	Location	Water Depth (b.g.l.)												Annual Record		
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG.	AX	MIN.
1992	BWDB																
	DTW #	SS 27	4.37	4.92	5.62	5.71	5.36	4.28	3.18	3.44	1.92	2.54	3.73	2.92	4.00	5.71	1.92
		SS 54	4.79	4.95	6.35	5.47	4.95	4.00	3.08	3.32	1.78	2.67	2.68	3.34	3.95	6.35	1.78
		SS 72	4.70	4.97	5.68	5.83	5.28	4.34	3.14	3.40	1.84	2.64	3.72	3.26	4.07	5.83	1.84
		SS 122	4.52	4.78	5.50	5.95	4.36	3.45	2.25	2.48	1.41	2.59	2.51	3.07	3.57	5.95	1.41
		B 203	3.99	4.35	6.13	5.24	4.47	3.53	2.74	2.96	1.51	1.62	2.73	2.54	3.48	6.13	1.51
		SS 155	4.35	4.60	5.38	5.25	5.13	4.22	3.10	3.36	1.72	2.97	3.82	2.90	3.90	5.38	1.72
		SK 109	2.82	3.68	4.06	3.76	3.49	0.85	1.25	1.56	0.76	1.70	2.22	2.31	2.37	4.06	0.76
1992	BWDB	PA 15/A	6.19	6.65	6.80	6.43	5.71	4.97	3.77	3.60	3.44	3.70	4.54	5.60	5.12	6.80	3.44
	WELL #	PA 27	4.81	5.59	6.10	6.55	5.98	5.46	4.60	4.27	4.19	3.53	3.98	4.48	4.96	6.55	3.53
		PA 57	5.07	5.59	5.82	6.27	5.99	5.43	4.47	4.24	4.12	3.48		4.24	4.97	6.27	3.48
		PA 60	5.82	6.13	6.22	5.50	4.82	3.74	1.84	?	?	3.33	3.80	5.07	3.86	6.22	0.00
1993	BWDB																
	DTW #	SS 27	4.28	5.52	5.82	6.07									5.42	6.07	4.28
		SS 54	3.25	4.65	4.94	5.12									4.49	5.12	3.25
		SS 72	4.26	5.43	5.73	5.96									5.35	5.96	4.26
		SS 122	3.14	4.57	4.81	4.67									4.30	4.81	3.14
		B 203	3.26	4.29	4.59	4.67									4.20	4.67	3.26
		SS 155	4.32	5.37	5.67	5.72									5.27	5.72	4.32
		SK 109	4.05	4.98	5.20	5.27									4.88	5.27	4.05
1992	BWDB	PA 15/A	?	?	?	?											
	WELL #	PA 27	?	?	?	?											
		PA 57	?	?	?	?											
		PA 60	?	?	?	?											

Source : GW Circle II, BWDB, Dhaka, BADC, Sirajganj

B:\GENL\GRD-WAT.WK1

Table G2: Groundwater Level Data in DPHE Tubewells in CPP Sirajganj

Station No	Location Village	Union	Water Levels Records							
			1990		1991		1992		1993	
			B.G.L	P.W.D	B.G.L	P.W.D	B.G.L	P.W.D	B.G.L	P.W.D
01	Char Khoksabari	Khoksabari	5.75		4.93		5.31		6.09	
02	Brahmangati	Khoksabari	5.71		5.18		5.89		6.33	
03	Guncrgati	Khoksabari	5.76		5.31		5.41		5.95	
04	Brahmokhola	Bohuli	5.68		4.59		5.26		5.18	
05	Khaga	Bohuli	5.68		5.18		6.25		5.99	
06	Beel Gazaria	Bohuli	5.73		5.64		7.64		6.45	
07	Itali	Songacha	5.78		5.08		6.57		6.35	
08	Simla	Songacha	5.94		5.59		6.57		6.25	
09	Naoda Fulkocha	Songacha	5.73		4.93		6.15		6.17	
10	Fulkocha	Bagbati	6.09		6.09		6.25		6.35	
11	Alokdia	Bagbati	6.34		6.09		6.58		6.3	
12	Ichamati	Bagbati	6.09		6.71		7.65		7.01	
13	Roghunathpur	Sialkol	5.1		5.34		6.33		5.64	
14	Shaympur	Ratankandi	6.55		6.17		7.75		6	

Source: Department of Public Health Engineering, Sirajganj. April data, standard time for national data collection.

Appendix 3: PUBLIC HEALTH

Malaria

The Vector. Benign malaria is transmitted by the vector An.philippinensis and the only indigenous species of malaria in floodplains (Stratum 4) is currently P.vivax. This is rarely fatal but does cause morbidity. The annual malaria cases reported are frequently less than 1,000 per district. In Sirajganj Thana, no clinical malaria cases are reported during the period 1989 to 1993.

Malaria in the floodplains is unstable and has epidemic potential and all sections of the community are exposed. Greatest morbidity is expected in children and pregnant women. There is no drug resistence and the occurence is highly seasonal.

Environmental factors. The vector breeds in restricted habitats of clean water with filamentous algae (eg. Spirogyra spp.) and other subaquatic vegetation (eg. Hydrilla verticulata). Village ponds in full sunlight with a high oxygen dissolved concentration are prefered habitats. The vector cannot tolerate silty or polluted water. Environmental management could be used for control. It include raising groundwater table by irrigation, covering ponds with water hyacinth and, the opposite, removing all aquatic vegetation from ponds. Floating aquatic vegetation is inimical to larvae and included Azolla, Salvina, and Eichhornia, as well as duckweed. Waterlogging inhibit the dissolved oxygen concentration of ponds, which in turn inhibit the growth of green non-filamentous algae (also shade inhibit grwoth) on which some vector feed, eg. An.philippinensis.
The vector may also breed in very low densities in paddy fields during the partial shaded stage. Other breeding sites included blocked rivers and canals and beels. Shallow borrow pits and drains are not important. Breeding habitats have become progressively rare during the past decads due to environmental changes associated with intensified agriculture, drainage congestion (roads, river embankments, siltation of channels) and human population density. This resulted in high organic pollution of waterbodies which act as a deterrant to vector breeding.

Vector control. After introduction of residual house spraying with DDT the vector became rare and malaria cases decreased dramatically in the region. Sporadic cases were treated with chloroquine accompanied by focal DDT spraying. The malaria prevalence rate (annual parasite index) stabilized in the range of 0.4-0.8 per thousand.

The health service has limited resources to monitor and control malaria and provide curative services. However, chloroquine treatment of sproadic cases remains cheap, effective and accessible. Vectors can be controlled by residual house spraying with insecticides, although the replacements of DDT are much more expensive and may be unavailable. Therefore, the health service capability to respond to local outbreaks is likely to become more limited.

Recommendations. Secondary vectors have recently been incriminated. These may tolerate a wider range of breeding conditions. However, the conditions are already established (pre-project) and no substantial increase is expected as a result of new embankments. However, the status of these vecotrs should be kept under review.

Overall risk assessment: The low prevalence of benign malaria as well as sporadic epidemics on the floodplains is likely to continue and further FCD/I works are unlikely to increase vector abundance.

Kala-azar

One confirmed case of Kala-azar was reported in 1991 in the Sirajganj Thana. However, there were annually about 300 cases reported during the last years in Singra and Kazipur Thana (FAP 2.1992.Volume 15:H3-1).

Vector and Habitat. There is a widespread epidemic of fatal Kala-azar in the floodplains. The most vulnerable communities are poor, rural cattleholders. The single vector species, a sandfly called Phlebotomus argentipes, breeds in moist but not saturated, organically rich soils.

Seasonal flooding may limit vector breeding, but the association between vector abundance and land use has not been well established. Cases appear to be clustered close to embankments. Historical evidence show that deeply flooded areas reported far fewer cases and it seems that in some localities floods are an important deterrent factor to vector breeding.

The vector lives and breeds in close association with human dwellings, where villagers live close to their cowsheds. There is evidence of larval respondiveness to soil moisture and of adult vector association with species of cultivated plants that are grown on flood-free land.

Vector control. Kala-azar (visceral leishmaniasis) is epidemic in Bengal. Residual house spraying for malaria control suppressed the vector. Case incidence is now increasing also in the region and there have been small epidemics also in the Sirajganj area. The vector can be controlled by residual house spraying with insecticide (see section on malaria).

There is no control programme, and disease surveillance is rather limited. Accurate diagnosis is difficult and expensive, and widely available tests do not distinguish the disease from several other infections. The treatment is expensive and public health facilities at Sirajganj town are limited.

Overall Risk Assessment: There is significant risk that prevalence in some localities will increase as a result of flood control and drainage works. The health servoces does have only limited capability to manage this risks without additional support.

Filariasis

Community Vulnerability. There is a widespread but low prevalence of bancroftian filariasis. The disease is transmitted by a mosquito and occurs in both rural and urban foci. The prevalence rate was higher in males. The large number of hydrocoeles caused considerable morbidity.

Environmental Factors. The vector mosquito is common and widespread. It breeds in peridomestic ponds, pools, and ditches where water is polluted by organic materials. The flushing action of seasonal flooding contributes to vector control and there is only limited endemicity. Interrupted flooding without proper drainage and the increase in polluted water sources will greatly enhance vector abundance.

Vector Control. Available surveillance data suggest a slow upward trend in prevalence. There is no national drug treatment or control programme. Diagnosis is simple and drug therapy is cheap and effective during the early stages of the diseases.

Overall Risk Assessment.The vector abundance will depend on proper design and operation. Polluted water sources require regular flushing. Drainage obstructions should be avoided.

Table P1: Diseases (Clinical Cases) in the Sirajganj Thana for the Years 1989 Until 1992

Sl. No.	Name of Major Disease	No. of Patients				
		1989	1990	1991	1992	Total
01.	Diarrhoeal Diesease	50370	54002	80462	75988	260822
02.	Clinical Malaria	-	-	-	-	-
03.	Int. Worm Infection	29845	31317	34224	37133	132519
04.	Peptic Ulcer	17004	20739	28928	39361	106032
05.	T.B.	-	-	-	17	17
06.	Acute Res. Infection	20155	23964	34033	29707	107819
07.	Skin Diseases	15201	25456	43287	49919	133863
08.	Hepatitis	13	37	84	75	209
09.	Tetanus	-	-	-	-	-
10.	Deptheria	-	-	-	-	-
11.	Night Blindness	-	2	2	-	4
12.	Difficiency Disease	17982	18369	18497	34289	89137
13.	Anemia	25561	24900	26133	49691	126285
14.	Asthma	3075	4072	4326	2451	13924
15.	Whoping Cough	7	32	32	1	72
16.	Measles	102	98	72	17	289
17.	Chicken Pox	84	62	104	55	305
18.	Diabates	-	-	2	6	8
19.	Eye Disease	10348	10703	14903	9200	45154
20.	Ear Disease	4905	5062	6563	6752	23282
21.	Dental Disease	4317	4441	7469	5816	22043
22.	Hypertention	183	200	711	290	1384
23.	Poisioning	10	12	45	36	103
24.	Injuries	4260	4432	5485	4244	18421
25.	Ous & Gynee Compl.	395	457	733	560	2145
26.	Filariasis	-	-	-	-	-
27.	Kala-a-Zar	-	-	1	-	1
28.	Mental Disease	18	23	47	28	116
29.	P.U.O	6446	11239	2935	8486	29106
30.	Others	40711	46592	57902	72161	217366

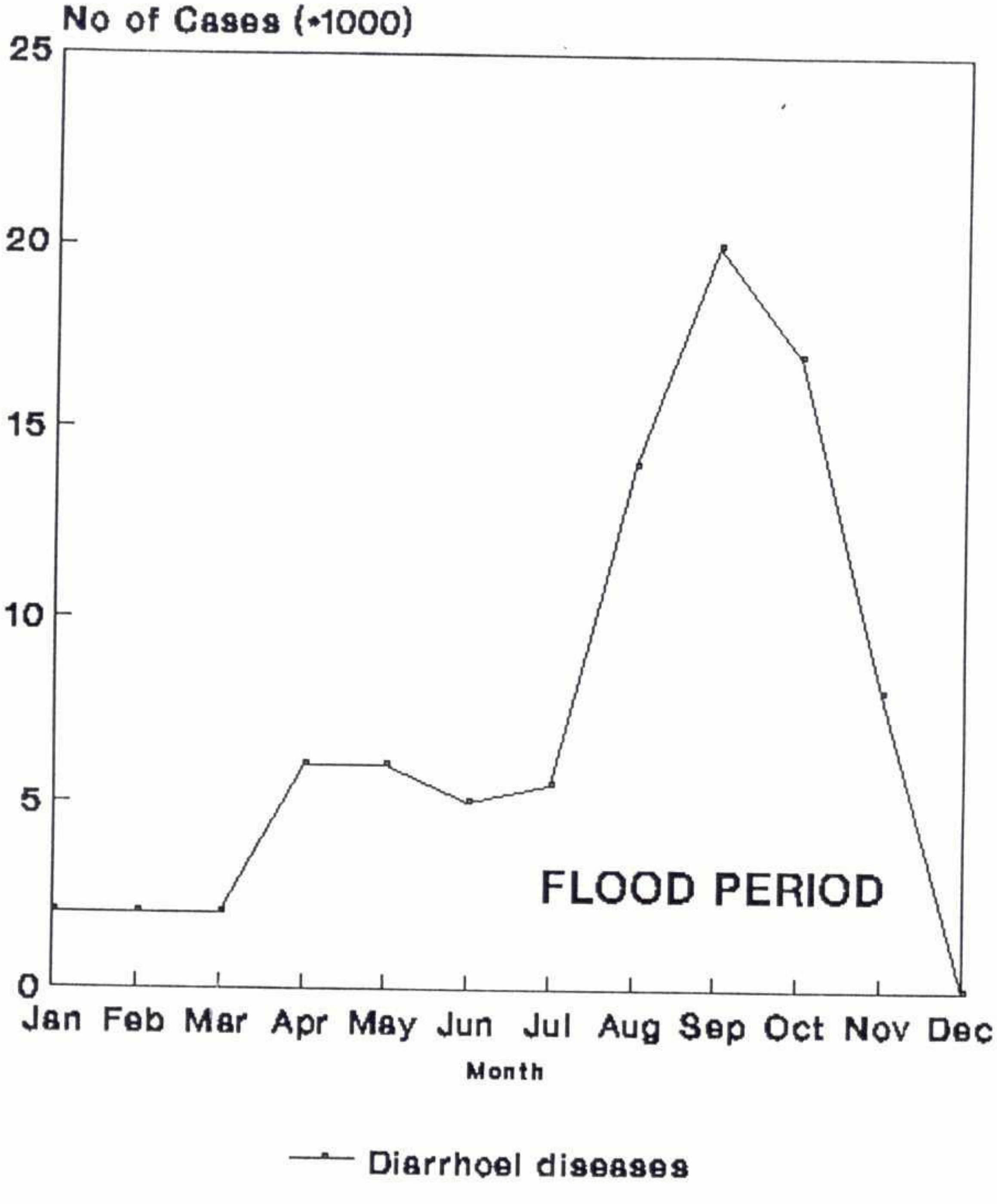
Source: Department of Health, Sirajganj

Table P2: Summary Health Impact Assessment: Vector Borne Diseases and Flood Control and Drainage in Bangladesh

Health Hazard	Community Vulnerability	Environmental Factors	Health Service Capability	Health Risk Change
Benign malaria P.vivax	Prevalence currently low, no drug resistance. Non-fatal, causes morbidity	Floods and pollution minimize vector breeding. The status of secondary vectors may be increasing	Chloroquine widely available, diagnosis simple. Existing health service adequate but requires strengthening. Focal vector control	No change
Malignant malaria P.falciparum	Highly susceptible, circulating labor provides & reservoir. Prevalence very low. Fatal, drug resistance common	Floods and pollution minimize vector breeding. No significant local transmission at present	Not adequately prepared for local epidemics	No change
Kala-azar	Highly susceptible, epidemic in progress, reservoir in post kala-azar dermal leishmaniasis sufferers. Fatal and debilitating. Evidence of association with embankments.	Vector widespread. Peri-domestic breeding in association with cattle sheds. Insufficient data about association with soil moisture and plant species and hence with embankments	Inadequate supply of drugs, diagnosis difficult, no vector control program. Surveillance and vector research needs strengthening	Significant risk of association with embankments in some localities
Filariasis (bancroftian)	Widespread, but low prevalence with both rural and urban foci. Non-fatal but debilitating	Vector thrives in foul water which will be increased by poor drainage	Surveillance poor. Drug therapy cheap and simple; diagnosis simple. No vector control or treatment program	Slow but widespread increase
Dengue and Dengue Hemorrhagic Fever	Vulnerability is high. No information about prevalence	The vector is present, but not associated with embankments	Supportive treatment in intensive care units would be required and is not widely available	No change
Encephalitis (J.E)	Pig keeping/rive growing communities are vulnerable. Disease belived to be very rare. No data on virus prevalence	Natural reservoir expected in ardeid birds with pig as amplifier host. Vector is common in ricefields and other water bodies	Supportive treatment in intensive care units would be required and is not widely available	No change
Schistosomiasis	The disease is absent	No data on presence of vector snail	No experience of the disease	No change

Source: ISPAN

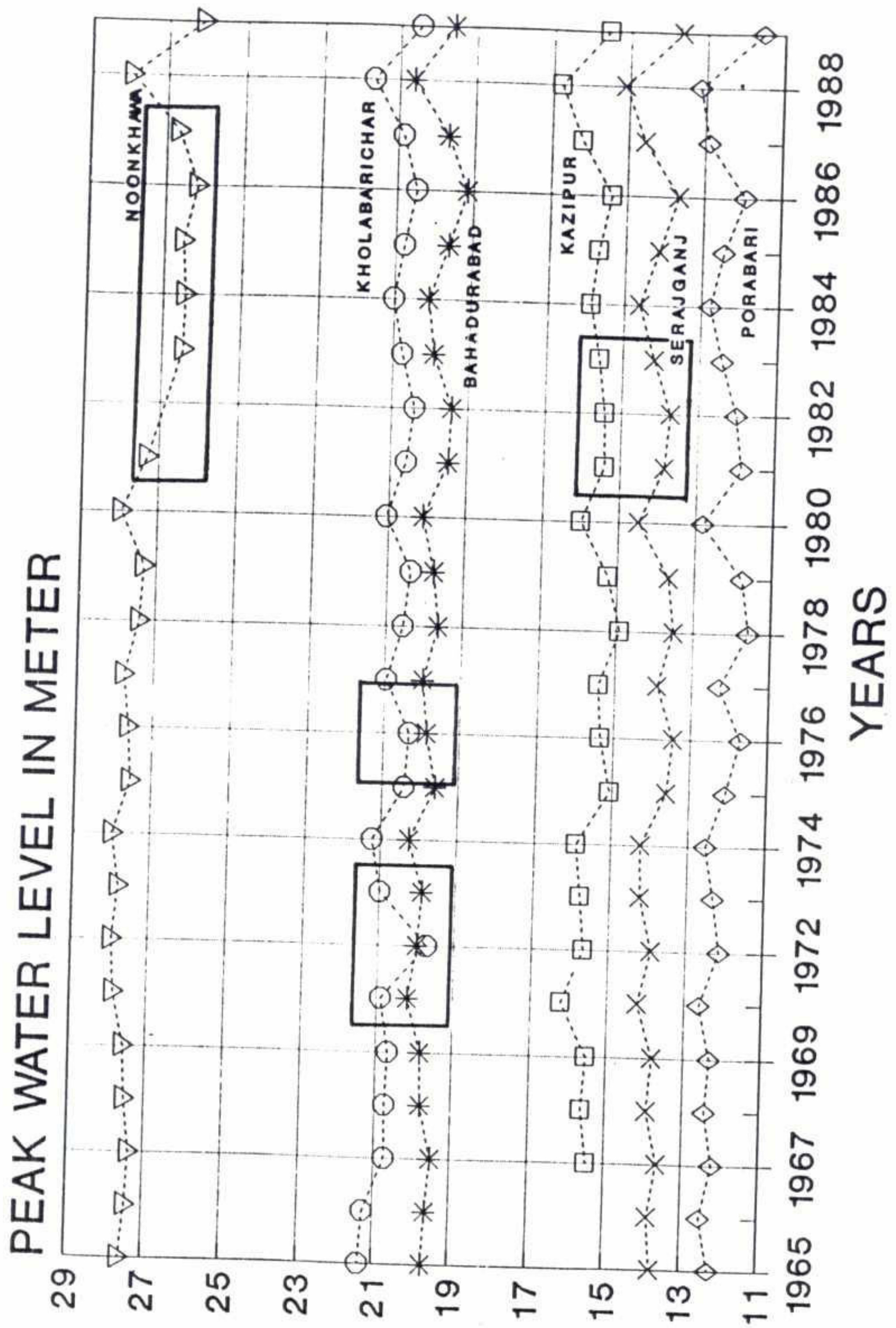
Figure P1: Prevalence of Diarrhoeal Disease in the Sirajganj Thana in 1992



Source: Dept. of Health, Sirajganj

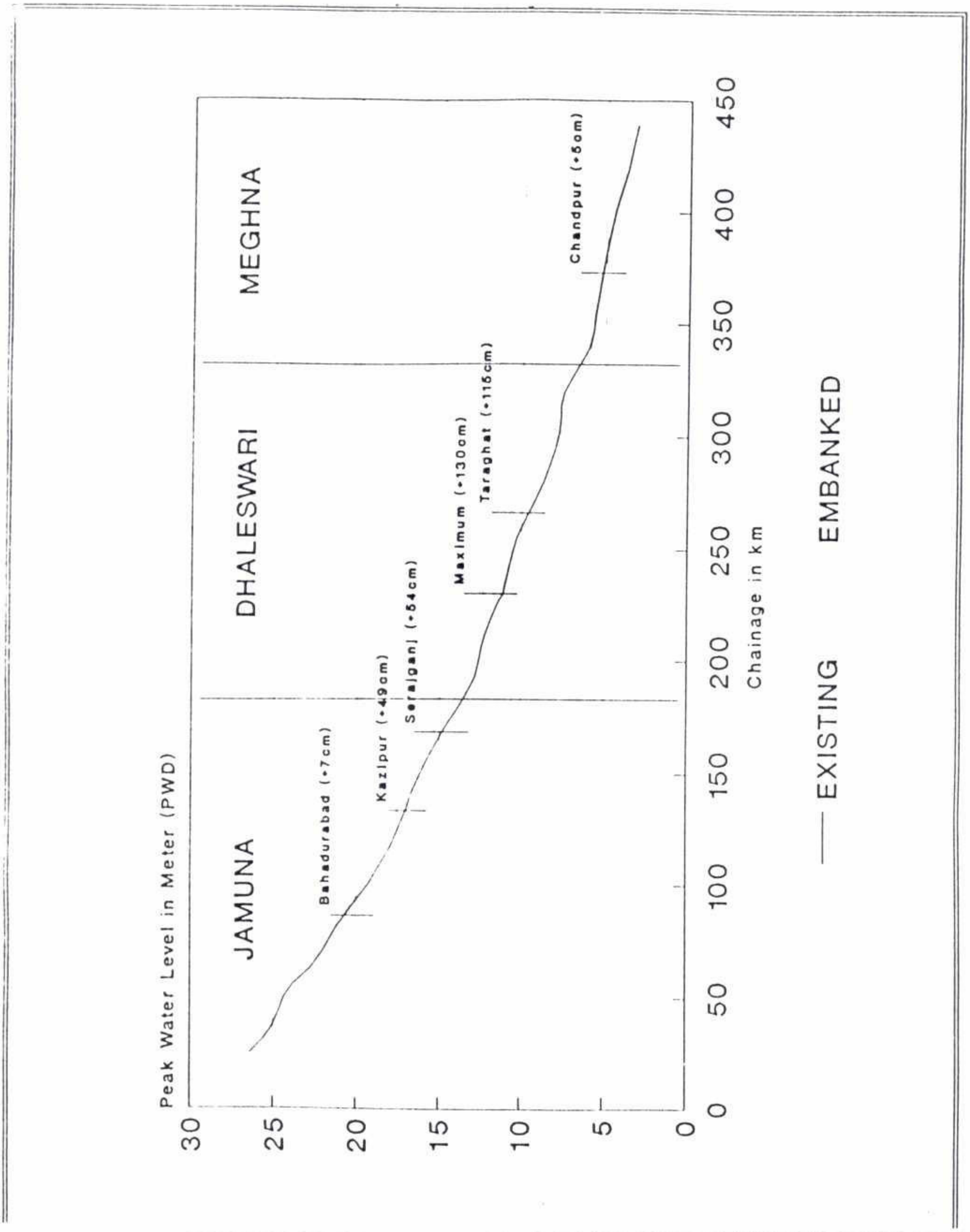
Appendix 4: HYDROLOGY

Figure H1: Peak Water Level in the River Jamuna



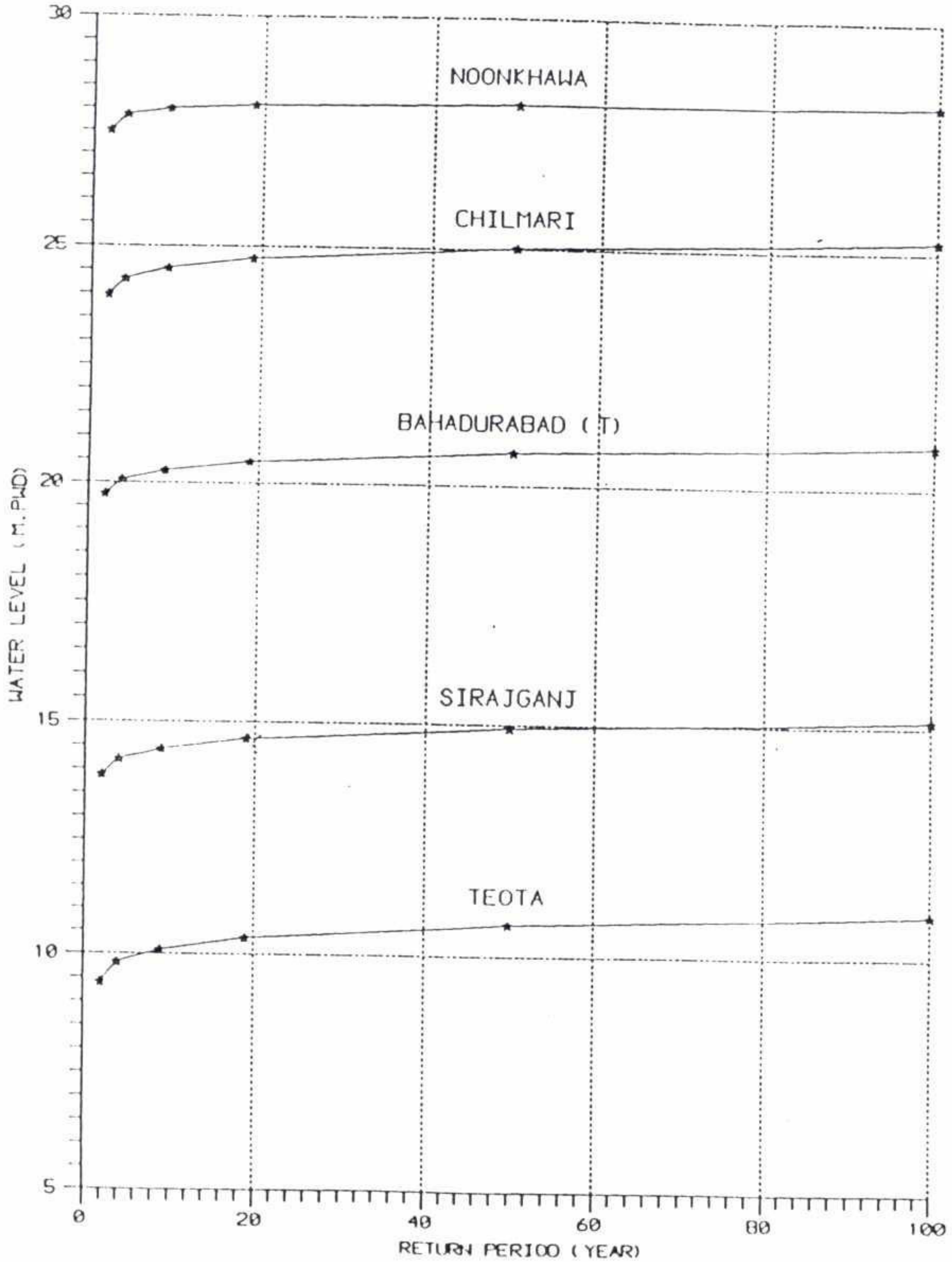
FAP25 FLOOD MODELLING & MANAGEMENT	FLOOD HYDROLOGY STUDY
	Water Level Data Review : Peaks in Jamuna
	JUNE 1992

Figure II2: Comparison of Peak Water Levels Profile: Jamuna-Dhaleswari-Meghna System in 1988



FAP25 FLOOD MODELLING & MANAGEMENT	FLOOD HYDROLOGY STUDY
	Comparison of Peak Water Level Profile : Jamuna-Dhaleswari-Meghna System in 1988
	JUNE 1992

Figure H3: Peak WL Frequency Curves of the Brahmaputra



Peak WL Frequency Curves
Of the Brahmaputra

Halcrow/DHI/EPC/DIG

November 1992

Appendix 5: WATER QUALITY

Table W1: Ground & Surface Water Quality at some Survey Stations in the NWR

LOCATION	OXYGEN			GENERAL			NUTRIENTS		OTHERS		
	DO	BOD	COD	pH	TS	TDS	NO4	NH4	Cl	SO4	Fe
	mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Andasuria Beel (Bakapur)	8.4	4.2	20	7.5	100	65	0	0.2	11	0	1
Atrai/Barnai confl.	6.9	2.8	26	7.7	105	70	0	0.1	8	0.4	1.1
Atrai/Barnai confl. HTW	2.2	12.1	42	6.8	230	178	0	1.3	22	8.5	1.6
Atrai/Nandokuja confl.	6.2	3.1	65	8	406	350	0	0.6	18	0.4	0.9
Atrai/Nandokuja STW	2.6	7.5	22	6.7	257	212	0	1	20	14.1	0.9
Bamandanga Beel	8	3	30	8	117	54	0	0.3	6	0	0.9
Bamandangha Beel STW	2	22	40	6.7	290	165	0	1.6	14	0	8
Bangali River (Sariakandi)	8.3	1.5	28	8.2	126	88	0	0.2	7	0	0.9
Burail River	8	3.9	38	8	215	162	0	0.3	9	0.1	1
Ghargot River (Gaibandha)	7.5	6.6	40	8	174	102	0	0.3	6	0	1.1
Halti Beel (Chalan Beel C)	8	6.6	26	7.7	207	152	0	0.2	17	12	1
Halti Beel STW	2.4	9	55	7.2	375	315	2	0.4	13	35.2	1
Harudangha Beel	8	2.5	12	7.4	46	25	0	0.6	4	0	1.1
Harudangha Beel STW	0.8	12	18	6.5	133	53	0	1.2	6.8	0	2.9
Jamuna River (Kurigram)	8.7	2.6	25	8.2	212	182	0	0.1	6	11.3	0.7
Teesta/Jamuna confl HTW	2	40	38	6.5	160	101	0	0.2	4	0	1.2
Teesta/Jamuna confl. DTW	0.3	2.5	32	6.7	184	92	0	1.3	6	1.1	5.8
Jamuna River (Manos Reg.)	8.6	3	21	8.1	132	46	0	0.3	7	0	1.6
Jamuna R. below Burail confl.	8.5	5.8	30	8	158	108	0	0.4	4	18.2	1.2
Kumirdaha Beel	7.8	5.8	32	8	177	65	0	0.4	4	0	1.2
Kumirdaha Beel STW	1.9	8.5	50	7	290	198	0	2	38	41.5	2.1
Atrai/Nandokuja confl.	1.8	40	52	8.2	394	332	0	1.2	15	0	1.9
Atrai/Nandokuja confl.	5.4	4	60	8	384	330	0	0.7	19	0.1	1.1
Padma River	8.2	4	40	8.1	232	190	0	0.2	14	22.5	1
Sib River (Chaubaria)	6.9	2.7	24	7.7	152	94	0	0.3	14	0.5	1.9
Teesta River	8.4	1.8	12	7.7	149	51	0	0.2	8	0	1.8
Utraeel Beel (S Central)	7.6	5	22	7.5	145	94	0	0.3	10	0	0.9

DO = Dissolved Oxygen
GOD = Biological Oxygen Demand
COD = Chemical Oxygen Demand

Source: FAP 2

Table W2: Human and Fish Pathologies Close to Water Sampling Stations in the NWR

LOCATION	COLIFORMS no/100ml	HUMAN DISEASES REPORTED		FISH DISEASES From	To
Andasuria Beel (Bakapur)	120	Diarrhoea	Dysentery	Aug	Oct
Atrai/Barnai confl.	116	Cholera	Dysentery	Sept	Dec
Atrai/Barnai confl. HTW	34	Cholera	Dysentery	NA	NA
Atrai/Nandokuja confl.	190	Diarrhoea	Dysentery	Oct	Dec
Atrai/Nandokuja STW	96	Diarrhoea	Dysentery	NA	NA
Bamandanga Beel	120	Dysentery	ND	Aug	Sept
Bamandangha Beel STW	80	Diarrhoea	Dysentery	NA	NA
Bangali River (Sariakandi)	170	Diarrhoea	ND	NDA	NDA
Burail River	40	Diarrhoea	ND	NDA	NDA
Ghargot River (Gaibandha)	TNTC	Diarrhoea	Dysentery	NDA	NDA
Halti Beel (Chalan Beel C)	60	Diarrhoea	Dysentery	Oct	Nov
Halti Beel STW	100	Diarrhoea	Dysentery	NA	NA
Harudangha Beel	50	Diarrhoea	Cholera	Sept	Feb
Harudangha Beel STW	120	Diarrhoea	Dysentery		
Jamuna River (Kurigram)	300	Dysentery	ND	Nov	Dec
Teesta/Jamuna confl HTW	100	Dysentery	ND	NA	NA
Teesta/Jamuna confl. DTW	0	Dysentery	Diarrhoea	NA	NA
Jamuna River (Manos Reg.)	250	Diarrhoea	Dysentery	Sept	Oct
Jamuna R. below Burail confl.	70	Diarrhoea	Dysentery	NDA	NDA
Kumirdaha Beel	130	Diarrhoea	ND	Sept	Oct
Kumirdaha Beel STW	40	Diarrhoea	Dysentery	NA	NA
Atrai/Nandokuja confl.	80	Diarrhoea	Cholera	Feb	Mar
Atrai/Nandokuja confl.	TNTC	Diarrhoea	ND	Feb	Mar
Padma River	100	Dysentery	Diarrhoea	Oct	Nov
Sib River (Chaubaria)	110	Diarrhoea	Cholera	Sept	Oct
Teesta River	160	Diarrhoea	ND	Oct	Nov
Utraeel Beel (S Central)	140	Diarrhoea	Dysentery	Oct	Nov

TNTC = Too Numerous to count

Source: FAP 2

Table W3: Repoprted Use of Fertilizers and Biocides Close to Water Sampling Station in the NWR

LOCATION	FERTILISERS	BIOCIDES
Andasuria Beel (Bakapur)	Urea; TSP; MP	Dicremon; Malathion; Sumithio
Atrai/Barnai confl.	Urea: TSP; Zinc sulphate	Diazinon; Malathion; Sumithion
Atrai/Barnai confl. HTW	No data	No data
Atrai/Nandokuja confl.	Urea; TSP; MP	Sumithion; Furadan; Heptachlo
Atrai/Nandokuja STW	No data	No data
Bamandanga Beel	Urea: TSP; Zinc sulphate	Thiodin; Thionol; Danada
Bamandangha Beel STW	No data	No data
Bangali River (Sariakandi)	Urea; TSP; Zinc sulphate	Sumithion; Dieldrin; Furadan
Burail River	Urea: TSP; MP	Diazinon; Malathion; Nogos
Ghargot River (Gaibandha)	No data	No data
Halti Beel (Chalan Beel C)	Urea: TSP; Zinc sulphate	Basudin; Furadan; Nogos
Halti Beel STW	No Data	No data
Harudangha Beel	Urea; TSP; Gypsum*	Dimecron; Malathión; Basudin
Harudangha Beel STW	No data	No data
Jamuna River (Kurigram)	Urea; TSP; MP	Thiol; Malathion; Thiodin
Teesta/Jamuna confl HTW	No data	No data
Teesta/Jamuna confl. DTW	Na data	No data
Jamuna River (Manos Reg.)	Ure; MP; Gypsum*	Dieldrin; Basudin; Nogos
Jamuna R. below Burail confl.	Urea; TSP; Gypsum*	Nogos; Aldrin; Malathion
Kumirdaha Beel	Urea; TSP; Gypsum*	Furadan; Nogos; Basudin
Kumirdaha Beel STW	No Data	No data
Atrai/Nandokuja confl.	Urea; TSP; Zinc sulphate	Sumithion; Furadan; Basudin
Atrai/Nandokuja confl.	Urea; TSP; Zinc sulphate	Heptachlor; Basudin; Nogos
Padma River	No Data	No data
Sib River (Chaubaria)	Urea; TSP; Zinc sulphate	Sumithion; Faradan; Thiodin
Teesta River	Urea; TSP; Zinc sulphate	Furadan; Malathion; Thiodin .
Utraeel Beel (S Central)	Urea; TSP; Gypsum*	Furadan; Thiodin; Sumithion

TSP Triple Superphosphate
MP 'Muriate of Potash' - i.e. Potassium Chloride
Gypsum* Commonly Reported, but may be Confused with Lime.
Zinc Sulphate - Widely used to Counter Soil Zinc Deficiency,

Source: FAP 2

Table W4: Summary of Water Quality Data for Wells in the NWR (Feb-Mar 1992)

Site cod	Location	Type	DO mg/l	BOD mg/l	COD mg/l	pH	NH4 mg/l	Cl mg/l	SO4 mg/l	Fe mg/l	Coliforms no./100ml
G6	Chandipur (TRE)	DTW	0.3	2.5	32	6.7	1.3	6	1.1	5.8	120
R10	Natore (Ananda Nagar)	STW	2.6	7.5	22	6.7	1	20	14.1	0.9	160
R19	Gaibandha (Jumar Bari)	STW	1.9	8.5	50	7	2	38	41.5	2.1	120
R17	Halti Beel (Piprul)	STW	2.4	9	55	7.2	0.4	13	35.2	1	110
G2	Harudanga Beel	STW	0.8	12	?	6.5	1.2	6.8	0	2.9	50
R6	Natore (Singra)	HTW	2.2	12.1	42	6.8	1.3	22	8.5	1.6	300
G5	Bamandanga Beel	STW	2	22	40	6.7	1.6	14	0	8	100
G7	Chandipur (TRE)	HTW	2	40	38	6.5	0.2	4	0	1.2	100
	Range :	Min	0.3	2.5	22	6.5	0.2	4	0	0.9	50
		Max	2.6	40	55	7.2	1.6	38	41.5	5.8	300

Source: FAP 2

Table W5: Summary of Water Quality Data for Beel & Temporary Rivers in the NWR (Feb-March 1992)

Site cod	Location	Water source type	DO mg/l	BOD mg/l	COD mg/l	pH	NH4 mg/l	Cl mg/l	SO4 mg/l	Fe mg/l	Coliforms no./100ml
G1	Harudanga Beel	Permanent beel	8	2.5	12	7.4	0.6	4	0	1.1	116
R4	Utraeel Beel (S Central)	Flushed beel	7.6	5	22	7.5	0.3	10	0	0.9	250
R16	Halti Beel (S Central)	Flushed beel	8	6.6	26	7.7	0.2	17	12	1	170
G4	Bamandanga Beel	Flushed beel	8	3	30	8	0.3	6	0	0.9	40
R18	Gaibandha (Kumir Daha)	Flushed beel	7.8	5.8	32	8	0.4	4	0	1.2	140
R7	Natore (Singra)	Nandokuka R (T)	6.9	2.7	24	7.7	0.3	14	0.5	1.9	80
R5	Natore (Solakura)	Gur R. (Temp)	6.9	2.8	26	7.7	0.1	8	0.4	1.1	80
R2	Naogoan (Choubaria)	Sib R. (Temp)	6.9	2.7	24	7.7	0.3	14	0.5	1.9	0
R9	Natore (Chaskor Bazar)	Atrai R (Temp)	6.2	3.1	65	8	0.6	18	0.4	0.9	70
R8	Natore (Chaskor Kheaghat)	Nandokuja R (T)	5.4	4	60	8	0.7	19	0.1	1.1	34
G8	Gobindapur	Ghagot R. (T)	7.5	6.6	40	8	0.3	6	0	ND	40
	Range :	Min	5.4	2.5	12	7.4	0.1	4	0	0.9	0
		Max	8.4	6.6	65	8	0.7	19	12	1.9	250

Source: FAP 2

Table W6: Summary of Water Quality Data for Permanent Rivers in the NWR (Feb - March 1992)

Site cod	Location	Water source type	DO mg/l	BOD mg/l	COD mg/l	pH	NH4 mg/l	Cl mg/l	SO4 mg/l	Fe mg/l	Coliforms no./100ml
R12	Sariakandi Ferry Ghat	Bangali R.	8.3	11.5	28	8.2	0.2	7	0	0.9	60
R1	Kurigram (Jorgas Ghat)	Jamuna R.	8.7	2.6	25	8.2	0.1	6	11.3	0.7	130
G3	Pirgacha (Painal Ghat)	Teesta R.	8.4	1.8	12	7.7	0.2	8	0	1.8	100
R13	Pabna (Char Pechakola)	Hurasagar R.	8	3.9	38	8	0.3	9	0.1	1	190
R11	Rajshahi (Darga Para)	Padma R.	8.2	4	40	8.1	0.2	14	22.5	1	1000
R15	Gaibandha (Manos Reg.)	Jamuna R.	8.6	3	21	8.1	0.3	7	0	1.6	1000
R14	Pabna (Nakalia Bazar)	Jamuna R.	8.5	5.8	30	8	0.4	4	18.2	1.2	120
	Range :	Min	8	1.8	12	7.7	0.1	4	0	0.7	60
		Max	8.7	12	40	8.2	0.4	14	22.5	1.8	1000

Note Coliforms = 1000 (actual no. 'too numerous to count')

Source: FAP 2

Appendix 6: PEOPLES VIEWS ON ENVIRONMENTAL PROBLEMS AND POSSIBLE SOLUTIONS IN THE CPP SIRAJGANJ

SC# 01	SC# 02	SC# 03	SC# 04	SC# 05
Problems *Water congestion *Drought *River bank erosion *Homestead & Kitchen garden destructed *High mortality of livestock and poultry *Flooding from Jamuna due to BRE breaching *Water borne diseases *Crop damage	*Flood from the Jamuna *Water congestion *Sand deposition *Homestead destructed *Fish disease *High mortality of livestock & poultry *Disease	*Flood from Jamuna *Water congestion *River erosion *Sand deposition *Female disease *Diarrhoea *High mortality of livestock & poultry	*Flood from Jamuna & Ichamati *Water congestion *Drought *Extensive fish disease *Mortality for livestock & poultry *Crop damages *Disease	*Flood from BRE breaching *Water congestion *Sand deposition *Drought & dealining fertility *Dried well *Water bodies silted up *Extensive fish disease *Strengthen of drought animals *Child & female diseases *Poor medicare for cattle and poultry
Solutions *Drainage *Sluice in embankment *Stable BRE *Medicare for livestock & poultry *Ensure health support *None	*Stable BRE with sluice *Flushing and drainage *Re-excavation of khals *Control fish disease *Medicare facilities for livestock & poultry *Stop corruption of local clinic poeple *None	*Groynes and other possible means *Immediate measure against bank erosion *Bridge cum sluice *Improve existing Govt.health care system *Medicare for livestock and poultry *None	*Controlled flooding *Canal re-excavation *Medicare for cattle & poultry *Control disease *Health care *None	*Control flood with groyne *River re-excavation *Control diseases *Control corruption of clinic and hospital people
SC# 06	SC# 07	SC# 08	SC# 09	
*Flood *Lack of tubewell and useable water *River bed silted *Water congestion *Declining livestock *Lack of health care *Child & female diseases *Expensive fish disease *Crop damage	*Flooding from Jamuna *Sands deposition *Drought *Water congestion *Declining soil fertility *Lack of drinking water *Diseases & corruption of hospital people *Extensive fish disease	*Flood from Jamuna *Water congestion *Crop damage due to BRE breach *Lack of drinking water *Lack of fuel & homestead *Expensive fish diseases *Drought	*Water logging *Flood due to back water flow from Ichamati river via Rahmatganj khal *Municipal drain *Drinking water scarcity *Dust from tobacoo factory and jute mills *Black smoke from brick fields *Smell from hid godowns & congested water *Vegetation destruction & shortage of fuel *Sanitation problem *Municipal garbage *Diseases	
*Strengthen BRE *Arrange drinking water *Excavation of water bodies *Medicare for livestock & poultry *Health care *Control fish diseases *None	*Stable BRE *Re-excavation of khals *Artificial water supply to crop land from river *Arrange drinking water *Health care *Control fish diseases *None	*Control flooding *Khal re-excavation *Strength BRE *Arrange drinking water *Fish disease to be checked *Health care *None	*Drainage improvement by regulator & culvert *Construct sluice gate & flood control *Construct new drain & repair existing congested drains *Extend water supply network and sink more tubewells *Shift tobacco cutting factory *Stop hide processing *Provide sanitary latrines free of cost *Improve medical facilities	