ENVIRONMENTAL EVALUATION OF TANGAIL COMPARTMENTALIZATION PILOT PROJECT

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A PROJECT REPROT

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ABSTRACT

The Compartmentalization Pilot Project (CPP) is one of twenty-six components of exhaustive Floor Action Plan (FAP) undertaken by Government of Bangladesh after disastrous Floods of 1987 and 1988.

The CPP is an experiment with controlled flooding, and works with the concept of subdividing the total project area into compartments with a view to achieve better water and environmental management. If the concept works effectively, similar project would be adopted in other Flood Control Drainage and Irrigation (FCDI) projects in Bangladesh in future. The CPP study area is located in north-central region of Bangladesh, close to the left bank of the Jamuna River and bounded by Dhaleswari and Pungli Rivers. It is transected by the Lohazong River. Total area of the project is approximately 13,000 ha.

While working with the subject efforts were given in collecting related reports, maps, data etc., studied and analyzed the same, discussed and exchanged views with the project officials as well as the beneficiaries. The present report is the outcome of this endeavor.

The report presents an evaluation of Environmental Impact Assessment (EIA) of the CPP, Tangail. In evaluating the EIA process in the project different aspects of EIA covering study of the major fields like methodology, baseline situation, environmental components and Environmental Management Plan (EMP) were undertaken. Attempt was made to put suggestions to different findings as regards EIA of the Project.

Of the different areas of baseline study, the important ones include hydrology, drainage, land resources, biological resources, human resources and hazards and risks. The important environmental components addressed cover modalities of identification of Important Environmental Components (IECs) and description of IECs. The Environmental Management Plan (EMP) addresses evaluation of Impact Management and Impact Monitoring and Reporting.

The study indicates that the main beneficial impacts of the project include increase in irrigated area, improvement in agricultural production, reduction in crop damage losses, improvement in homestead security and crop production, increase in culture fish production, improvement in terrestrial habitat availability to wildlife and improvements in socio-economic factors related to agriculture.

The negative impacts include reduction in agricultural crop diversity, marked declines in capture fish production and harvests, reduction in aquatic habitats and in wildlife species depending on such habitats, reduction in water-based transportation, decrease in socio-economic parameters related to fish and fishing egg. Subsistence fishing income and fish-based nutrition and an increase in environmental contamination with pesticides and other agricultural chemicals.

Inspite of the fact that the project has created some additional environmental degradation to pre-project situation, it is required that the negative impacts should also be monitored so as to ensure that the degradations are kept well within the acceptable limit. The aspects to be monitored include soil fertility, bio-diversity, agro-chemical use, pest management, homestead forestry, water pollution programme and people's participation. The

monitoring plan so far undertaken has been found effective and fruitful and should be continued even in post project situation.

The observed environmental enhancements in the field of reduction of flood, agriculture, employment generation, fisheries, soil, socio-economy, afforestation etc. indicate that this project is environmentally acceptable. In order to make the environmental enhancement sustainable, monitoring and evaluation of these parameters should be continuously undertaken during the project period and even in the post project situation.

ABBREVIATIONS AND ACRONYMS

ADB	:	Asian Development Bank
AEZ	:	Agro-Ecological Zone
BADC	:	Bangladesh Agricultural Development Corporation
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BBS	:	Bangladesh Bureau of Statistics
BINA	:	Bangladesh Institute of Nuclear Agriculture
BKB	:	Bangladesh Krishi Bank
BRDB	:	Bangladesh Rural Development Board
BRRI	:	Bangladesh Rice Research Institute
BS	:	Block Supervisor
BWDB	:	Bangladesh Water Development Board
CC	:	Chawk Committee
CE	:	Chief Engineer
CPP	:	Compartmentalization Pilot Project
CIDA	:	Canadian International Development Agency
COD	:	Chemical Oxygen Demand
DAE	:	Department of Agriculture Extension
DC	:	Deputy Commissioner
DDC	:	Development Design Consultants Ltd.
DO	:	Dissolved Oxygen
DOE	:	Department of Environment
DOF	:	Department of Fisheries
DPHE	:	Directorate of Public Health Engineering
DTW	:	Deep Tubewells
E/N	:	Exchange of Notes
ECNEC	:	Executive Committee for National Economic Council
EE	:	Executive Engineer
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
EPP	:	Environmental Protection Plan
EQS	:	Environmental Quality Standards
ERD	:	External Resources Division
FAO	:	Food and Agricultural Organisation
FAP	:	Flood Action Plan
FCDI	:	Flood Control, Drainage and Irrigation
FFW	:	Food for Work
FGD	:	Focus Group Discussion
FPCO	:	Flood Plan Co-ordination Organisation
GDP	:	Gross Domestic Product
GIS	:	Geographical Information System
GOB	:	Government of Bangladesh
Ha	:	Hectare
HWL	:	High Water Level
HYV	:	High Yielding Varieties
ICDDR,B	:	International Centre for Diarroheal Disease & Research, Bangladesh
IEE	:	Initial Environmental Examination

IPM	:	Integrated Pest Management
ISPAN	:	Irrigation Support Project for Asia and Near East
IUCN	:	International Union for the Conservation of Nature
KSS	:	Krishak Shamabay Samity
L/A	:	Loan Agreement
LCS	:	Landless Contracting Society
LGED	:	Local Government Engineering Department
LOI	:	Letter of Invitation
MFA	:	Ministry of Foreign Affairs
MOEF	:	Ministry of Environment and Forest
MOU	:	Memorandum of Understanding
MPO	:	Master Plan Organisation
MWR	:	Ministry of Water Resources
NCA	:	Net Cultivable Area
NGO	:	Non-Government Organisation
NWP	:	National Water Plan
OFTD	:	On-Farm Testing and Demonstration
O&M	:	Operation and Maintenance
PAP	:	Project Affected People
PC	:	Project Committee
PP	:	Project Proforma
PWD	:	Public Works Department
RHD	:	Roads and Highways Department
RRA	:	Rapid Rural Appraisal
SCWMC	:	Sub-Compartmental Water Management Committee
SDE	:	Sub-Divisional Engineer
SE	:	Superintending Engineer
SEI	:	Significant Environmental Impact
SOB	:	Survey of Bangladesh
SRDI	:	Soil Resources Development Institute
SRP	:	Systems Rehabilitation Project, BWDB
STW	:	Shallow Tubewells
TBM	:	Temporary Bench Mark
TK	:	Taka
TNO	:	Thana Nirbahi Officer
TOR	:	Terms of Reference
UP	:	Union Parishad
WARPO	:	Water Resources Planning Organisation
WCP	:	Wetland Conservation Plan
WMP	:	Wetland Management Plan
WUG	:	Water User Groups

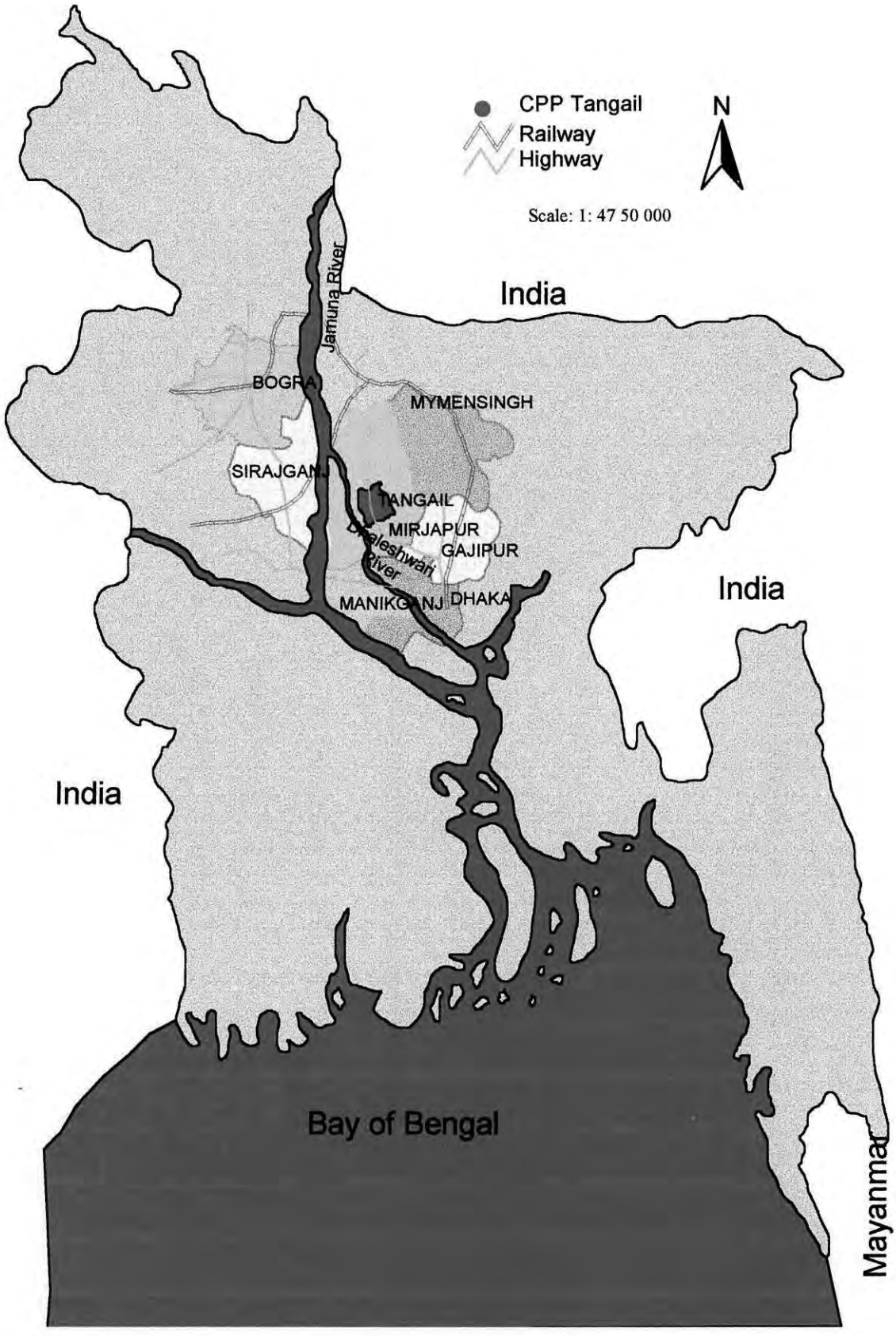


Fig. 1.0 CPP Project Map & Bangladesh Map

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1
Introduction

1.1 General

Environment, in its broad concept, encompasses the entire range of diverse surroundings in which we live in and react to events and changes. It necessarily includes the land, water, air, vegetation and the whole system of social order. The environment in any region, in its natural uninterfered conditions, is in a state of dynamic equilibrium which provide for balance in nature. In the way of making over exploitation and interfering with nature, this equilibrium is disturbed leading to different forms of environmental hazards of all forms of life.

Bangladesh being one of the least developed and most densely populated countries in the world, has caused intensive use, and in many cases overuse of forests, fisheries and land resources. The resulting increase in environmental imbalance and degradation, mainly in terms of declining soil fertility, water tables (especially in northwest regions), natural forests, wetlands, coastal and urban environments, fisheries and quality of water and air have been a concern.

The main factors, inter-alia, include the following: (i) high population pressure and low environmental awareness at all levels (ii) improper cropping sequences, unbalanced use of fertilizers and pesticides misuse in agriculture (iii) an ineffective industrial and urban pollution control enforcement and monitoring system (iv) poorly designed flood control, drainage and irrigation works without EIA studies (v) over cutting and clear felling of forests and artificially low stumpage prices and royalties for forest products together with structural shortages of alternative sources (i.e. in addition to fuel wood/cow dung) of household energy in rural areas (vi) lack of community control over open-access resources (vii) indiscriminate use of ground water (viii) inadequate land use planning and land tenure regimes and (ix) institutional and administrative weaknesses among the agencies having environmental mandates and monitoring/enforcement responsibilities.

Evidently time has come to take necessary effective measures in arresting environmental degradation through reasonable exploration of natural resources, planning development projects exercising proper care with respect to environment and, moreover, making the mass people environmentally conscious.

It is, with this end in view, while planning the Compartmentalization Pilot Project, CPP (FAP-20), Tangail, the issue of environment has duly been taken care of and a full scale study has been aimed at so that implementation of the project affects environment of the project area in the least.

The findings, conclusion and suggestions of the study are furnished in chapter-6. Attempt has been made to furnish them specifically from the contributor's end.

1.2 Literature Review

In conducting Environmental Evaluation of Compartmentalization Pilot Project (FAP-20, Tangail), data, maps, reports were collected through direct contact with the Project Offices/Consultants, especially the Team Leader of the Project. Relevant reports were also borrowed from WARPO, FPCO, BWDB and other sources. The list of report and literature reviewed is provided in the "List of References".

In addition, the author undertook frequent visits to the project office and the project area in order to discuss and make exchange of views with the project officials and the beneficiaries. This helped immensely in evaluating the environmental situation both at present and in the project condition.

The major fields of evaluation covered Baseline Condition of Environment in the project area, Important Environmental Components and Environmental Management Plan.

1.3 National Background

In the delta area of Bengal the farmers, over centuries, organized themselves to cope with their environment. They used to do this without even appreciable support and assistance and interference from the Government. Embankments were built to control flood. It was customary to cut openings in the embankments to irrigate lands and close them again before the next flood. People maintained the embankments and the channels at the same time. Thus it can be said that the people were engaged in a sort of integrated water management in which flood protection, drainage and irrigation were handled in a balanced way. The rivers and khals brought fish fry to the fields. The farmers got profit from the positive influence of the flooding of their land because it increased land fertility.

Now, this situation has changed so markedly and in such away that the major attention was diverted from monsoon irrigation to flood protection. The first national water master plan (1964) gave major emphasis on flood protection. A new concept, the concept of polder was introduced. Some projects were planned and carried out based on this concept. In going for full protection the negative effects of floods were reduced within the polder. Though isolated polder gave solutions for the enclosed areas, they often created problems in the surroundings because of high water levels. Moreover, the polders required a high level of management capacity of Government agencies and an effective consensus for balancing the various interest that were involved. These conditions were not always met and, as a result, people outside the polders frequently cut the embankments.

Following the disastrous floods in 1987 and 1988, several studies were undertaken to investigate how to protect the country better against the devastating effects of floods. The result provided alternatives. These alternatives constitute on the one side "full protection" and on the other "living with floods".

1.4 Regional Background

For the purposes of the FAP, the country has been divided into five regions shown in Figure 1.1. The division differs from that used in the National Water Plan (NWP) in order to conform with the regional studies. The NWP northeast region has been divided into a Northeast Region and a North Central Region, and the NWP's south central and southwest regions have combined into a single South West Region.

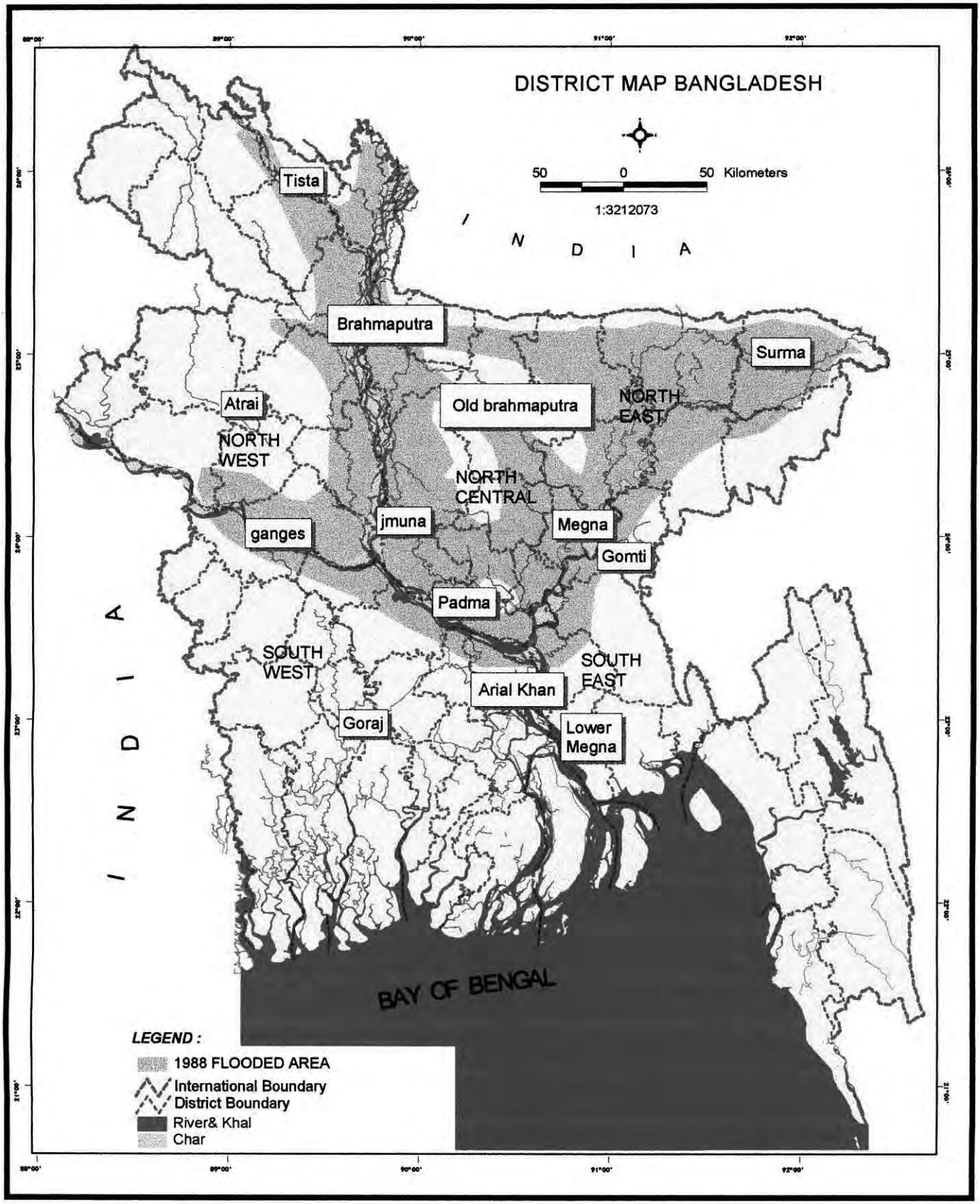


FIGURE : 1.1 MAP OF THE FAP STUDY REGION

The North West Region bounded by the Jamuna on the east and the Ganges to the south, is drained by the Teesta, Atrai and other perennial rivers originating in India. The region comprises a large uplifted block, the Barind Tract, in the center-west, bordered by the Teesta and related floodplains in the north, the Karatoya-Bangali floodplain in the east and the Ganges floodplain in the south. Annual rainfall ranges from 1,250 mm in the west to more than 2,200 mm in the north and northeast. Seasonal flooding is mainly intermittent or shallow, but a substantial area in the southeast is deeply flooded when high stages of the Jamuna impede outflow from the Hurasagar channel through which some 80% of the region's drainage flows. Substantial areas are double cropped, partly with the help of tubewell irrigation which has spread rapidly in the past decade, but drier western areas and low-lying areas in the southeast are mainly single cropped. Population density ranges from 5/ha to 9.5/ha, averaging 7/ha. The Brahmaputra Right Embankment (BRE), dating back to the 1960s, extends 217 km along the Jamuna, and there is an embankment along the entire length of the left bank of the Ganges. Other existing works aimed at water control include numerous polders along the Lower Atrai and embankments along other internal rivers. Bank erosion is a significant problem in places along the Jamuna, leading to loss of land which has forced the retirement of the BRE over more than half of its length and requiring costly investments in attempts to protect Sirajganj town.

The North Central Region is bounded by the Jamuna river in the west, the Old Brahmaputra Channel in the north, the Lakhya and Meghna rivers in the east, and the Padma in the southwest. It is crossed by the Dhaleswari, the major distributary of the Jamuna. The region comprises the Jamuna floodplain and parts of the Old Brahmaputra, Ganges and Old Meghna floodplains, together with a large uplifted bloc, the Madhupur Tract, in the centre-north. Annual rainfall ranges from 1,600 mm in the west to 2,200 mm in the northeast. Seasonal flooding is mainly shallow in the north becoming deeper in the centre and south where drainage is impeded when the lower Jamuna, Padma and Meghna rivers are at high flood stages. Many floodplain areas are double or triple cropped, and there has been a rapid expansion of tubewell irrigation in recent years. Population densities range from 3.5/ ha in parts of the Madhupur Tract to over 12/ ha in some flood plain areas. The region has about 200 km of existing embankments to provide protection against overbank flooding, of which 50 km extend along the left bank of the Jamuna. Various forms of flood control and drainage project serve about 73,000 ha. The Greater Dhaka area was badly hit by the 1988 flood and works to protect Dhaka city were started immediately after the floods.

The South West Region is bounded by the Indian border in the west, the Ganges-Padma in the north, the Lower Meghna in the east and the Bay of Bangal in the south. The region covers 4.0 m.ha of which 2.5 m.ha is cultivated, 0.4 m.ha is coastal mangrove (including the Sunderbans) and 0.7 m.ha is taken up by rivers and beels. Population density ranges between 5/ha in the southwest to 9/ha in the north. The region mainly comprises the Ganges river and tidal floodplains, with the low-laying Gopalganj-Khulna beels in the centre. Annual reainfall ranges from 1,500mm in the west to 3,000mm in the southeast. Seasonal flooding is mainly shallow in the west and on the tidal floodplain in the south, but is deep in the centre and east. There is double and triple cropping in the north and east, but southern parts of the tidal floodplain and low-lying beel areas are mainly single cropped. In recent years, brackish water shrimp cultivation has spread rapidly, and is now a substantial source of foreign exchange earnings. Southern and western parts of the tidal floodplain have been enclosed by the Coastal Embankment Project since the 1960s, and embankments have been built along most parts of the Ganges and Padma right banks. The Ganges-

Kobadak Project provides irrigation to Kharif crops on 52,000 ha in the northwest, and tubewells and low-lift pumps provide dry-season irrigation to substantial areas in other parts of the region.

The South East Region occupies the area between the Indian border in the east, the southern part of the Sylhet Basin in the north, the middle and lower Meghna channels in the west and the Bay of Bangal in the south. The Meghna estuarine and river floodplains occupy most of the region, with a small strip of piedmont plain adjoining hills along the eastern border. Annual rainfall ranges from 2,000 mm to 3,000 mm. Local relief is much less in this region than in the other regions, and substantial areas in the north and centre are deeply flooded; flooding is shallow in the southeast and near the coast. Flooding is mainly by ponded rainwater, but eastern parts are affected by flash floods from the eastern hills. The southeast is the most intensively cultivated of the regions. Of the cultivated area of 776,000 ha, some 30% is irrigated by tubewells and low-lift pumps. Population density for region averages 14.5/ha and exceeds 22/ha in some areas. Existing flood control and drainage projects in the region include Chandpur (56,000 ha), Meghna-Dhonagoda (17,000 ha), and Gumti Phase I (37,000 ha). Bank erosion is serious along parts of the lower Meghna, posing threats to Chandpur town and the Chandpur Irrigation Project.

The North East Region is bounded in the north and east mainly by hills bordering India, in the west by the Old Brahmaputra and Lakhya rivers, and in the south by the Meghna river and the northern boundary of the Southeast region. This is the wettest region of the country, with annual rainfall ranging from 2,200 mm in the west to over 5,000 mm in the northeast; the region also receives runoff from hills across the northern border where rainfall totals exceed 10,000 mm. Population density ranges from 2.5/ha in the centre to 8/ha in parts of the west and south. There are three main physiographic units: the Old Brahmaputra floodplain in the west and south; the Surma-Kusiyara floodplain in the east; and the low-lying Sylhet Basin in the centre-north. Seasonal flooding is mainly shallow in the east and west, with flash flooding along the foot to the hills. Central and southern areas are subject to deep flooding, and depression centres (haors) within the Sylhet Basin and along the foot of the northern hills remain wet through the dry season. A single crop of boro paddy is grown in the haor areas and in depressions on the Old Brahmaputra floodplain. This crop is irrigated by low-lift pumps or traditional techniques and, in some areas, protected against early floods by low embankments which are overtopped in the main flood season. Higher land in other areas is mainly double cropped. Tubewell irrigation is extensive in parts of the Old Brahmaputra floodplain, but not elsewhere. Some eastern rivers have embankments designed to contain monsoon floods, but problems arise from breaching of embankments and siltation of river beds.

1.5 Sectoral Background

Agriculture is considered to constitute the most important sector in Bangladesh economy. This sector alone contributes 35% of the Gross Domestic Product (GDP) and 20% of exports. It also provides almost 70% of total employment in the country. The contribution of the agriculture sector is often affected by drought in dry season or floods in the rainy season, which lead to low productivity. Current Government policy is embodied within the current Fifth Five-Year Plan (1995-2000) which sets objectives for development within the water resources sector. The central strategy of this policy, as reflected in the National Water Plan, is to make use of irrigation and flood control for improving agricultural productivity and employment. Emphasis is given in the plan to minor irrigation and to flood control and drainage (FCD) projects as the principal means to achieve these goals. Priorities are established maximizing

the benefits of existing facilities, and where new projects are required, selecting those that have a short gestation period. Allied to these, priorities are strengthened in operation and maintenance (O&M), and water management capabilities as well as involvement of the private sector in developing new areas and in providing support services to existing schemes. Other strategies are also recognized as being important. These include augmentation of surface water resources from the main rivers and integrated development of both surface and ground waters resources.

1.6 Project History

Bangladesh adopted the outlines of an Action Plan for flood control and drainage in June 1989 and the Government of Bangladesh requested the World Bank to assist in preparing a Flood Action Plan (FAP). This request was endorsed at the G-7 meeting of industrialized countries in July 1989, which called for the international community to help find solutions to the flood problem in Bangladesh which are 'technically, financially, economically and environmentally sound'. The FAP was in turn endorsed at a special conference of the Government of Bangladesh and donor organizations in London in November 1989, and is presently being implemented.

The FAP comprises a number of studies and pilot projects which are expected to lead to water resource management and related projects, with an emphasis on flood control and drainage. In the first two years of the Plan, 1990-92, Regional Water Resource Development Planning Studies were undertaken to identify alternative water resource management strategies for different regions of the country. Those were followed by feasibility studies for priority investment projects. A number of complementary socio-economic and environmental studies were carried out in order to improve understanding of the impact of flooding and of Flood Control, Drainage and Irrigation (FCDI) projects, and to recommend economic, social and environmental guidelines and criteria appropriate for use in planning and implementing such projects.

The main focus of the Flood Action Plan is defined by the Government of Bangladesh is the well-known Eleven Guiding Principles as shown below:

ELEVEN GUIDING PRINCIPLES OF FAP

- Phased implementation of comprehensive water management plan aimed at controlled flooding for rural areas to meet the needs of agriculture, fisheries, navigation, flushing, soil productivity and recharging the surface water/groundwater resource with minimum dislocation to the environment.
- Protection of urban, commercial, industrial and public utility centres and communication network.
- Development of water management plan by following the environmental impact assessment guidelines and guideline for project assessment.
- Encouraging maximum possible popular participation by beneficiaries in the planning, implementation, operation and maintenance of water management infrastructure and facilities.
- Effective land and water management of the protected and unprotected area through compartmentalization and floodplain management approach. Where feasible existing projects should be restored to full operational level through rehabilitation and modification.
- Improvement of the flood forecasting system and establishment of a reliable and comprehensive flood warning system with adequate lead time and at the same time evolving techniques for dissemination.
- Strengthening and equipping the disaster management mechanism including building infrastructure for quick and effective communication and transmission during disasters.
- Conveyance of the large cross-boundary flow through the major rivers with the help of embankments as appropriate.
- Improvement of the conveyance capacity of the river network to ensure efficient drainage through appropriate channel improvements and ancillary structures to provide regulation and conservation.
- Effective river training works for the protection of embankments, infrastructure and population centres, linked wherever possible with the reclamation of land in the active floodplain.
- Introduction of floodplain zoning where feasible and appropriate.

Emphasis is given on 'controlled flooding' and 'controlled drainage'. Floods would be controlled in such a way that maximum profit can be achieved from the beneficial effects of river water flooding, while minimizing the disadvantages. The Flood Action Plan (FAP) comprises twenty-six components and supporting activities. The Compartmentalization Pilot Project-FAP 20 is one of them. The components of the Flood Action Plan is hereunder.

Flood Action Plan Studies

FAP No.	The Studies	Funding Source	Fund Commitment (million US$)
	Main Studies		
1.	Brahmaputra Right Embankment Strengthening	IDA	3.36
2.	Northwest Regional Study	UK, Japan	4.60
3.	North Central Regional Study	EU, France	3.56
4.	Southwest Area Study	France, EU	2.85
5.	Southeast Regional Study	ADB, UNDP	3.83
6.	Northeast Regional Study	IDA, UNDP	2.20
7.	Cyclone Protection Project	Canada	14.60
8A.	Greater Dhaka Protection Project	EU, IDA	1.00
8B.	Dhaka Integrated Flood Protection Project	Japan	3.00
9A.	Secondary Town Integrated Flood Protection Project	ADB	0.57
9B.	River Bank Protection Project	ADB	0.55
10.	Flood Forecasting and Warning + Expansion	IDA	1.15
11.	Disaster Preparedness	UNDP, Jap+ Denm. UNDP	2.70+3.01 1.10
	Supporting Studies		
12.	FCD/I Review	UK, Japan	1.60
13.	Operation & Maintenance Study	UK, Japan	0.60
14.	Flood Response Study	USA	0.92
15.	Land Acquisition and Resettlement Study	Sweden	0.40
16.	Environmental Study	USA	4.037
17.	Fisheries Study and Pilot Project	UK	3.40
18.	Surveys and Mapping	Finland, France	6.71
19.	Geographic Information System	Switzerland, Germany	
20.	Compartmentalization System	USA	4.36
21/22	Bank Protection, River Training and AFPM Pilot Project	Netherlands, Germany	17.09
23.	Flood Protection Pilot Project	USA	0.30
24.	River Survey Programme	EU	14.70
25.	Flood Modelling and Management	Denmark, France, Netherlands, UK	4.39
26.	Institutional Development Programme Macro-Economic Study	France	3.60 0.41
		Total=	110.59

1.7 The CPP Concept

The key successful environmental assessment of CPP lies in understanding the concept of compartmentalization. In order to provide water management in the project areas with flood protective measures and to contain the extent of flood in respect of duration and intensity during embankment breach, this concept of Compartmentalization has evolved in Flood Action Plan (FAP). A compartment can be defined as an area in which effective water management, controlled flooding and drainage is made possible through structural and institutional arrangements. Compartments will, over time and in pace with development of institutional capacities, build up into continuous management systems along the main rivers with intended benefits which will include flood control structures, increased crop production and crop diversification. The concept of compartmentalization will be demonstrated in pilot areas to test its operational feasibility and institutional viability. While the CPP is the first scheme for implementation presently, the same will be adopted in future other FCD/I projects if found effective.

1.8 Objectives of the Study

The main objectives of this Project are to study:

(1) Effectiveness of Compartmentalization concept in achieving Controlled Flooding and drainage in the CPP area.

(2) Evaluation of environmental and social benefits and disbenefits of Compartmentalization

(3) Effectiveness of mitigating measures in elimination and reduction of adverse environmental impacts

(4) People's attitude, acceptability, and participation towards implementation, operation and maintenance of the project

(5) Applicability of the concept in sustainable water management in this country.

Chapter 2
Project Definition

2.1 The Project Area

The CPP area is located in the north-central region, several km east of the left bank of the Jamuna River. As defined by FAP 20, the western boundary of the CPP area is formed by the Dhaleswari River, a distributary of the Jamuna, and its distributary the Elanjani River. The Pungli River is the eastern boundary, and Gala Khal, which connects the Lohajang and Pungli Rivers, forms the northern boundary. A village road from Silimpur to Korotia and on to the Pungli Rivers is the southern boundary. The Lohajang River, a tributary of the Dhaleswari, flows in a NW-SE direction across the project area. It merges with the Elanjani River to the south and outside the project area boundary. The project area occupies part of the young Brahmaputra Flood plain. The overall drainage is toward low-lying land in a southeasterly direction. Total area of the project is approximately 13,200 ha. It includes portions of three thanas: Tangail Sadar (83 percent), Delduar (14 percent) and Basail (3 percent). Based on projections from 1981 census, the population in the project area is approximately 240,000 in 1991.

There is an embankment-cum-road with improper section along the left bank of the Dhaleswari and Elanjani Rivers. Four regulators were constructed along this embankment in the 1970s. These were operated with wooden fall boards of 0.9 x 1.2 meter in size. The embankment-cum-road continues along the left bank of Gala Khal and right bank of the Pungli River. Two Khals, Suruj and Bartha, originating from the Pungli River, are closed as a result of the existing embankment construction that is also used as a road. The Pungli River does not directly contribute to flooding in the CPP area. The main entry route of water to the area is the Gala khal and its branches, Sadullapur and Rasulpur khals. The details are shown in Figure 2.1.

Within a compartment (in the case of Tangail compartment 13,200 ha) there are many different watersheds, which necessitate the division of the compartment in sub-compartments. Sub-compartments are in principal hydrological units. However, often a compromise has been made between administrative and physical conditions, and hydrological significance. The boundaries have been chosen with two objectives in mind: the area not being too big, since it is also the basis (second level) for the institutional set-up; and the boundaries are clearly marked watershed boundaries, or it is relatively easy to make them into watershed boundaries by closing culverts and bridges and providing regulators. The major roads were the natural choices. The size varies to a large extent: 1250 ha gross to 250 ha gross.

At this level, Sub-Compartment Water Management Committees are formed with members from NGOs, local government, government departments (extension workers), farmers water user groups and other interest groups (fishermen, women and landless).

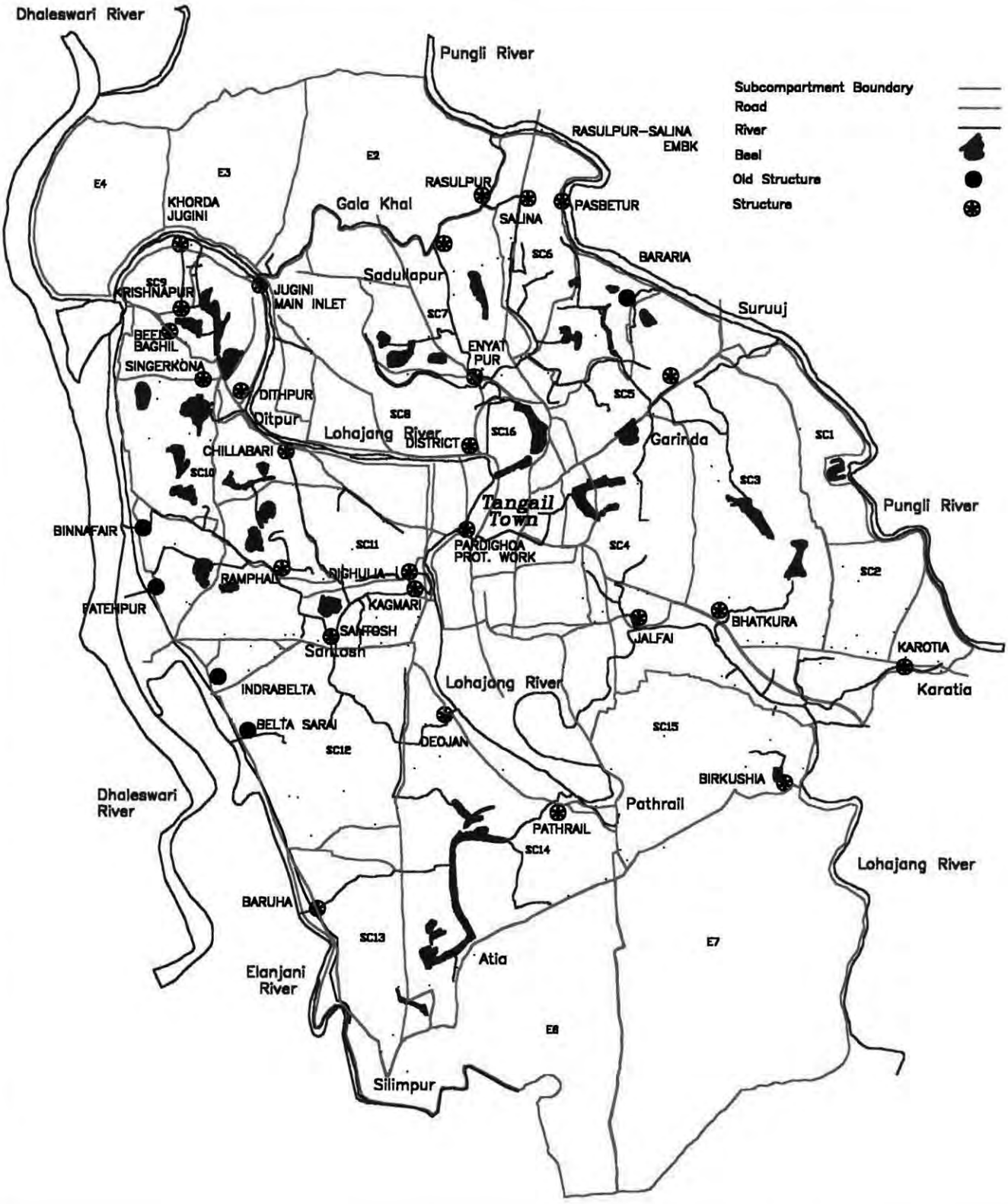


Figure 2.1 Project Area Showing Project Details

The land use of sub-compartments along with gross area, settlement area, beel area, river area, is shown in Table 2.1.

Table 2.1 : Landuse in Sub-Compartments

Sub-compartment No.	Gross Area ha	Settlement ha	Beel ha	River ha	Gross Cultivable/ha
1	247	55	1		191
2	544	105			439
3	1116	170	15		931
4	804	195	31		578
5	369	101	6		262
6	669	133	13		523
7	796	120	6		670
8	778	134	3		641
9	402	86	28		288
10	876	169	25		682
11	1167	337			830
12	1037	222			815
13	457	122	3		332
14	1186	260	63		863
15	767	203	14		550
16	619	431	26	6	156
LFP	1366	255	27	72	1013
TOTAL	13200	3098	261	78	9763

Source: CPP GIS Atlas, September 1996.

The details of the sub-compartments are furnished in Figure 2.2

2.2 Development Alternatives

Various development alternatives which have been thought of are furnished in the section.

2.2.1 Planned Project Alternatives

The CPP has got six project alternatives. These alternatives are based on revised Inception Project, (1992), Interim Report (1992) and several discussions on other related FAP activities (FAP16 & FAP19). The alternatives are:

- Alternative 1a: this alternative consists of full compartmentalization with (a) gated structures at the periphery including provision of full or part navigations facilities at Lohajong and Sadullapur, (b) 20 km peripheral road (c) feeder road cum embankment with bridges and ungated structures at the southern side and (d) regulating structures between Lohajong and Sub-compartments 9, 10 and 11.

- Alternative 1b: This alternative is same as 1a but without navigation facilities at Lohajong and Sadullapur. This also includes mooring facilities at the two locations.

- Alternative 2b: This is same as 1b but having flow regulator between Lohajong and remaining compartments.

- Alternative 3a: This is same as 2b but inclusive of closed/regulated structures in the southern embankments keeping Lohajong out-fall open.

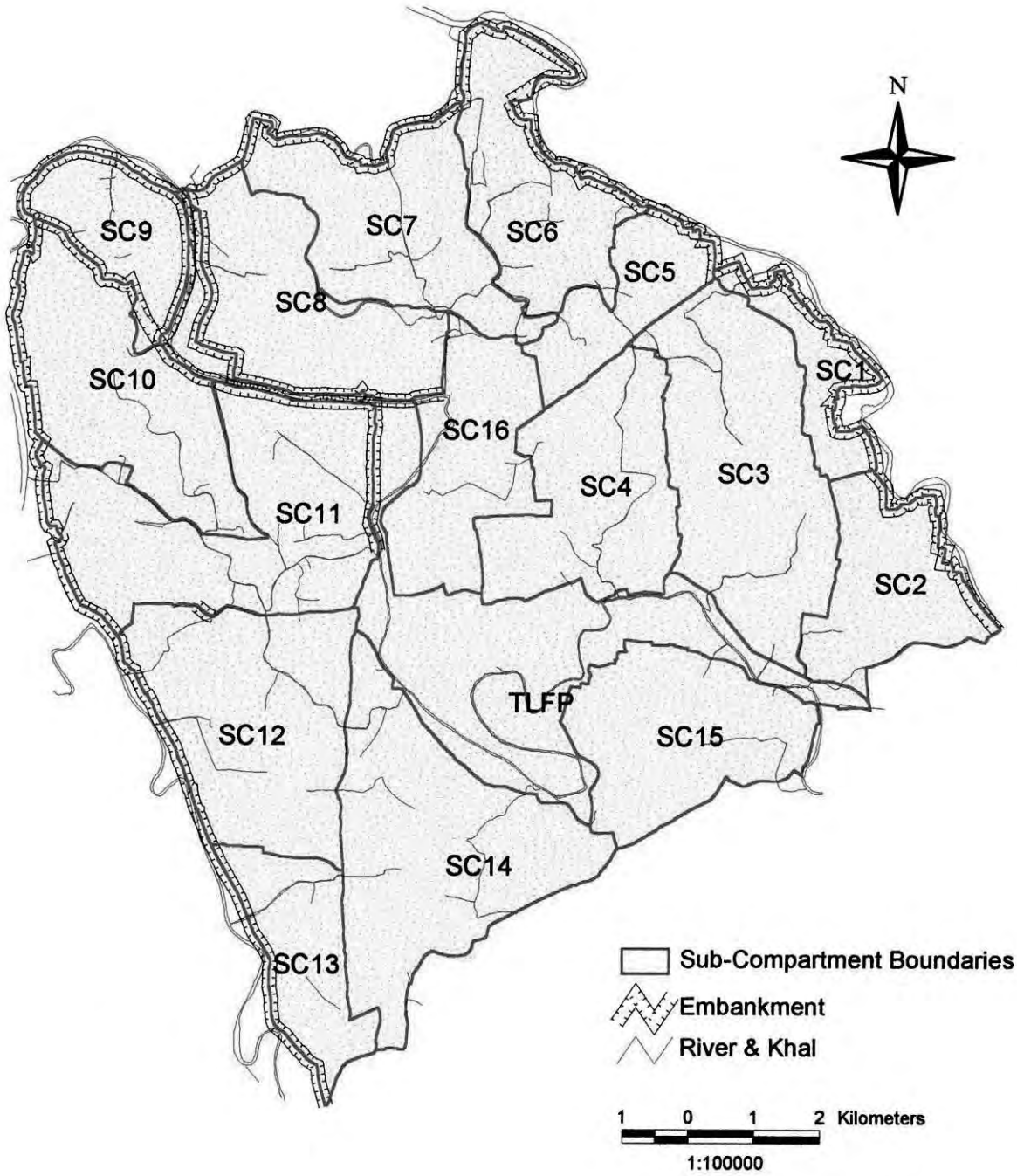


Figure 2.2 Sub-Compartment Boundaries of the Project

- Alternative 3b: Same as 3a but with complete peripheral road.
- Any of the above alternatives may be implemented subject to the principles of community participation, institutional development and the results of testing water management techniques. The aim of the peripheral control of the compartment is to allow normal or semicontrolled flooding but to prevent/reduce major floods with gated or partly ungated structures.

2.2.2 Implementation Phases

The project implementation was originally scheduled to be completed in three phases - Phase I (1992-93), Phase II (1993-94) and Phase III (1994-95) but the physical intervention could not be completed timely because of land acquisition and delay in arriving at an unanimous consensus through people's participation. Subsequently, the project implementation was rescheduled and it is expected to be completed by June, 2000.

2.2.3 Development Options for EIA

As CPP is being implemented over a time period spanning several years, it offers excellent opportunities to measure the effects of development and to take constructive action to mitigate negative impacts before further development is undertaken.

Option I: No intervention (i.e. future without project)

Option II: Controlled flooding and water management (future with project). This alternative corresponds to project condition with 3a alternative as described under article 2.2.1. This reflects the maximum environmental changes due to maximum flow control and consequent impact.

Option III: This option consists of detailed hydrological prediction with respect to future water levels in each sub-compartment through modelling. But due to uncertainty in implementation of development options, this was dropped.

2.2.4 Development of Local Institutions for Water Management

The CPP implementation options, as detailed under article 2.2.1, being a function of full scale beneficiary participation, initiation of a process of consultation to communities and development of local institutions is absolutely necessary. With this end in view the following activities were undertaken:

- formation of LCSs for earthwork;
- formation of WUGs at field level;
- establishment of SCWCs; and
- establishment of CPP Executive Committee

The above committees have been formed in close collaboration with BRDB, DAE and NGOs.

Chapter 3
Environment Baseline Description

3.1 Hydrological Resources

3.1.1 Climate

Tangail Climate has the characteristics of dry and mild winters as well as hot and wet summers. There exist four distinct seasons, and these are: (a) winter from December to February (b) unstable pre-summer monsoon from March to May (c) summer monsoon from June to September and retreating monsoon from October to November. Monthly data for a number of climatic parameters in the project area are presented in Table 3.1.

The spatial distribution pattern shows a general trend which constitutes gradual rainfall increase from west to east and from south to north. Average annual rainfall in and around the project area ranges from 1606 mm at Atia to 1882 mm at Mirzapur stations respectively.

The three agro-climatic period are the Kharif-1 (March to May), Kharif-2 (June to October) and Rabi seasons (November to February).

Table 3.1 Climatological Data (Average for 1960-1990)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Mean Rainfall (mm)												
	14	19	33	103	203	331	308	337	224	153	20	6
Mean Daily Temperature (°C)												
Maximum	25	28	32	35	33	31	31	31	31	31	29	26
Minimum	12	14	18	22	24	25	26	26	26	24	18	14
Relative Humidity (%)												
0900	71	71	68	72	82	85	87	86	84	81	76	79
1800	61	54	46	48	67	81	83	82	83	80	74	71
Potential ET (mm/day)												
	2.0	2.8	4.4	5.4	5.1	3.9	3.8	3.5	3.7	3.4	2.5	1.8

Source : WARPO (1992) and FAO (1998)

3.1.2 River System and Channel Network

Starting from the off-take of the Lohajang River at Ramdebpur in the north west corner of the project area to Karatia in the south east, the CPP area covers 16 sub-compartments and the Lohajong flood plain (LFP). The channels in the eastern part of the project area originate mainly from Gala Khal whereas those originating from the Lohajong and Elanjani rivers form the channel network system for the western part of the project (Fig 2.1).

Boilla Khal, originating from Sadullapur and flows through Enayetpur village and ultimately enters subcompartment 5 via Shibpur. The Khal subdivides into two branches near Kandila. Of the two branches, one flows southward and enters subcompartment 3 and ends at Beel Gharinda and the other flows northward to Bamonkushia village and continues upto the southern end of Burai Beel. This khal, from Burai Beel, flows south to Gharinda market and enters subcompartment 3

through a road culvert. A branch of this khal flows eastward along a road borrow pit to Suruj market. This khal enters subcompartment 2 through Guguedao bridge and is connected to Suruj khal at Golabari. From this point it flows towards Hatila Beel. The Suruj Khal that originates from the Pungli River was closed in 1990.

Rasulpur Khal, another important khal, flows southward along the borrow pit of Tangail-Jamalpur road. The khal flows through subcompartments 5 and 6. The khal has got two branches. While one of the branches flows through Shibpur village to Baroshila Beel, the other branch flows through Agbethoir village to Burai Beel.

The Bartha Khal, originating from the Pungli River passes trough subcompartment 5. This khal was closed at its off-take in 1979 because of heavy sediment load and the threat it imposed on agricultural land.

The Gala Khal, with three other khals-Bhatkura, Julfi and Tangail form the channel network originates from the Lohajong River and runs through subcompartments 1, 2, 3 and 4. Bhatkura Khal connects the low lying areas of subcompartment 1 and 2. Julfi Khal connects the low lying areas of subcompartments 4 and 3 to the Lohajang River. Tangail Khal passes through Tangail town and Biswaser village and drains into the flood plain of subcompartment 3 near Darun Beel. Magurata Khal from Gala Khal and District Khal originating from the Lohajang River form the channel system for subcompartment 8.

So far as channel system of the western part of the project is conserned, the same consists of a number of khals. These khals are Jugni, Ghoramara, Khalibari, Gaizabari, Digholia, Sontosh, Deojan and Aloa-Tarini. All the khals originate from the Lohajang River. They are within the same network, two more khals named Barobelta and Indrobelta which originate from Elanjani River. Jugni and Kalibari khals pass through subcompartment 9. The Goramara Khal passes through southeast of subcompartment 11. Sontosh Khal passes through subcompartment 12, connects the Kumuria Beel in subcompartment 14 through the Aloa-Tarini Khal. Deojan Khal flows through subcompartment 14 and ends at Atia-Kumuria Beel. Pathrail, Kumulli and Brikushia khals, all originating from the Lohajang River make up the channel system of subcompartment 15.

Figure 3.1 shows hydrometric map of the project.

3.1.3 Drainage

It is reported that drainage congestion is the main problem in CPP area. That adequate drainage is not effected through the existing drainage channel network is a fact. Premonsoon drainage does not occur properly due to the main channels being either silted up or they do not have the required capacity to handle the required volume of water. It is this poor drainage during this season that cause damage to boro crops at harvesting stage and T. aman at seedling stage.

Compartmentalization Pilot Project Tangail

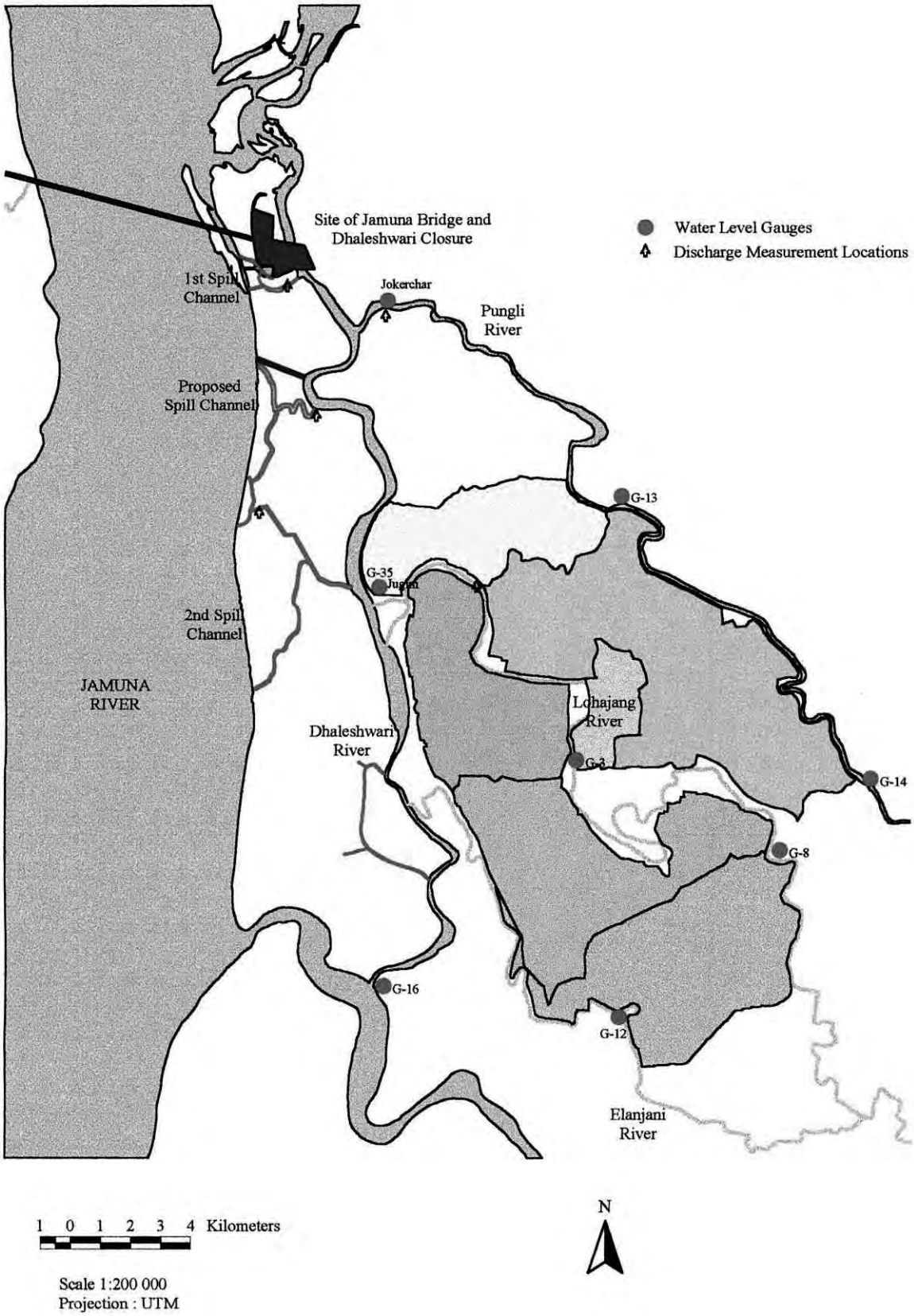


Figure 3.1 Hydrometric Map of the Project

Where the flood water starts receding during October, drainage to rivers begins. Because the Khals originating from the Pungli River have been closed at their off-take, drainage to this river does not take place. Julfi and Bhat Kura Khals act as the main drainage channels in this project area. Through its two main branches Sadullapur and Rasulpur khals, the Gala khal connects subcompartment 7 the low-lying areas of subcompartment 6, 5, 3 and 2. As a result, the low lying areas of several beels-Gharinda, Burai, Hatlia and Dharun beels and other low pockets connect either Julfi Khal or Bhatkura khal through the channel network described above. Pre and post monsoon drainage from this area occurs through these two khals to Lohajang River when the water level in the river permits drainage.

Flood water enters the area on the right bank of the Lohajang River through existing khals and channels. These khals and channels, also act as drainage channel. Drainage is effected through these channels to the Lohajang and Elanjani rivers. For subcompartment 9 and 10 Kalibari Khal functions as main drainage channel. Ghoramara Khal serves as the main drainage channel for subcompartment 10, 11, 12 and 14 to the Loahjang River. Drainage from subcompartment 12 to the Elanjani River is effected through Barobelta and Indrobelta Khals. Birkushia khal acts as the main drainage channel for subcompartments 14 and 15. At present, most of the khals mentioned hereinabove, have either been silted up or they have inadequate drainage capacity.

3.1.4 Surface Water and Flood

It is the Jamuna River system which influences the CPP areas. The intensity of flood in the project area is thus determined by flood conditions in the Jamuna and its distributaries-Lohajang, Elanjani and Pungli rivers. Of course, Galakhal and its branches play an important role in further intensifying the flood in the project area lying between Lohajang and Pungli rivers. Due to rain early flood occurs in April and May. The depressions and low lying areas, in absence of proper drainage, remain submerged. The water level in the area, during monsoon, goes high as a result of rain/runoff and riverbank spill.

At the end of June water enters Gala khal through Lohajang and Pungli rivers. Flood water from Gala Khal takes its course through Boilla Khal to subcompartments 3 and 5 and floods the Gharinda and Burai beels and the adjacent low-lying areas. Floods flow eastward from Gharinda to Suruj market along a road and borrow pit and then enter the agricultural land (chawk) around Parkushia village. From this point, the flood water enters subcompartment 2 through Gugodao bridge and continues toward Hatila Beel through Khal and floods the areas across its path. As a result of the flood flow through Bhatkura and Julfi khals, the Subcompartments 1, 2, 3 and 4 become flooded.

Because the Bartha and Suruj khals are closed at their off-take, there is no direct flood water flow from Pungli river into the project area. Similarly, the entry of flood water to the project area is prevented by the existing embankment along Dhaleswari/Elanjani Rivers.

The areas between the Loahjang and Dhaleswari/Elanjani rivers get flooded through the canals and khals originating from the Loahajang river. Through Jugni and Kalibari

khals flood water enters sub-compartment 9. Ghoramara Khal is the entry route of flood water to subcompartment 10 where it spreads over the entire southern part. Flood water entry route to subcompartment 12 is Santosh khal. After flooding subcompartment 12, flood water spreads over subcompartment 14 through Aloa-Tarini Khal. Flood water enters subcompartment 15 through Pathrail, Kumuli and Birkushia khals.

3.1.5 Ground water

It is recorded that there are 616 shallow tubewells (STW) and 76 deep tubewells (DTW) in the project area. These wells are used for irrigating about 5500 ha of land. Hand tubewells are, generally, used for supply drinking water. It is seen that subcompartment 9 has the highest density of STW-7.9/km^2. In subcompartments 2, 8, 9, 11, 14 and their flood plain contain about 50% of the STWs. Compared to STWs, DTWs are less frequent in the project area. Subcompartment 15 comprises the highest density of DTW-1/km2. In sub-compartment 2, 11, 12 and 14, more than 50 percent of DTWs is concentrated.

For irrigation and domestic purposes ground water resources are extensively used in the CPP area. Abstraction, for obvious reason, results low using of the groundwater table in dry season. However, recharge during the wet season restores the ground water table. According to FAP 20 (1992) report the highest level, for the period 1989-91 was 12.3 m (PWD) and the lowest was 7.0 m PWD. The trend for the last five years does not, however, indicate any significant reduction in groundwater level in the project area. The fluctuation of the level of ground water for the period 1987-91 is shown in Figure 3.2.

3.2 Land Resources

3.2.1 Land Types and Land Use

Land types consist of flood depth phases of flood plain soils. To designate land types according to flood depths is a common practice in Bangladesh. Generally depths are computed on the basis of 1 in 5 frequency water levels as recommended by MPO. The data representing 1:5 water level for areas under various land types, generated through GIS, is presented in Table 3.2. According to these data 71% of land in the CPP area is available for cultivation. Depending on flood depths and inundation period, the actual area under cultivation changes both annually and seasonally. Settlements account for 27% of the areas. This includes urban areas. Water bodies are limited to only 1% and rivers occupy the remaining 1% of the area. Subcompartment 1 and 4 and the subcompartment designated as Lohajong flood plain consists of more than 50% of the flood free land type (F_0). Whereas almost 50% of the flood prone land type (F_3) is found in subcompartments 10, 11 and 12. Only 4.4%, according to these figures, of land in the CPP area is considered flood free (F_0) land. The land type and land use map is shown in Figure 3.3.

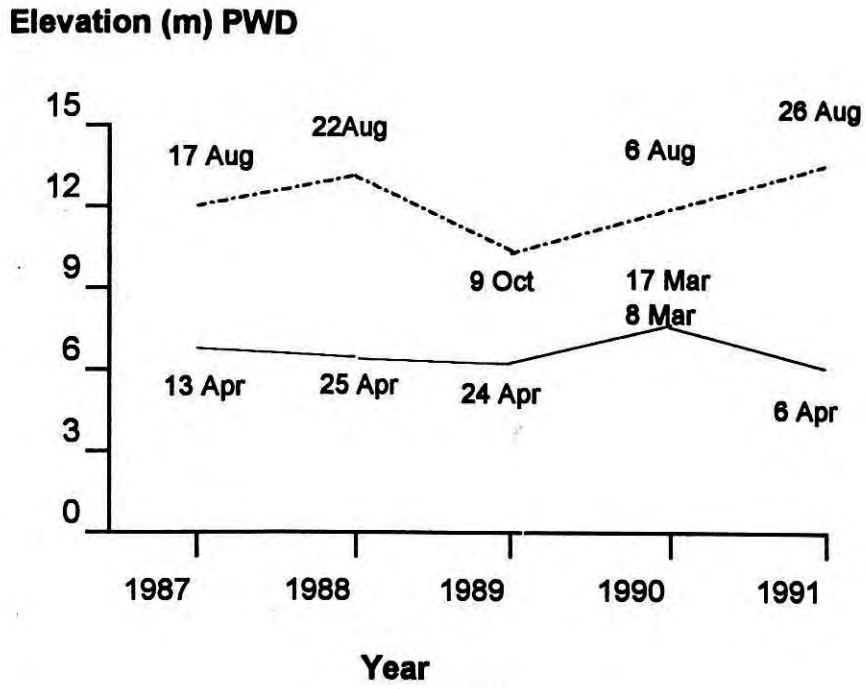


Figure. 3·2 Recorded Highest and Lowest Gronndwater Elevation, CPP Study Area, 1987–1991

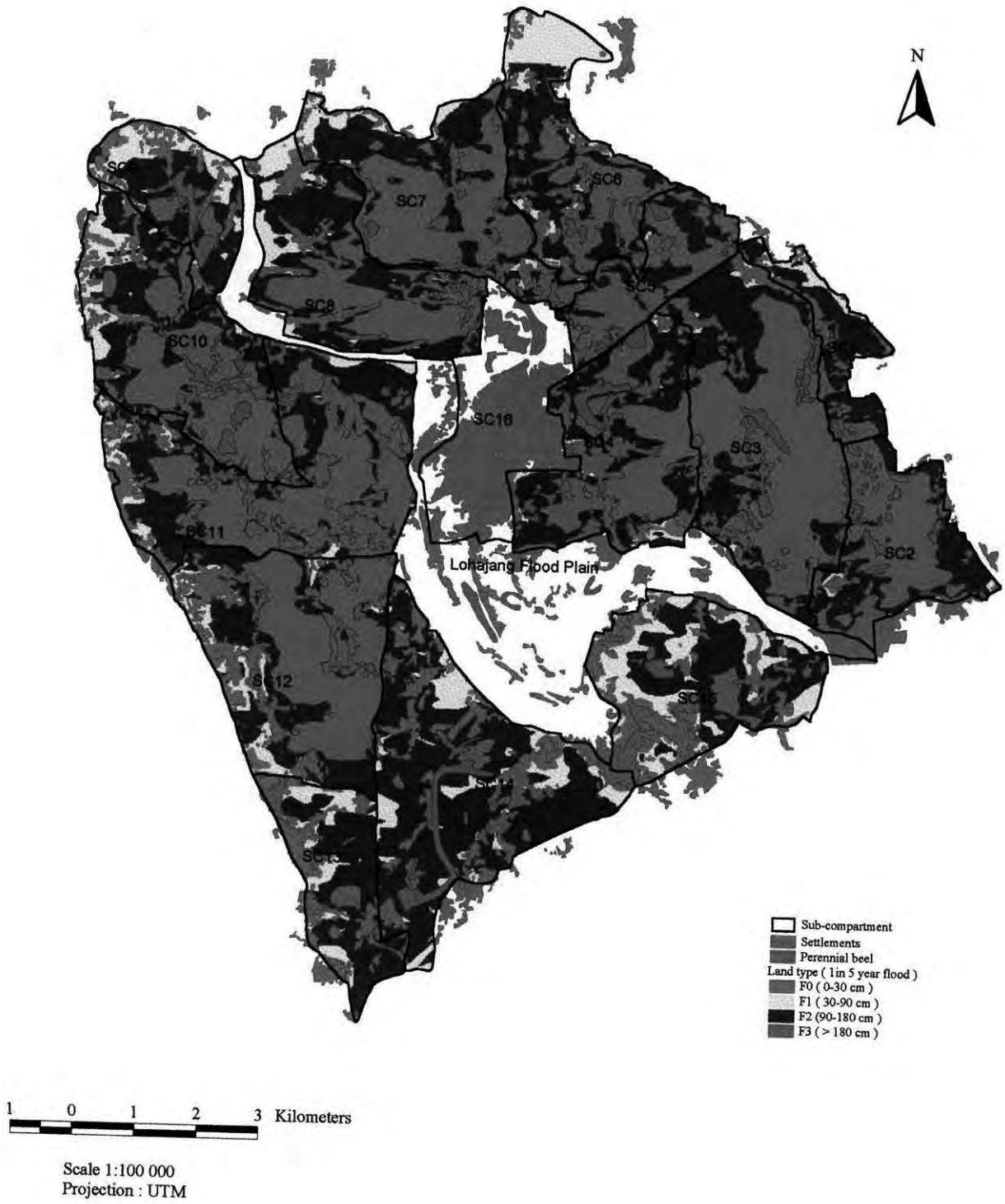


Figure 3.3 Land Types Based on Flood Depth (Base)

Table 3.2 Land Types in the Area

Land Type	Flood Depth (m)	Area	
		(ha)	(%)
F_0 (highland)	0.0 to 0.3	576	4
F_1 (medium highland	0.3 to 0.9	1821	14
F_2 (medium lowland)	0.9 to 1.8	4248	33
F_3 (lowland)	> 1.8	2552	20
Subtotals		9197	71
Settlements		3502	27
Water Bodies		134	1
River		164	1
Totals		13000	100

Sources : GIS data base 1992

3.2.2 Soils

A soil survey of the CPP area was carried out by the Soil Resources Development Institute (SRDI) in 1985. Soils in the project area have developed in alluvial sediments laid down by the Brahmaputra-Jamuna river system. Four soil series and two miscellaneous land types have been identified so far. Areas of soil association and percentages of soil series occupying each soil association are given in Table 3.3.

Table 3.3 Soil Associations and Soil Series of the Project Area

Soil Association	Area (ha)	Soil Series	Proportion (%)
Young Brahmaputra alluvium			
Sonatola association	575	Sonatoal	100
Sonatola-Dhamrai association	3205	Sonatola	75
		Dhamrai	15
		Silty Alluvium	10
Dhamrai-Sonatola association	1188	Dhamrai	70
		Sonatola	20
		Sabhar Bazar	10
Sandy and silty	16	Sandy alluvium	90
alluvium complex		Silty alluvium	10
Old Brahmaputra alluvium			
Sonatola association	2442	Sonatola	90
		Silmondi	10
Silmondi-Sonatola association	1146	Silmondi	70
		Sonatola	30
Savar Bazar-Silmondi association	625	Savar bazar	75
		Silmondi	25

Source: GIS data base 1992

Sonatola soils (about 63 percent) occur on the upper part of ridges. They are friable and silty loam in texture with weak structure. Silmondi soils (about 13 percent) occupy the lower parts of ridges. They are friable to firm, silty clay loam in texture and have moderate structure. Dhamrai soils (about 14 percent) occur on the lower part of ridges of young floodplains. They are weak to moderate in structure and have friable silty clay loam texture. Savar Bazaar soils occupy (about 6 percent) the deeply flooded basins and are characterized by their firm clay texture and strong structure. Sandy and silty alluvium (about 4 percent) are stratified, raw and undeveloped soils with variable texture. The soils in the project area are grey to olive brown in color and poorly drained.

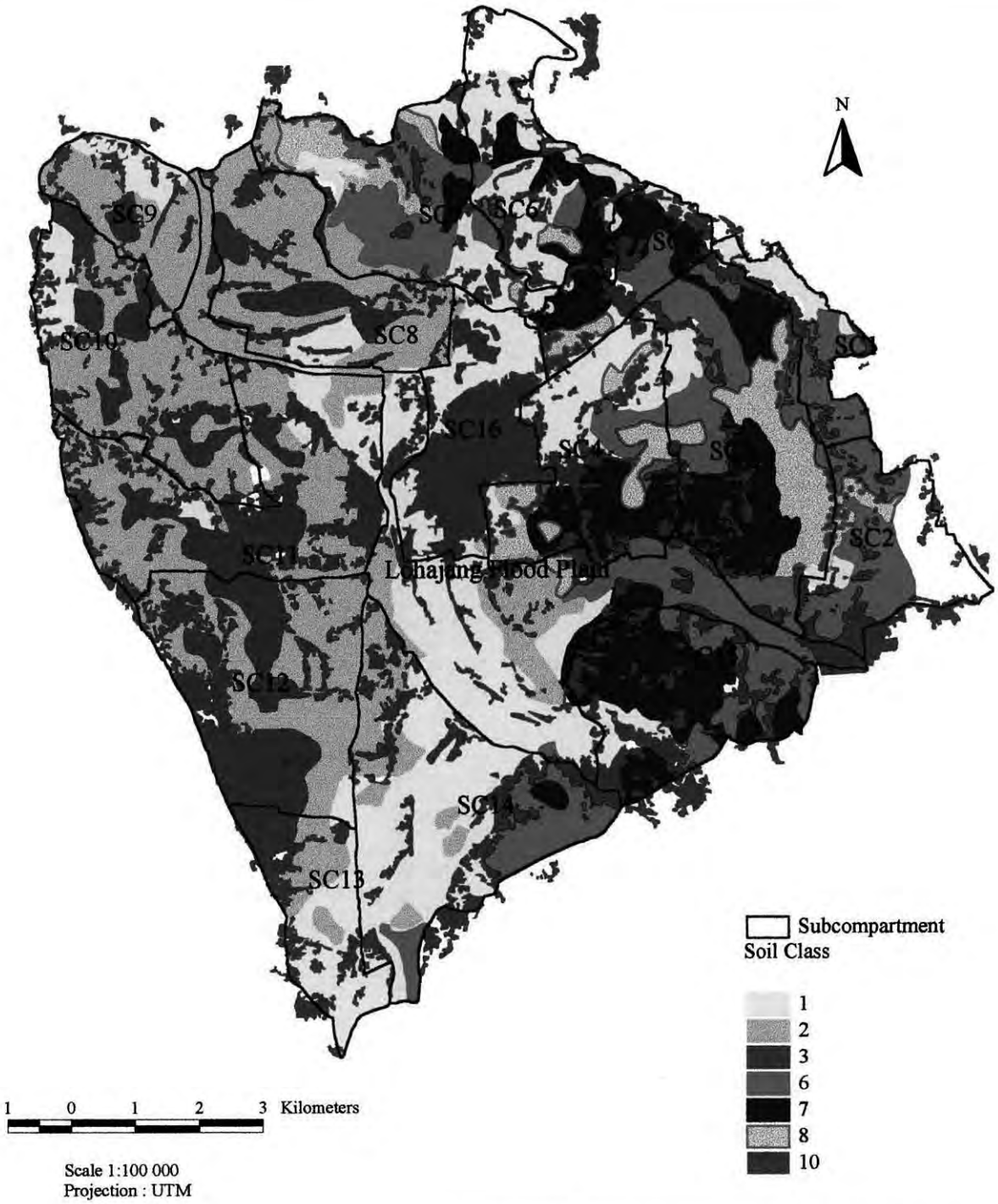
Agricultural output is limited in the project area by deep flooding and poor soil drainage. Due to unfavorable hydrological conditions, medium highland and medium lowland phases of Sonatola, Silmondi and Dhamrai soils are not suitable for growing high yielding varieties of T. aman. Lowland phases of these soil series are not suitable for ordinary T. aman. Low yielding varieties of broadcast aman (B. aman) is grown in the monsoon season. Savar Bazar soil series are more deeply flooded and remain wet early in the dry season, thus limiting the growth of dry land rabi crops. Agriculture is also limited by the heavy consistency of these soils that make cultivation with traditional plough and implements difficult.

In summary, the Project area comprises of very good agricultural land of about 63 percent of the cultivable area. It includes soils of highland phases of Sonatola and Silmondi. Good agricultural land includes mainly medium highland and medium lowland phases of Sonatola, Silmondi and Dhamrai soils that occupy 62.9 percent of the cultivable area. Moderate agricultural land is about 27.1 percent and occupies lowland phases of all soil series. Poor agricultural land occupies 3 percent of cultivable area and comprises silty and sandy alluvium complex. The soil classification map is shown in Figure 3.4.

3.2.3 Crops

Cropping Patterns

In the project area the cropping patterns are dictated by hydrologic regime and the patterns are based on rice. It is the drainage congestion for which the premonsoon cropping is constrained. The congestion is mostly from accumulation of rainfall runoff. When flooding from high water level in Dhaleswari, Lohajang and Pungli rivers limit the crop choice during monsoon this situation is aggravated. It is also seen that some times post-monsoon drainage congestion also acts as a constraint against crop production. For growing HYV boro rice in the winter season ground water irrigation is extensively practiced. Non-rice crops are grown usually in non-irrigated land in rotation with rainfed aus and aman rice varieties. This is, of course, done depending on the land type. Winter crops are inter cropped with sugarcane. Base line cropping pattern in the project area (base year 1992) are presented in Table 3.4.



Class	Land Type (mainly)	Soil Type (mainly)	Soil Structure
1	Medium high	Loam	High
2	Medium high	Loam	High
3	Medium low	Loam to clayloam	High
6	Medium high	Loam	High
7	Medium low	Loam to clayloam	Medium
8	Low	Clay to clayloam	Loam
10	Settlements		

Figure 3.4 Land Type based on Soil

Table 3.4 Cropping Patterns of Land Types in the Area

Cropping Pattern	Area under Cropping Pattern (ha)				
	F_0	F_1	F_2	F_3	Total
Sugarcane	506	-	-	-	506
B. Aus-Rabi	35	-	181	-	216
Jute-Rabi	35	-	834	-	869
B. Aus-T. Aman (L)	-	268	-	-	268
Jute-T. Aman (L)	-	692	-	-	692
Jute-T. Aman (H)- Rabi	-	76	-	-	76
Mixed Aus-Aman-Rabi	-	-	-	943	943
B. Aman-Rabi	-	-	-	71	71
B. Aman-Boro (H)	-	-	-	325	325
B. Aman –Mustard- Boro (H)	-	-	189	-	189
Boro (H)	-	-	-	1090	1090
T. Aman (H)- Boro (H)	-	101	-	-	101
T. Aman (L)- Boro (H)	-	437	272	-	709
TDW . Aman (L)- Boro (H)	-	-	1769	19	1788
TDW Aman – Mustard – Boro(H)		-	735	-	735
T. Aman (L) – Mustard – Boro(H)		134	-	-	134
T. Aman (H) – Mustard – Boro(H)		113	-	-	113
TDW . Aman (L)- Boro (L)		-	-	104	104
Mustard – Boro (H)		-	268	-	268
Totals	576	1821	4248	2552	9197

Source : CPP EIA Case Study, 1992

Agricultural Inputs

Present levels of inputs with respect to human labour, animal power, seed, fertilizer and pesticides are low in general. This is, in particular, rice in case of crops which are vulnerable to damage by floods and drainage congestion. In case of irrigated HYV boro followed by HYV aman and wheat the highest quality of inputs is used. Moderate amounts of fertilizers are used in sugarcane and oilseeds. Pesticides are mostly used in HYV boro, Table 3.5 and 3.6 shows input use for different crops. These tables are based on data collected in the field.

Table 3.5 Level of Production Inputs under Base Line Cropping Systems (1992)

Crop	Person Days	Pair Oxen Days	Seed (kg)	Fertilizers (kg)			Pesticides (kg)
				Urea	TSP	MP	
B. Aus	150	45	100	70	40	-	-
B. Aman	125	45	100	70	-	-	-
T. Aman (L)	160	42	30	90	50	30	-
T. Aman (H)	175	44	30	170	90	40	0.2
T.D. Aman	150	40	30	90	-	-	-
Boro (H)	220	50	30	220	110	60	0.7
Jute	180	45	9	80	50	40	-
Wheat	105	44	130	150	70	50	-
Sugarcane	275	40	5000	120	100	70	-
Oilseed	80	30	10	90	60	30	-
Pulse	50	30	-	-	-	-	-

Source : CPP EIA Case Study

Table 3.6 Agricultural Labor Requirements (Without Project)

Crop	Area (ha)	Person – Days Per Hectare												
		J	F	M	A	M	J	J	A	S	O	N	D	Total
1. B. Aus	484			15	35	40	20	30	10					150
2. Aus-Aman	523			15	30	30	5	5				30	20	135
3. B. Aman	585			15	30	30						30	20	125
4. T. Aman(L)	1803						10	40	30	20	10	25	25	160
5. T. Aman(H)	290							50	50	20	10	25	20	175
6. T.D. Aman	3447					10	30	30	20			30	30	150
7. Boro (H)	6476	50	50	15	30	40	15						20	220
8. Boro (L)	104	30	15	20	30	15						20	40	170
9. Jute	703			20	40	30	20	40	30					180
10. Sugarcane	506	40	40	20	10	10	10	5	5	25	30	40	40	275
11. Wheat	873	10	10	10	20							30	25	105
12. Mustard	1439	20	10								5	30	15	80
13. Pulses	350	5		10	10						5	10	10	50
14. Potato	300	20	20	60	10							30	50	190
15. Vegetables	100	30	30	40							20	50	40	210
Total (000s P/D)		39 5	378	182	305	374	250	238	166	55	47	298	36 3	3051

Source : CPP EIA Case Study

Agricultural Production

In the CPP area, crop production is characterized by flooding and drainage as detailed under 'Cropping Patterns' above.

Estimates of areas under different crops, generated by GIS from the cropping pattern and land type data and the results of the land use surveys and interviews with farmers on crop damage are presented in Table 3.7. It appears that a total of 36,356 tons of cereal including 34,376 tons of paddy is currently produced annually in the project area. Farmers lost an estimated 3175 tons of paddy because of flood damage and drainage congestion.

Table 3.7 Crop Production and Flood Damage

Crop	Damage free		Damaged		Production (Tons)	Production Lost (Tons)
	Area (ha)	Yield (t/ha)	Area (ha)	Yield (t/ha)		
B. Aus	405	1.5	78	0.5	648	78
Mix Aus-Aman	880	1.9	63	0.9	1729	63
B. Aman	510	1.6	75	0.7	869	67
T. Aman(L)	1264	2.2	539	1.0	3320	647
T. Aman(H)	240	3.0	50	1.2	780	90
T.D. Aman	1216	1.7	1411	0.4	2631	1835
Boro (HYV)	5294	4.5	158	2.0	24139	395
Boro (L)	104	2.5			260	-
Paddy					34376	3175
Wheat (H)	990	2.0			1980	-
Potato	360	9.5			3420	-
Jute	1637	1.8			2947	-
Sugarcane	506	40.0			20240	-
Mustard	1439	0.8			1151	-
Pulses	675	1.0			675	-
Vegetables	150	3.5			525	-

Source : CPP EIA Case Study

3.2.4 Forest and Homestead Vegetation

Natural vegetation, plantations and homestead groves and kitchen gardens constitute forest and homestead vegetation.

Natural Vegetation

Public land for forests is not available in the project area. Some naturally grown trees like Kharazora, Kadam, Koroi and Chambal, Shrubs like Rash, Dholkolmi, beth and patipata, and herbs like Ralmegh, Thankuni and Ratanotey are found along the marginal lands of roads and embankments. Because of their role in providing fuel, timber and herbal medicine, these species are economically important.

Plantations

There are about 262 km of existing roads in the CPP area. Of these roads about 18 km have been planted by Thana Banayan Prokalpa of the forest Department since 1989 (FAP 20, 1992a). Forest growing exotic tree species such as Akashmani, mahogany, eucalyptus and epil-epil have been planted in recent years. Older trees such as babla, mahogeany, koroi and paia grow along the Tangail-Sontosh and Tangail-Dhaka roads. The verges of unpaved roads within and/or between the villages are generally planted with banana, betelnut and mahogany by the neighboring households. Roadside plantations, particularly young seedlings are frequently damaged by heavy floods and browsing by cattle. Roadside vegetation in elevated areas on the eastern side of the Lohajang River is in good condition.

Homestead Groves and Kitchen Gardens

Homesteads occupy about 27% of the project area. It is, in average, seen that an area of about 0.01 ha in each homestead is used for gardens and groves. About 50 percent of the homestead is used for housing, 25 percent for trees (including other vegetation) and 25 percent for vegetable gardening. On average, an area of about 0.01 ha in each homestead is used for gardens and groves. About 50 percent of the homestead is used for housing, 25 percent for trees and other vegetation, and 25 percent of vegetable gardening. About 40 percent of the households have a piece of land ranging from 0.02 to 0.3 ha in extent which is located about 0.3 to 0.9m lower than the homestead but normally attached to it.

In the elevated areas the dominant trees include mangoes, jackfruit, citrus species, bamboos and bananas. In the low lying areas debdaru trees are dominant. Of the vegetable species brinjal is improtant because this is cash vegetable. Brinnal is grown in the palans. The palans of subcompartments 5 and 6 grow cabbage and cauliflower widely. These are also cash vegetable. Arum - another important cash vegetable, grows in low lying palans of subcompartments 1, 2 and 3, Cucumber, chili and sweet gourd are grown in abundance in subcompartments 3 and 4.

During 1987, 1989 and 1990 flood water damaged kitchen garden crops in 3 to 10 percent of the farm household. The severe 1988 flood inundated 95 percent of the household making enormous damage to kitchen gardens.

Energy Use

For cooking in the rural parts of the project area dried leaves, cow dung, jute sticks and crop residues etc. are used as source of energy. Abut 20% of urban households use kerosene as a cooking energy source and the remaining use fuelwood. In addition to source of energy kerosene is used for lighting houses. About 42% of rural households have electricity. While large farmers use cowdung as manure, the landless farmers use it as major fuel source. Fuel efficient trees such as neem, tetual etc. in the project area are used by brick field owners.

Livestock

In almost all rural household livestock are kept. For draft and transportation bullocks are used mainly. Cows are kept for milk. Goat, Sheep, Chickens and ducks are produced for cash income and as source of protein. Draft power availability is only 1.9 ha in the project area. This is lower than national average of 2.61 ha. The health condition, in general, of the livestock in the area is poor due to shortage of feed and fodder, lack of grazing field and diseases.

3.3 Biological Resources

3.3.1 Aquatic Habitat

Wetlands

In the project a diversity of wetlands are found. These wetlands include beels, ponds, borrow pits, khals, rivers and seasonally flooded areas (Table 3.8). There are 19 perennial beels in the Project area, covering an area of about 133 ha in April and 432 in December (Table 3.9). Of the perennial beels, Atia-Kumuria, Boro, Ghatak bari, Jugnidaha, Batchanda, Gharinda, Dhurun and Chakran beels contain valuable aquatic habitat. Lohajang the only river in the project area, covers an area of 165 ha during the wet season. In the central depression portion of most of the seasonal beels the land owners have excavated small ponds (pagars) with the dual objectives of catching fish and irrigating the boro crop. Most of the pagars retain water throughout the year.

Table 3.8 Aquatic Habitats within the CPP Area

Wetland/Inundated Areas	Area (ha)	Period of Inundation	Total Area (%)
Perennial Wetlands			
Beels	133	Year Round	1.0
Rivers	50	Year Round	0.4
Seasonal Wetlands			
Pre-monsoon	322	April-June	2.5
Monsoon	7138	July-September	54.9
Post-monsoon (Drainage condition)			
Post-monsoon (Drainage free condition)	8145	September-October	62.7
	1475	November-December	11.3

Source : GIS Data

Table 3.9 Perennial Beels within the CPP Area

SC No.	Name of Beel	Area		Union	Ownership
		December	April		
1.	Jugnidaha	7.0	7.0	Baghil	Khas
2.	Kestopur Beel	3.3	0.0	Baghil	Khas & Private
3.	Chowbari Beel	2.0	0.0	Baghil	Private
4.	Ghatakbari Beel	20.3	0.0	Dainnya	Private
5.	Baro Beel	37.9	4.3	Dainnya	Private
6.	Patnibari Beel	11.9	2.6	Tangail	Private
7.	Atia Beel	49.5	27.3	Atia	Khas & Private
8.	Mangalhar Beel	2.4	0.0	Atia	Private
9.	Batchanda Beel	5.2	5.2	Gala	Private
10.	Chakran Beel	8.0	0.0	Gala	Khas & Private
11.	Bartha Beel	5.3	0.0	Gala	Private
12.	Gharinda Beel	34.0	6.1	Gharinda	Private
13.	Dharun Beel	17.1	17.1	Gharinda	Khas & Private
14.	Aaghbetoir Kum	1.1	0.0	Gala	Private
15.	Bara Kum	1.6	0.0	Gharinda	Khas
16.	Sikder Kum	1.2	0.0	Gharinda	Khas & Private
17.	Garaildaha	5.9	8.1	Kazipur	Khas
18.	Kazipur	2.6	0.0	Kazipur	Khas
19.	Bajitpur	6.0	0.0	Kazipur	Khas
	Total	222.3	77.7		

Source : CPP EIA Case Study

Perennial water bodies in the project area increase gradually in size with the commencement of premonsoon rainfall during April through early June. At the onset of the monsoon rainfall in late June, the seasonal water bodies increase rapidly in size and reach their peak in August. During the monsoon (July to September), the isolated wetlands of the area interconnect and become large water bodies covering from 54.9 to 62.7 percent of the area.

With the commencement of pre-monsoon rainfall during April to early June, perennial water bodies increases in size gradually in the project area. The seasonal water bodies increase rapidly in size from the beginning of monsoon and the same get their peak during August. It is during the monsoon (July to September) that the isolated wetlands in the project area interconnect with each other and constitute large water bodies which usually cover 54.9 – 62.7 percent of the area.

The aquatic habitats of the western part of the project area receive water from the Lohajang River via Jugni, Kalibari, Gaizabari, Aloa-Rajbari and Deojan khals. They also receive water from the Dhaleswari and Elanjani rivers through Darjipara, Fatepur, Indrobelta and Barbelta khals, respectively. Flows in the four khals originating from the Dhaleswari and Elanjani rivers are regulated by sluice gates. The aquatic habitats of eastern part of the area receive flood water from the Lohajang

River through khal, from the Pungli and Lohajang rivers via Gala Khal, and directly from the Pungli River through Rasulpur Khal. Aquatic habitats of this part also receive water from the Lohajang River through Bhatkura and Julfai Khals.

Floods begin to recede from the project area in late August through September when the direction of flow changes and water is discharged from the project area southward mainly to the Lohajang through most of the same khals (except for Jugni and other khals in the western part of the project area which have regulators). Wetlands become isolated from one another by December and remain so until the following monsoon in June.

Water Quality

In the project area water samples from rivers, beels and ponds were tested for various parameters for the period from March through May. The test result revealed that they were found to be generally suitable for fish and other aquatic biota. It was seen that the overall quality of river and beel water was better than the pond water. The Dhaleswari, Lohajang, Pungli and Elanjani rivers are, in their chemical composition, similar. In Atia (6.9) and Bachanda (6.7) beels slightly acidic pH was found. This may have been due to the time of sampling (09.00 to 09.15 hours). A high concentration of chloride was found in water of a pond near Kandua. Of the beels, so far sampled, while Jugnidoho showed best water quality, Dharun showed the worst.

The Jamuna Fertilizer Company, located about 20km upstream of the CPP area, discharges wastewater directly in to the Jamuna River. Two samples of Jamuna River water, taken from downstream of the fertilizer plant, showed high concentration of nitrite, chloride and ammonia. Fish killing has occurred due to these discharges as reported by the local people.

Plankton

Populations of zooplankton in all sampled beels were found to be higher than those of phytoplankton. Crustaceans were the dominant zooplankton. The highest population of plankton was observed in boro beel which may be due to nutrient-rich bottom sediments, shallow depths and less surface coverage by water hyacinth.

Benthos

The sampled benthic fauna comprised three species of freshwater clans, six species of snails, three species of annelids and a variety of insect larvae. Low populations of annelids and insect larvae was observed in Patnibari, Baro and Kazipur beels. Atia Kumaria, Kazipur Baro, Dharun beel and Jugnidaho beel presently have a significant accumulation of hyacinth roots and detritus at the bottom which leads to low benthic fauna population.

Pesticides

In CPP area pesticides are extensively used for crop's pest control. From mid-March to mid-May insecticides are generally applied in boro fields. It is reported that the main agricultural pest is 'Pamri'. Of other kind of insecticides, Basudin is widely used. This pesticide is seen to be toxic to fish. Most insecticides are toxic to frogs, spiders, earthworms and few other kinds of species.

Inspite of being banned in Bangladesh, DDT was detected in pooled fish tissue samples with residues measured at 21.5 ppb and in fresh milk at 18.8 - 44.4 ppb by atomic absorption method at Bangladesh Atomic Energy Commission. It appears that DDT has got a widespread use illegally in the CPP area. Besides, dieldrin concentrations in fish tissue were 87.9 ppb and 4.5-16.9 ppb in milk. Concentrations of endosulfans (71.4-2001 ppb) were detected in milk samples. These levels are below the directly toxic range in terms of human health, but are well within the carcinogenic limits set by the U.S. Environmental Protection Agency. The long-term ecological effect of insecticide application has not been studied and could be potentially significant.

Macrophytes

It is observed that macrophyte diversity is high in CPP area. 34 species of aquatic macrophytes were found in 9 beel samples. Of this 34 species, 11 were marginal, 8 submergence, 11 bloating and 3 emergent. Water hyacinth is the most abundant macrophyte covering. More than 60% of the total area of the sampled beels is covered by water hyacinth.

In the CPP area spirogyra spp, - an alge is seen everywhere. It grows during the early monsoon, especially in jute growing areas. In extreme cases Spirogyra masses decompose from mid February to March and deteriorate the water quality. Microcystis blooms during the dry season specially in the pagars and ponds. The project area supports at least three species of duck weeds. hygroryza spp. provides feed for cattle. hydrila spp. along with other submerged macrophytes privies shelter to common wetland based fish breeding species. "Biskatali" is the common marginal macrophytes throughout the project area. Water lilies, helencha and kalmilata are consumed by local people. Fishermen set traditional fish shelters ("katha") with water hyacinth. During the breeding season macrophytes provide shelter to water hyacinth.

Utilization of Wetland

Within the CPP area wetlands are productive ecosystems which serves the needs of a human population of more than 189,000 by providing water for drinking, washing and bathing, for irrigating rabi crops, and by supporting fish production. There are 19 perennial beels in the area. Of these 19 beels only three beels, it is reported, are leased out partially by the government, every year. The other beels remain as common property resources. Fishing by general public in these leased wetlands is permitted on condition that only year is used. Women and children fish most of the wetland in the project area. They also collect mollusks for feeding ducks as well as for lime preparation. Aquatic macrophytes from the wetlands are used extensively as green manure and cattle feed. In these areas, it is noted, the farmers use 25% less fertilizer than in other areas.

3.3.2 Open Water Capture Fisheries

It is known that no less than 50 species* of freshwater fish and four species of small shrimp have been in the project area in different habitats. Fishermen and also villagers

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Source: CPP EIA Case Study

report that there is an abundance of major carps in the area. This is probably due to floods from the Jamuna that is very rich in major carp's parent stock and fry.

Sensitivity of Fish to Hydrologic Cycle Change

The hydrologic cycle variation in the flood plain of the Jamuna river plays an important role on the socio-economic condition of the fishing community in the project area. Thus it is seen that during dry season fish found in the project area take shelter in the perennial beds and pools of Lohajong river and they become very much vulnerable to over fishing. This is more pronounced in the beels.

The major carps, during pre-monsoon period, begin to migrate upstream for spawning from the lower reaches of the Jamuna and its distributaries. Such migration also takes place from beels at the downstream. Beel dependent fishes remain in beels throughout the dry season and they start spawning as soon as the water levels and temperature rise. The early fry of these species use the newly inundated low lands as their nursery ground. The adult fishes also use inundated low lands as feeding and spawning grounds.

During the early monsoon major carps begin spawning in the upper reaches of the Jamuna river and continue up to mid of monsoon. The eggs and early fry including some adults flowing downstream disperse laterally over the floodplain from June through early August. There they spend 4 to 5 months and grow as young or sub-adults. Lateral migration of fish from rivers to flood plain in the early monsoon takes place mainly during first few weeks of influx of water.

Lastly, it is the monsoon which is the peak period for major biological activities of freshwater fish species. This is because the decomposition of plant and animal residues enhances rapid growth of fish food organisms providing most suitable niche for floodplain and river breeding fish for biological activities like spawning, nursing, feeding and growth. But when flood start receding, fish species migrate back from the floodplain to the Lohajang and Pungli rivers where they spend the entire dry period.

Impacts of Previous Developments

It is observed that immigration of fish eggs, larvae and adult fish into the floodplain and beels has been getting hindered due to construction of regulators in four khals at the western boundary of the project. Again, in the north-eastern part of the area, closing of the khals has greatly made obstruction to immigration of fish from Elanjani, Lohajang and Pungli rivers.

Also construction of a diversion road by closing Boilla Khal on the Tangail-Madhupur road and Sibpur in early 1992 has stopped immigration of fish to the entire eastern part of the project area.

Fish Production

The overall national trend of fish in the country from the open water resources is declining and the CPP area is no exception to the trend. Of course, reliable data on fish production within the project area from different open water habitats is not

available. FAP 20 (1992d) has estimated the total open capture fisheries production in the project area at 380 tons/year (Table 3.10). At the national level, it has been estimated that the rate of reduction is about 2% per year (DOF 1983-89). The fishermen and villagers of the CPP area have also reported a gradual decrease in fish production.

Table 3.10 Annual Production of Fish (tons/year) in the CPP Area

Species	Rivers	Beels	Floodplain	Pits/Derelict	Total
Carps	2.2	21.6	4.0	0.6	28.4
Catfish	0.4	15.9	17.6	2.5	36.4
Live Fish	0.6	7.9	5.3	0.8	14.6
Hilsha	7.0	-	-	-	7.0
Small Shrimp	3.5	4.8	-	-	8.3
Small Fish	30.3	76.8	156.1	22.2	285.4
Total	44.0	127.0	183.0	26.1	380.0

Source : FAP-20 (1992d)

3.3.3 Closed Water Culture Fisheries

In the CPP area culture or pond fishery is not common. There exist about 450 ponds covering 64 ha in the area. Of the total number of ponds 187 no, 93 no and 170 no of ponds are cultured, culturable and derelict respectively (DOF 1986). There are number of constraints that impede pond/culture fishery in the area. The major constraints include inundation of ponds by flood water, preference to fishing open water fisheries resources, lack of technical knowledge about fish culture, and lack of technical and financial support from the Department of Fisheries and other agencies and fear of fish diseases (epizootic ulcerative syndrome).

Fish Culture Practices

The present status of fish culture is at a traditional level. The owners of the pond do not usually follow scientific methods of fish production management with respect to preparation of pond, etc. leading to slow growth rates and rendering productive fish vulnerable to various diseases.

Stocking of carp fingerlings are made from July to September in flood free ponds. These are collected from fishermen/hawkers or from contract fishermen. In case of a contract 50% of the production goes to the fishermen supplying fingerlings. The ponds that are prone to flooding are stocked in October through November after recession of flood water. Data collected from 15 ponds in the CPP area indicate that the ponds are overstocked with an average stocking of 26,453/ha*. But the DOF recommended density is 6750/ha in average. This together with non-maintenance of stocking ratio and rate, using artificial food irregularly and lack of monitoring of growth, survival and health condition of fish that make less production.

Source: CPP EIA Case Study

Production

It is estimated that annual production of fish from ponds in CPP area varies from 529* to 1310* with an average of 910kg/ha/yr. This figure is less than national average of 1055 kg/ha/yr* (DOF 1989). This is primarily due to inappropriate management in pond fish culture in the area.

In most cases contract fishermen who supplied fingerlings free of cost, harvest and sell the fish on a 50 percent share basis. In other ponds, fishermen sell fish either on 20 to 25% share or are paid on a daily wage rate basis.

3.3.4 Terrestrial Habitat

While during dry season about 98% of the CPP area is available as terrestrial habitat, during the peak flooding period where about 63% of the area is flooded, terrestrial habitat is limited to homestead, roadside vegetation and highlands. The CPP area provides 81 species of plants that economically as well as environmentally important. Of these plants, 19 provides fruit, 14 timber, 15 fuelwood, 29 vegetables and 4 species are shade trees.

In the project area river levee vegetation grows in a linear pattern. While shimul trees occurs at random along the river banks, beel edge vegetation is situated in circular pattern. Vegetations those are close to wetlands tend to be relatively luxurious in growth. Tall trees like korai close to beels provide shelter to helpless and threatened bird species.

In the central part of the project area is situated Inland Densely Vegetated ecological zones. These areas, characterized by dense vegetation covers 5-20 ha. The urban area vegetation possesses the highest number of exotic plant species. Since the early part of the present century timber plants like teak and mahogangy have been planted by local people and by officials since the early part of the present century. Mangoes and lichi are common fruit plants in the urban areas. The agricultural land of the project area provides support to the carnivorous and insectivorous wildlife.

3.3.5 Wildlife

Observation from April to May 1992 revealed that CPP area supports 177* species of wildlife. The wild life constitute 17 reptiles, 140 birds, 15 mammals and 5 amphibians. Of the total species of wildlife in the project there are 17 important wildlife resource. These wildlife resources consists of seven endangered and ten threatened wildlife species which directly or indirectly provides benefits/disbenefits to human populations. The important wildlife species are grouped according to their function.

3.4 Navigation

During the flood season, except for the deeply flooded areas, navigation routes play an important role in providing access to outside. Of course, there is a good road network for communication at large. The existing extensive rural road network

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* Source: CPP EIA Case Study

comprises 224.8 km* unmetalled road, 31.40 km major metalled road and 6.1km embankment-cum-road located along the western boundary of the project area. The use of water transport is only seasonal and covers 3 to 4 months during the wet season. Figure 3.5 shows the important navigation routes and the marketing networks.

3.4.1 Navigation Routes

Construction of regulators on the western embankment closed off the navigation routes in the northeast of the project area. But, at one time, it was such that most of the eastern and western low-lying parts of CPP area were connected with Pungli and Dhaleswari rivers through a number of khals Dhaleswari - Chillabari, Pungli -District Bazar and Pungli - Jugi Bazar are major existing navigation routes. The longest and at the same time most important route is from Chillabari to the char villages of the Dhaleswari river and this is the lone navigation route that connect the project area with the outside for both passengers and goods delivery.

3.4.2 Markets

In the CPP area there are two important markets – Jugni and Karatia. Both the markets are situated adjacent to Lohajong river. Jugni is one of the busiest markets in the area and serves most of the Dhaleswari charlands. The market is famous for jute trading. During flood season jute from charlands is marketed in this market and shipped to Charabari Ghat and subsequently to Dhaka. It is estimated that about 660* tons jute, 120* ton rice and 120* ton sugar cane is delivered to Jugni. Of the total merchandise 575 tons is shipped to Charbari. Besides, Tangail town, being a district headquarter, provides access to medical facilities, marketing of goods etc. Almost all charland people adjacent to the northern part of the project area use Lohajong river as their main route to reach Tangail Town.

3.5 Human Resources

Human resources constitute the project beneficiaries. In discussing human resources, population, livelihood, land ownership, tenancy market, credit relations, health and equity, gender relations, health and nutrition, education and awareness etc. of the people inside the project area are dealt with.

3.5.1 Population and Settlements

The population in the project area, according to 1981 census, was 190,430*. Of this total population 97,988 are male and 92,442 are female. The density of population in the area is 1465 person/Km^2 (1981) whereas the national average in boy persons/Km^2 (BBS 1985a). Based on the assumption of national exponential growth rate of 2.17, an increase of population density from 1645* person/km^2 in 1981 to 1820 person /Km^2 in 1991 is estimated.

In the project area Muslims, Hindus and other communities (Buddhist, Christian, tribal etc.) constitutes nearly 98, 11 and negligible percentage respectively.

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* Source: CPP EIA Case Study

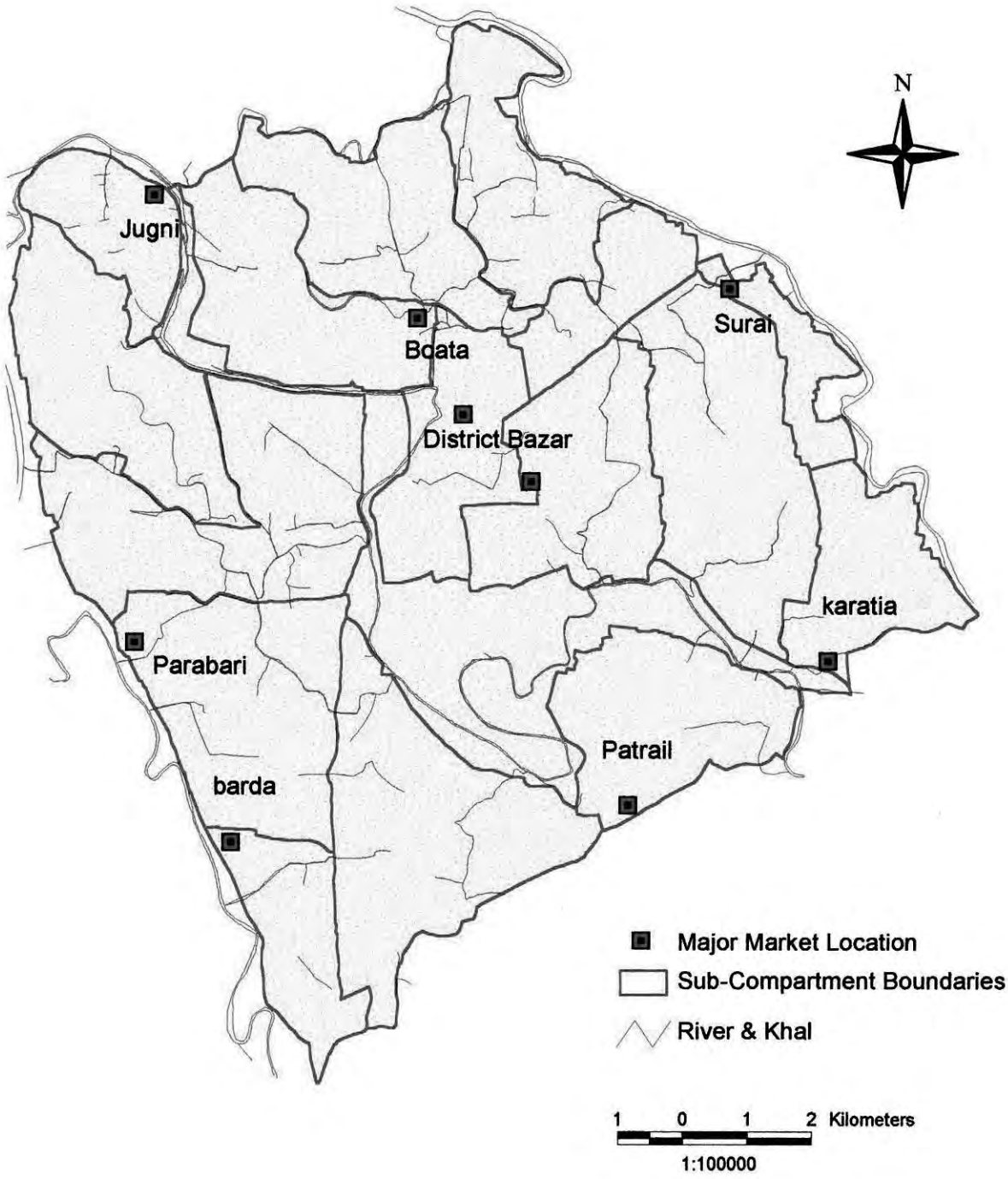

Figure 3.5 Market Location and Navigation Routes

Settlements, it is observed, are mostly concentrated along the riversides, khals and earthen roads. Settlement in high lands and beel are clustered.

3.5.2 Livelihood and Subsistence

Economy in the rural areas is mainly based on agriculture. Agriculture and Cropping pattern follow the flooding pattern which is partly controlled by the existing embankments.

While rice is the staple food crop (produced in 80% of total cultivated) area. Other important cash crops are Jute, sugarcane, wheat, mustard, pulses and potato, service, business and transport constitute the main occupational sectors in the urban areas. The CPP is historically famous for cottage industries, especially handloom and pottery. Besides, there are biri factories, brick fields, rice and flouer mills. During sowing and harvesting of HYV boro crop, hired labours are employed. Majority of the day labours come from the landless and poor households.

There is no large factory/industry in the project area and areas outside agriculture, few job opportunities exist. Very few woman labours are used in agriculture and for them income generating activities are limited to biri making and spinning.

According to a survey conducted by FAP 20 there are 325* professional fishermen households in the CPP area who earn their livelihood mainly by fishing. Professional fisherman generally fish in the flood plain, beels and rivers in the area. They also fish from pagars/ ponds on hired basis with the owners.

Every year khas beels are given lease to local fishermen's cooperatives through auction. Many of the professional fishermen are heavily indebted to large land owners, traders and businessmen to whom usually most of the khas beels are leased out. The professional fishermen face competition with the fisherman of adjacent areas in respect to fish catching in the Jamuna and Dhaleswari rivers. Many of them reported that they are being disappointed in this profession due to reduction in fishing facilities. A number of professional fishermen have already left for India and some have switched over to others professions like weaving, petty business etc.

3.5.3 Land Ownership Distribution Patterns

The distribution pattern with respect to land ownership in CCP area is no different from other part of Bangladesh. A few households who control much of the land but there are many who either own very little or no cultivable land at all. (Table 3.11).

Source: CPP EIA Case Study

Table 3.11 Main Occupation of Household Heads in the Project Area

Occupation	Percent of Household Head					
	Project Area			Adjacent Area		
	Rural (N=5918)	Fishing Villages (N=274)	Urban (N=1398)	Rural (N=7263)	Fishing Villages (N=249)	Urban (N=504)
Agriculture	28.5	-	6.3	37.2	0.4	17.8
Agricultural Labor	14.3	-	2.8	14.7	-	8.7
Non-Agricultural Labor	7.2	-	7.8	9.6	-	11.3
Service	7.6	-	29.2	8.5	-	6.9
Trading/Business	8.6	-	18.6	8.5	-	24.8
Fishing	0.1	98.2	2.5	0.1	99.6	-
Inherited Community Professional	15.0	-	3.5	6.6	-	14.3
Transport Worker	9.5	-	14.8	6.1	-	7.9
Others	9.2	1.8	14.5	7.2	-	4.3

N = number of household heads
Source : FAP 20 (1992c)

The overall distribution pattern in the area shows that the highest proportion of ownership of land is by the large and medium farmers. But, on the other hand, the small and marginal farmers who constitute about 67 percent claims lowest proportion of land. The distribution is thus not equitable. The Gini ratio (GR) provides on inequality coefficient of 0.40 for the project area (a Gini ratio of 1.00 indicates uniform distribution of land ownership).

3.5.4 Tenancy Market

There exists an extensive tenancy market in the project area. It is share cooping in or out which consists of predominant form of tenancy. This accounts for almost 85% of total rented land. Mortgaging in or out consists of other type of tenancy arrangement. This is but payment of a fixed sum of money to the mortgagor by the mortgagee against a collateral of land that the later has the right to cultivate as long as the mortgage money is not repaid. The normal rate of mortgage is Tk. 60,000* to Tk. 75,000* per ha in the irrigated area. For non-irrigated area this rate is between 35000* and 45000 taka/ha*.

3.5.5 Credit Relations

In the project area most of the farmers need increased production. The average credit obtained, however, in 1991 from non-institutional sources by farm households was considerably higher than from institutional sources. It is seen that more than 41% of the farm households and 25% of the non-farm households including professional fishermen borrow money from non-institutional sources. The rate of interest is in some cases, more than 100% or above. Two thirds of the households borrow money from institutional sources at 16-20 % interest rate. The rate of high interest is mainly due to the fact that there are a number of problems regarding credit acquisition from institutional sources.

Source: CPP EIA Case Study

In the project area advance sale of crops before harvesting is almost absent. Of course, field data indicate that marginal and small farmer usually sell their crops immediately after harvesting in order to meet household expenses. Sometime small farmers sell their land in distress situations. Bandhak (mortgage) of land occurs at different rates and most of the mortgage transactions occur due to debt repayment and family maintenance reason.

3.5.6 Wealth and Equity

Land consists of the principal form of wealth in both the project and adjacent areas. The distribution of land is, however, not equal. Data show that only a few (7 to 8) households in a village own much of the cultivable land (2 ha/family). The percentage of landsless households is high (nearly 52%). The villagers were interviewed by the EIA team. The interview indicated that the small and marginal farmers' economic condition has deteriorated during the past 5 to 6 years due to flooding, drainage congestion and siltation problem. The majority of the landless and poor households have limited sources of income and hence very small or no savings at all.

3.5.7 Gender Relations

In the project area, like all other areas in Bangladesh, women have limited access to land. Less than 6% of women receive property from their fathers. Neither benefit from crop production nor small-scale industry hardly go directly to the women. However, now a days, women are increasingly joining the labour force in agriculture, traditional crafts and cottage industries. Major sources of income for women is biri-making. Women also work as maids and receive their wages in kind.

The inducement of NGO and Grameen Bank in the development process is helping poor women through group savings and credit delivery to become economically independent. Women in the area presently more mobile and they are now travelling as far as Tangail Town to seek employment.

3.5.8 Health and Nutrition

A case study has been conducted. The study reveals that the most common diseases are diarrhoea, intestinal worm infestation, skin diseases and acute respiratory infection. More than 25% household are affected by waterborne disease like cholera, typhoid fever, dysentery and jaundice. Skin infection becomes acute during post-monsoon period and remains so until the beginning of the next monsoon. Contaminated water is the primary cause of water-borne diseases. Approximately 90% of rural households drink safe, tubewell water but in some villages there is a severe scarcity of safe water.

A minority of households, located in rural areas, use unsafe ring well water. In the fishermen community majority households do hardly get access to tubewells or ring wells. This community, as such, use surface water for drinking. Lack of surface water poses a major health hazard during the dry season. In some villages water gets so contaminated during this period that it causes irritation to the eyes and skin. Anaemia is aggravated by worm infestation. Tangail Thana Health Office is running a

mobilization campaign on sanitation and local government and NGOs are providing inputs for construction and distribution of low cost latrines.

Govt. health services in the area consist of a general hospital (100 beds) in Tangail. In addition, one out-patient clinic, one TB clinic and five Union Health Centres have been in operation. There is also one private hospital and two clinics. There is only one maternity hospital with 8 beds. FP and MCH services are provided by family welfare centres. The rate of adoption of family planning is about 60% of eligible couples.

It is seen that, in the project area, nutritional deficiencies become prominent during pre-harvest lean seasons in September/October and February/March. Resources of capture fisheries, however, modify the normal trend of seasonal nutritional deficiency related to the crop cycle. Study shows that capture fisheries provide for main source of protein and vitamin A for people in the project area. Vegetable is also a major source of nutrition.

3.5.9 Education and Awareness

In the project area the overall rate of literacy is 41%. The rate of literacy with respect to male and female is 50% and 32% respectively. The literacy is, of course, defined as being able to put signature only. In general the rate of literacy is higher in the project area compared to adjacent areas due to a relatively high level of urbanization. Female literacy in the project area is also higher due to influence of Tangail Town. In an average 400 children take their education in primary school. 80% of the children enrolls at the primary age. Of this only 45% attend regularly and the dropout rate is nearly 25%. Poor attendance and high dropout is but poverty related. Many parents from the very poor family regard education as unimportant for the future of their children. Many families withdraw their daughters from school at puberty for religions reasons. Survey shows that in farm, non farm and fishermen's households a high proportion of female respondents wanted only a minimum education for their daughters. Difficulty in physical access and school closure on account of flooding affects secondary education. Also lack of good communication affects girls' participation.

3.6 Tangail Town

Tangail Town is the district headquarter covering total area of 260 ha. Its estimated zone of influence is about 84 km^2. The population of Tangail Town, according to latest municipal survey (January 1992) is around 152,200 (Tangail Pourashava 1992)[*].

3.6.1 Flood and Drainage Condition

The Lohajang River, flowing through the central region of the town divides it into two parts in NW-SE direction. The town area is relatively low lying. Because the town is not flood protected, flood water from Lohajang river enters the town through Muslim Akur Takur Para, Taltala, Dighulia and District Council building area by over topping the eastern bank during high river stages.

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[*] Source: CPP EIA Case Study

Tangail canal is connected to the Lohajang river. The canal flows through the middle of the town. This canal previously served as the major drainage and sewage passage of the town. But it has, due to increasingly growing habitation, been silted up causing severe drainage congestion. In 1988 flood, Tangail town was entirely inundated to a depth of as high as 1.5 m. It took 15-20 days for water to get drained.

In addition to drainage problem, river bank erosion is a problem to the town. Lohajang river bank erosion has been continuing for a long period. The impact is worse near the stadium.

3.6.2 Groundwater

The Department of PHE installed 8 DTW and handed over them to the Municipal Authority exclusively for drinking water supply purposes. Water is supplied from an overhead tank through pipes in urban households. There are 12,700* residential holdings in the municipal area but only 1585 (15%) have a piped supply. There are 17 street hydrants and 165 commercial pipes water connections in Tangail Town. About 85% percent of the urban people drink water from the hand tube well (HTW) source. But the number of HTWs in Tangail town is only 492. There are also 135* dug wells in the area mainly used for washing & bathing and working. Municipal water supply is not satisfactory from all the DTWs in all seasons.

3.6.3 Land Use Pattern in Tangail Town

Tangail Town is mainly rural based and agricultural activities occupy 51%* of the municipal area, 34%* of the municipal area is occupied by housing and settlement. The developed urban areas cover about 640 ha*. Homestead, administration, commerce and industry and educational institutions cover 56%, 9%, 9% and 5% of the urban areas respectively.

The main urban area lies on the east of river bifurcating the towns from north to south. Comparison of 1983 and 1991 aerial photographs showed that the urban expansion took place in northern direction along the Tangail-Jamalpur road and in southeast direction towards Tangail-Dhaka road.

Source: CPP EIA Case Study

Chapter 4
Important Environmental Components

4.1 Modalities of Identification of IECs

The EIA team consisting of Environmental Scientists, Hydrologist, Terrestrial Biologist, Social Anthropologist, Agronomist, Sociologist, Fisheries Biologist, Resources Economist identified the environmental components likely to be impacted positively or negatively, directly or indirectly by the planned physical interventions. These assessments have been arrived at after thorough field visits, careful review of project reports and available literature. Besides, consultation was undertaken with Project Affected Persons (PAPs) in the form of Focus Group Discussion (FGD) and Rapid Rural Appraisal (RRA) techniques by the EIA team. The following important project actions were identified:

1. **Controlled Flooding**: This is achieved by upgrading the existing horseshoe type embankment from Silimpur to Karotia along western, northern and eastern boundaries. The level of up-gradation corresponds to 1988 flood with a 30 cm freeboard. This is equivalent to a 1:7 year return period flood with a 90 cm freeboard. The upgraded section will conform to BWDB standard design criteria including sufficient stability and protection against seepage with provision of road transport without weakening of the embankment. The embankment, which crosses the existing major rivers/khals will have regulators. The main regulator at Jugini over Lohaganj river is of 5 vents (3v-3mx3m and 2v-1.5mx3.00m). There are several minor inlet regulators along the eastern and western peripheral embankment. Besides, provision for modification of existing four inlet regulators was made. The main purpose of the main regulator is to regulate the river flow after July 15 during normal flooding and to keep the water level of Lohajang river sufficiently low in order to allow drainage towards the river.

2. **Controlled Drainage and Water Management:** The physical features include upgrading and re-sectioning of the southern section of the peripheral embankment/ road, the drainage inlets and outlets within sub-compartments.

3. **Internal Water Control and Management Structures:** These comprise of improvement of drainage khals, construction of minor and medium inlet structures within the sub-compartments to regulate flow within sub-compartments and the flood plain including erosion control and bank protection works along the Lohajang and other adjacent rivers.

4. **People's Participation and Institutional Development**: People's Participation in CPP is defined as "involving peoples in all Phases of Compartmentalization with the aim that they will operate and maintain these compartments, so as to ensure sustainable development". With this end in view, CPP has undertaken a detailed and extensive institutional development and training plan proposed to be implemented within a Participatory framework.

The structural interventions result following influences:

- Control of normal and abnormal flooding.
- Controlled drainage and water management.
- Removal of drainage congestion and upkeepment of required water level for agricultural purposes.
- Protection of river bank and erosion control

The following Important Environmental Components (IECs) were identified:

- Water Resources (hydrological parameters)
- Land Resources (Agricultural practices)
- Fisheries and Wildlife resources (biological resources)
- Socio-economic conditions, (human concerns)

4.2 Description of IECs

The schematic arrangement of the relationships between the project features and hydrological parameters with the resulting arrays of impact of hydrological changes on water, land and biological resources is shown in Figure 4.1.

In determining the nature and seasonal distribution of resources, the hydrological cycle is predominant. Because of this, the IECs have been considered in terms of seasonal hydrological determinants. The determinants include flooding, rainfall, drainage congestion, siltation and erosion. The main hydrological events in the project area are shown in Figure 4.2.

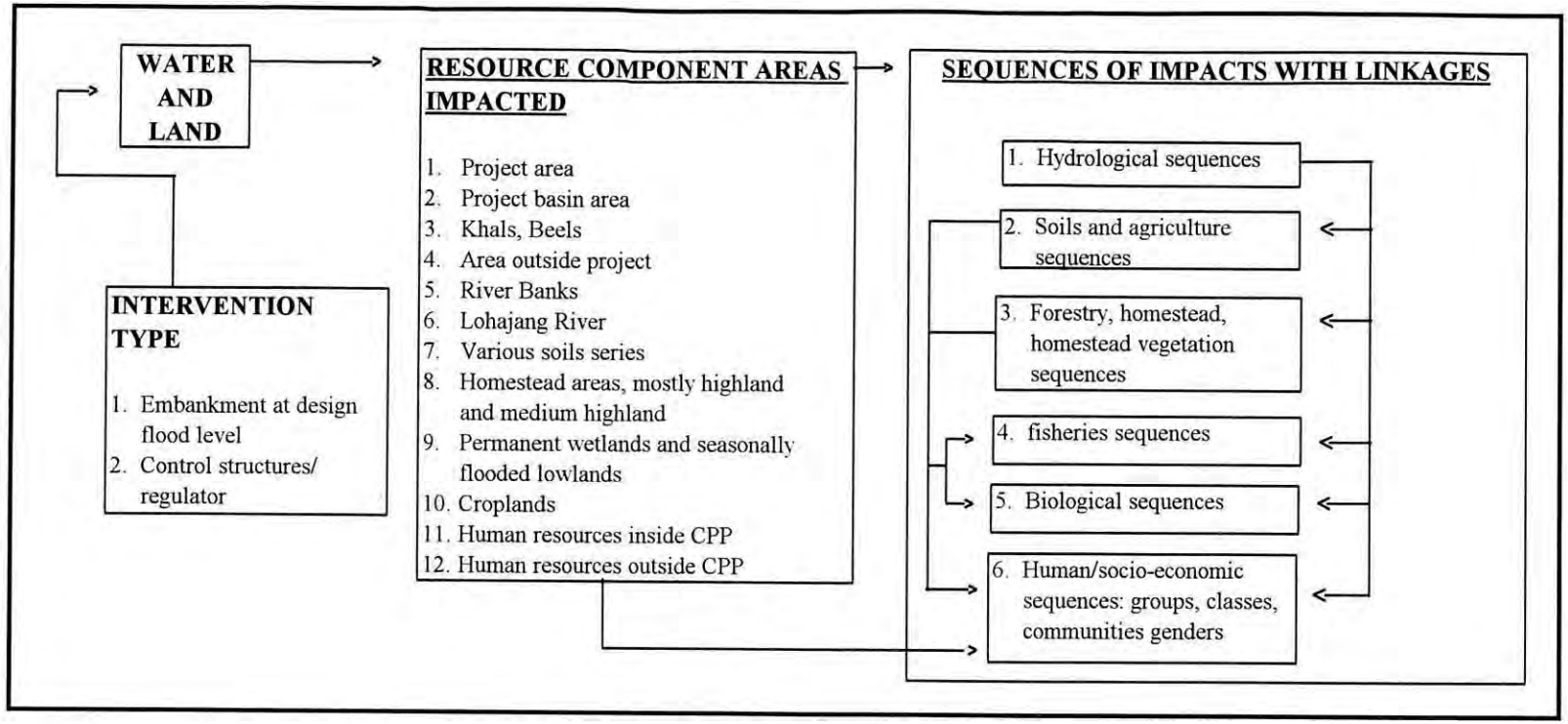


Figure 4.1 Environmental Cause and Effect Sequences in the CPP Area

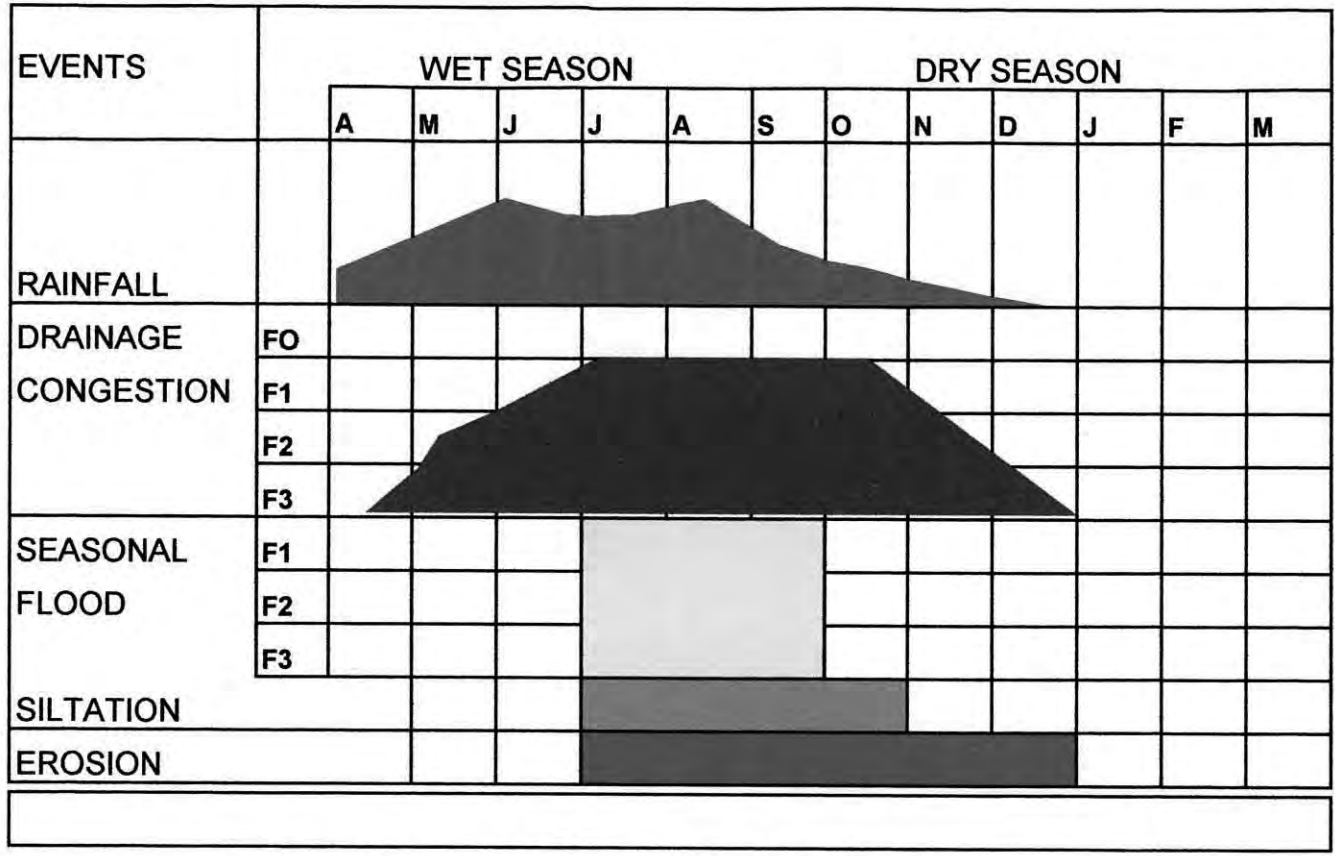


Figure 4.2 Hydrological Events in CPP Area

Chapter 5
Environmental Management Plan

5.1 General

The growing environmental awareness is increasingly focussing attention upon the interactions between development actions and their environmental consequences. CPP aims at testing the concept of compartmentalization which comprises various structural and non-structural development plans with a view to reduce flood hazards and to create an environment friendly situation for enhancement of agricultural production through water management. The implementation of CPP is associated with construction related impacts, change in water level, extent of flooding (depth, duration and frequency), cropping pattern, capture fisheries, navigation and to certain extent dislocation of wildlife and boat navigation. Some of the socio-economic impacts include agricultural land loss, population displacement, changes in land ownership, livelihood of fishermen and boatmen. Based on EIA case study undertaken by ISPAN and FAP 16/19 in 1992, CPP has developed the Environmental Management plan in 1994. While framing the EMP the FPCO guidelines were also followed. The EMP comprises the following main elements:

- Environmental Protection Plan
- Environmental Monitoring Plan
- People's Participation
- Disaster Management
- Institutional Strengthening
- Environmental Auditing
- Reporting

The schematic arrangement of EMP is shown in Figure 5.1

5.2 Environmental Protection Plan

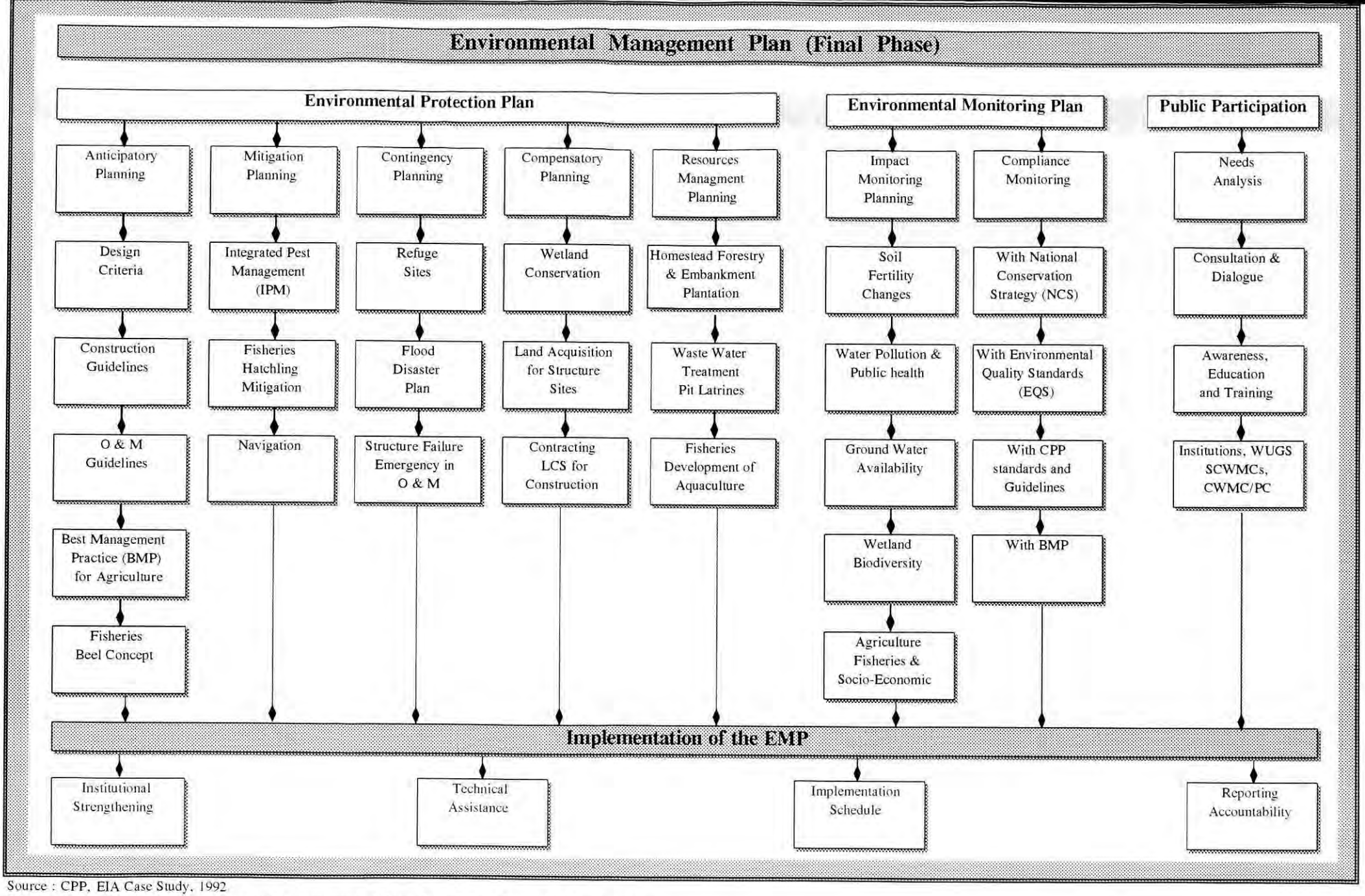
This relates to planning process of different structural and non-structural interventions. The planning targets as adopted in CPP demonstrate a clear commitment to adopt environment friendly and sustainable use of natural resources. The main strategies for EPP are:

- Development of **anticipatory planning** which includes adoption of protective measures, modification of activities, selection of alternatives, changes in construction procedures/ materials and adoption of supplementary programme.

- Adoption of **contingency planning** to prevent accidental hazards such as flood proofing or disaster shelter or refuge sites.

- Compensation or **off-set measures** for irreversible and residual impacts which include resettlement of affected people, development of alternative resources, replacement of cost resources and replacement of cost production.

- **Enhancement measures** to maximize positive impacts. These are: specific environmental enhancement measures, replacement or upgrading of affected resources, technical support to increase production, training of effective management of resources and introducing community management practices.



Source : CPP, EIA Case Study, 1992

Figure 5.1 : The Environmental Management Plan for CPP Tangail (Final Phase)

The ongoing activities of CPP related to EPP are furnished below:

Anticipatory Planning

The CPP has considerable flexibility in its planning approach and short term to long term adjustments are possible at any time. The ongoing development plans of CPP are:

- Flood protection with provision of peripheral embankment including inlet and outlet regulators. It indicates that flood is controlled and not protected fully. Flood water can be brought inside the compartment as per needs of the stakeholders. Here lies the flexibility of planning of CPP that is controlled flooding is ensured and hence termed as controlled flooding.

- Removal of drainage congestion which improves water management for agriculture. It helps removal of pre-monsoon water logging (favourable environmental situation for b. aus), reduction of post monsoon drainage congestion (conducive to t. aman HYV cultivation) and early drainage in dry season (suitable for rabi crops or winter vegetables or boro seedlings). This indicates conducive environment for crop diversification and intensification.

- Adoption of "Beel Concept" i.e. water management for fisheries which is likely to be achieved by controlled drainage i.e. sill levels of outlets are fixed in such a way so that minimum 1.5m deep water is maintained during dry season to improve the survival rate of brood fish.

- Water management for navigation i.e. main structures should allow boat traffic.

- Urban drainage i.e. improvement of Tangail Khal (4 km)

Contingency Planning

Contingency planning like many major development projects is necessary to provide safety and control measures against accidental events like breaching and overtaking of embankments, sluice gate/regulators failures, cutting of embankments etc. The CPP has undertaken following contingency measures for flood disasters or abnormal flooding.

- In case of full flood protection of the compartment if such situation at all arises adjacent areas (E_1 in the north and E_2 in the south as shown in Figure 5.2) are likely to be affected with higher water levels (0.5m to 1.00 meter)

- CPP proposes 17 sites as flood shelter of which 9 sites are to be improved and 8 are for new construction

- CPP also proposes to raise the rural roads within adjacent areas E_1 and E_2 which are likely to be affected due to the compartment

- The refuge sites can accommodate many people for short period along with domestic animal

- CPP also proposes training programme for the rural people for disaster management and flood preparedness.

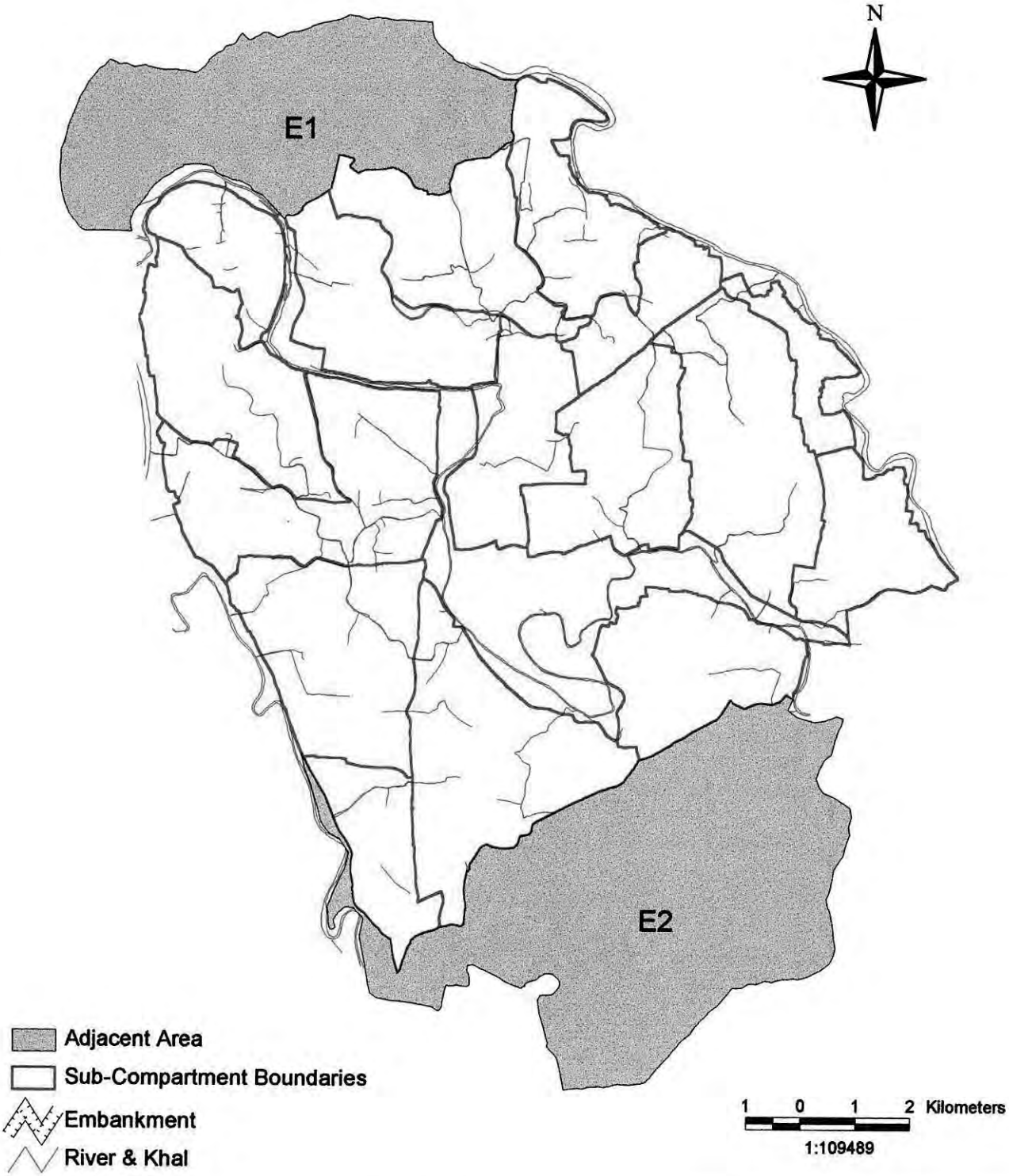


Figure 5.2 Adjacent Area

Compensatory Plan

Anticipatory planning and mitigation measures are not always sufficient to remove all the environmentally negative impacts of CPP. Even though the CPP planning is flexible some residual impacts are inherent to occur. The CPP within EMP addressees both the biophysical and socio-economic residual impacts in order to trade-off the resulting consequences to PAPs and ecosystem. Based on the principles of equity and fairness the CPP has developed the following compensatory plan.

- Compensating losses of wetland habitats (selection of two perennial beels for wetland management plan).

- Compensating loss of land due to physical interventions

Enhancement Measures

Because of flood protection, culture fisheries are proposed to be encouraged as the banks of the ponds are not overtopped. Aquaculture extension and training programmes are adopted to enhance fisheries cultivation.

5.3 Environmental Monitoring Plan

5.3.1 General

Environmental monitoring is an important management tool to monitor the changes inside and on adjacent areas compared to the pre-project situation. This will, in turn, provide guidelines to the project planners and decision makers to make necessary adjustments for reaching the overall objectives of the project.

It will provide an early warning or predictions of the significant impact deserving suitable immediate actions for sustainibility of the project. It will predict the magnitude and significance of the environmental elements both positive and negative and constantly monitor the likely changes related to structural and non- structural interventions necessary for sustainable water management.

The environmental monitoring plan comprises the following resources based activities:

- Soil fertility changes both inside and outside of the project.
- Biodiversity monitoring of ecologically sensitive habitats specially for beels and homesteads.
- Monitoring of agro-chemical use.
- Integrated pest management (IPM)
- Monitoring of groundwater table fluctuations
- Embankment plantation and social forestry.
- Monitoring of water pollution.
- Public health issues.
- Environmental education and training.

5.3.2 Soil Fertility

EIA case study CPP, Tangail indicated negative impacts on soil fertility and soil moisture status within the project because embankment will impede flood water entering the compartment thus reducing depth, duration and frequency of flooding. This will reduce the deposition of fresh river-borne sediments.

Continuous monitoring of river-borne sedimentation at 15 sites in and outside CPP and annual monitoring of soil fertility at 20 intensively cultivated location both inside and outside, are being carried out. The collaborating agencies are SRDI, BINA-Mymensigh and ICDDR, B. This programme starts in the month of February 1997 and will continue up to 2000. But in 1996 soil properties like soil profile, texture, PH value, nitrogen, phosphorous, potassium, zinc, sulfur, boron, organic matter, pesticide residues etc. were tested and are stored in CPP Environmental data base files.

5.3.3 Bio-diversity

The bio diversity monitoring programme has been initiated in sub compartment –10 (Baria beel) with the neighboring village and in sub-compartment–14 along with the adjacent home stead. The activities consist of ecological description of floras and fauna in the site including common, rare, endangered and threatened species together with its social and economic values. The Programme has started since 1997 and will continue up to 2000.

5.3.4 Agro-chemical Use

Improved water management will result diversified and intensified crop production. Of late, it has been observed that intensity of pesticide use has been increased sharply because of high yielding variety of crops, changes in cropping pattern and land use, dry season irrigation facilities etc. The demand of chemical fertilizer use has been widespread. The cropping intensity of CPP will be around 220%* from 203%* in pre-project condition which means farming will be more socially acceptable and economically viable. The more is the cropping intensity more will be the use of agro-chemicals and farming will be more susceptible to agricultural pests and diseases.

High toxic and persistent agro-chemicals available even in the rural areas are very harmful. Farmers are neither aware of environment hazards and health risk associated with improper handling, storage and indiscriminate use of fertilizers/pesticides nor they have the knowledge about the harmful impacts on the non-target animals which may be predators (frogs, toads, birds etc). To maintain the ecosystem, the monitoring of agro chemical's sale, storage, handling and application of pesticides to farming is necessary. CPP has selected 15 farmers for training on the above issues and monitored the sale of pesticides by dealers, wholesale and retailers. The collaborating agency is DAE/Tangail and the environmentalist as well as the agronomist of CPP is responsible for the work.

5.3.5 Integrated Pest Management.

Out of EMP, CPP has initiated steps to promote integrated pest management activities in 1994. With collaboration of DAE/ Dhaka and Tangail, the CPP has conducted Six IPM schools (training programme for 210 farmers) and has trained 7 extension

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Source: CPP-EMP, Final Phase, February 1997

officers of DAE/Tangail. Training leaflets and video films about IPM and biological controls of pests were issued to the farmers and extension officers.

Future activities include continuation of this programme in collaboration with DAE. Every year 2-3 new IPM schools have been established and this programme will continue up to 2000. The CPP environmentalist with the assistance of agronomist and in collaboration with DAE/Tangail are imparting the on-form training on IPM to farmers.

5.3.6 Groundwater Table

Water is the most abundant resource on the earth. Its abundance makes it the commonest of substances. Bangladesh is endowed with adequate quantity of groundwater resources. Flood control, drainage and irrigation (FCDI) projects generally have impacts to reduce groundwater recharge by enhancing drainage and reduce the area, depth and duration of flooding. As groundwater is being utilized for water supply (both rural and urban) and irrigation proposes, its importance is keenly felt for integrated water management. As such observation of seasonal water table fluctuation, assessment of groundwater recharge condition and its abstraction both for domestic and agriculture use are of specific value to the CPP. With these ends in view, CPP started taking data from 17 observation wells of which 13 wells belong to DPHE and the other to BWDB. Data are available from 1987 and shown the Table 5.1 and Table 5.2. All data are stored in CPP. Despite large scale extraction of groundwater by STW/DTW's for dry season there are no complaints by farmers regarding shortage of groundwater. These indicate that there is no trend of depletion of groundwater table during April/May when the extraction is maximum.

Table 5.1 Ground Water Table Data of BWDB Wells within CPP (April-May) in metre

TW Code	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
TA-03	6.10	6.25	6.25	5.25	5.65	5.45	5.15	5.70	5.60	5.55	5.70
TA-09	5.45	5.35	5.60	4.40	4.90	4.25	3.85	3.35	5.50	5.00	5.00
TA-35	4.05	2.90	5.05	4.15	4.75	NDA	4.50	3.75	5.25	NDA	4.05
TA-39	NDA	NDA	NDA	5.35	5.50	5.85	5.50	5.30	6.20	5.80	6.60

Source : CPP, EIA, Case Study, 1992

NDA : No Data available

Table 5.2 Ground Water table data for DPHE tubewells in CPP, Tangail for the Period 1987-2000 (April/May), metre

TW Code	Village/Union/Supervisor	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
TW 1	Gala/Gala/Mohammed Ali	5.18	5.72	5.74	4.85	5.97	6.22	5.49	5.03	5.1	5.64
TW 2	Gala Bazar/Gala/Bazar Committee					5.74	5.99	5.46	5.13	5.15	5.25
TW 3	Kathuajugini/Baghil/Mohadev Howlader					5.56	5.66	4.83	5.33	5.33	5.4
TW 4	Shrifaliata/Davnna/Baghil Bazar	5.03	5.64	5.94	4.93	5.54	5.94	6.05	5.79	5.84	5.92
TW 5	Chowbaria/Davnna/Abul Hossain					5.46	5.64	5.72	5.28	5.3	5.61
TW 6	Gopalpur/Baghil/Mirza Abdul Sattar	5.26	5.44	6.02	5.05	5.64	5.69	5.64	5.69	5.71	5.92
TW 7	Kabilapara/Porabari/Abdul Hakim					5.49	5.69	5.49	5.26	5.25	5.38
TW 8	Beltasarai/Porabari/Rahim Uddin			5.79	5.11	5.49	5.64	5.49	5.33	5.35	5.48
TW 9	Baruha/Silimpur/Atowar Rahman					5.54	5.64	5.54	5.33	5.35	5.48
TW 10	Baroria/Gharinda/Johurul Haque					6.63	6.88	5.82	5.53	5.41	5.48
TW 11	Surujbazar/Gharinda/Bazar Committee	5.26	5.66	5.82	4.8	6.22	6.53	5.64	5.21	5.43	5.46
TW 12	Khudirampur/Karatia/Afaz Uddin					7.04	7.29	5.77	5.03	5.05	5.99
TW 13	Birpusia/Karatia/Gias Uddin Lebu	5.41	5.31	5.66	4.83	5.94	6.22	5.33	5.23	5.25	5.64

Source : CPP, EIA, Case Study, 1992

5.3.7 Embankment Plantation and Homestead Forestry

The project authority in collaboration with Forestry Department/Tangail and local NGOs has undertaken the above programme in order to boost up forestry and agro-forestry resources and to increase bio-diversity in homesteads regarding promotion of local species with the help of local people. The activities include identification of suitable homesteads, organization and plantation sites, distribution of seedlings to enhance floral diversity tree for fuel, timber, fodder, food, medicinal or herbal importance, training facilities on site preparation, plantation practices, protection, care taking and upkeepment of the plantations. These activities will continue up to 1999.

5.3.8 Embankment Plantation Programme

The above programme has been undertaken to provide embankment protection both for riverside and country side slopes against erosion due to rain and waves during monsoon and abnormal flooding, CPP has selected turfs like vertiver and bina, These will not only stabilize the embankment slopes but also enhance the supply of fodder besides becoming resources for farmers who will utilize them as fencing, roofing and related farm household activities. The programme already is in practice and has been found most effective in respect of preventive maintenance of embankment and is likely to continue till 2000.

5.3.9 Water Pollution Programme

The spread of infectious disease by water pollution is a well known hazard. Polluting substances in natural sources of water have their origins in a variety of places. These

sources are: natural, agricultural, municipal, industrial etc. ISPAN in 1992 (CPP, EIA case Study) indicated a high degree of pollution of surface water. Common services of pollution are human faecal and domestic wastes. Agro-chemicals, waste from cottage industries (chemical dyes used in Tangail Sarees) and other urban pollution are becoming important. It is apprehended that the movement of polluted water is greatly influenced by the CPP interventions or the controlled flooding and drainage works.

Monitoring of the spread of polluted waters and detailed knowledge about the harm likely to occur due to toxins or pathogens under flood conditions are required to establish criteria for water pollution management within the project. These criteria should recommend the possible health and environmental risks associated with polluted waters.

There are 25 observation sites for monthly measuremens. The following monitoring programme are being continued under this project:

0 7 Recreational water sites - Dhaleswari river, Lohagong river (2 spots), Rasulpur Khal, Barua Khal, Darun beel and Bara beel.

0 4 Drinking water sites: Hand operated tuwbewells.

0 4 Irrigation water wells: STWs and DTWs.

0 6 Fishing habitats: Atia beel, Jugini beel, Santash pond, Ghatakubari beel and Agbetur pond.

0 4 Hot spots in Tangail town:

Micro biological test is being carried out in the ICDDRB Laboratory, Dhaka, The following parameters are being examined in laboratories.

Recreational Water : Temperature, P^H, Ammonia COD (Chemical oxygen demand) and faecal coliform bacteria.

Drinking Water: Temperature, P^H, Ammonia, COD, Iron, electrical conductivity (EC) and faecal coliform bacteria.

Irrigation Water: Temperature, P^H, Ammonia, COD, iron and electrical conductivity (EC)

Fishing Water: Temperature P^H, Ammonia, Dissolved oxygen (DO), Ammonia, Electrical conductivity (E.C) Total hardness $CaCO_3$.

Hot Spot: Temperature, P^H, Ammonia, Dissolved oxygen (D.O), Chemical Oxygen demand (C.O.D) , faecal bacteria coliform.

The preliminary data on the above parameters are furnished in Appendix-A in Tables A.1 through A.30. "Preliminary findings indicate that serious pollution of faecal coliform (FC) bacteria occur in all open water bodies and one incidence in hand tubewell groundwater site. Ammonia pollution occurs in both open water bodies and in some groundwater at levels higher than EQS of Bangladesh. The COD is high in all open water bodies and in some groundwater. DO is within acceptable ranges for fish habitat. EC and hardness values (important parameter for fish habitat) are constantly low; pH is with in acceptable limit for human consumption although moderate alkalinity (range pH-8-9) in some water bodies may slightly affect fish. Iron content is

high (up to 12mg/l) is STWs and DTWs groundwater which is common in Bangladesh.

5.3.10 Disease Incidence Monitoring

Compartmentalization will change the flooding pattern (depth, duration, frequency) resulting positive impacts related to agricultural production which in turn improve the socio-economic conditions of the people living within the project. It was anticipated in the EIA that vector borne diseases may be increased.

Data are being collected annually from the civil Surgeon's office, Tangail. The data will be related to the number of patients enrolled in the hospital and treated for different diseases. The information will be analyzed which will indicate the disease incidence trend during the post project and pre project situation within the compartment as well as in the adjacent areas.

5.4 People's Participation

5.4.1 General

The role of people's participation in sustainable development cannot be over emphasized. The perceived needs of people should be reflected in all development initiatives. The process of people's participation recognizes a decision making process which takes into account preferences and interests of those clearly affected by a particular decisions; and finally produces decision which are not only acceptable as legitimate but are also the result of a balance between what is socially desirable, economically viable, technically and ecologically sound, legally pertinent and politically feasible.

5.4.2 Compartmentalization Pilot Project (FAP 20)

FAP 20 included the strategy of 'involving people in all phases of compartmentalization with the aim that they will operate and maintain these compartments, so as to ensure sustainable development'. Three different phases were identified for the process.

a. The Needs Assessment

This involves in identification of the existing water management related situation and the problems caused by flooding and water congestion and the finding of people's opinion on the potential structural and non-structural solution.

b. Consultation

Through consultation, determination of the option and finalization of the interventions (the different stages of the consultation process were initial meeting with interest groups, follow up meeting if required, with representatives of different interest groups and combined meeting with elected representatives, local elites and members of different interest group and concerned government and non-government agencies). The project has been divided into 17 sub-compartments including 202 villages with a total population of 2,59,019. As

many as 175 consultation meeting were conducted with the participation over eight thousand people.

c. Institutionalization

Creation of various bodies for the implementation, operation and maintenance.

Specific action of FAP 20 with regard to people's participation included the following :

- Formation of Project Council (Formed in 1996);
- Formation of Chawk Committee (80 out of 100 completed);
- Formation of Sub-compartment Water Management committee, (SWMC) (15 out of 16 completed)
- Implementation through Labour Contracting Societies (LCS);
- Embankment Maintenance Group (EMG) and Structure Maintenance Group (SMG).

5.5 Implementation Cost of EMP

The cost estimate of the EMP during period 1997 to 2000 are furnished in Table 5.3. The detail of activity in terms of co-ordination and institutional cooperation, objectives , scope of works etc. have been outlined in previous section.

Table 5.3 Cost Estimate of EMP during 1997-2000

In Thousand Taka

Description of resources management activities	1997	1998	1999	2000	Total
Monitoring of soil fertility	235	130	130	165	660
Bio diversity monitoring	115	70	70	200	455
Monitoring of agro-chemical	10	10	10	10	40
Integrated pest management (IPM)	50	50	50	20	170
Ground water monitoring	------	-----	------	40	40
Homestead forestry / embankment plantation	120	120	120	10	370
Water pollution monitoring	180	100	100	20	400
Public disease incidence monitoring	-------	-----	-----	40	40
Environmental education, training dialogue etc.	100	110	110	160	480
	810	590	590	665	2655

Chapter 6
Findings and Suggestions

6.1 General

In course of studying and evaluating the environmental aspects of CPP the author took utmost effort in reviewing the related reports and consultation to project officials including beneficiaries. The outcome of reviewing of reports and consultation was substantiated through extensive field visits.

The areas of study cover assimilating the reports, taking full idea as to the project itself, exploring the baseline situation, assessment of important environmental components and evaluating EMP. The details of the study are available in the foregoing chapters.

Field visits and discussions with project officials reveal that the full testing of compartmentalization has not been carried out and the final framework of the institution is yet be developed. However, the author, during the process of study, has come across some observations on environmental issues of CPP. This chapter deals with these findings and specific suggestions from the contributor's end.

6.2 Boatmen

a) Findings

A regulator has been constructed in CPP at Jugni over Lohagong river and it is claimed that the structure is boat- friendly. But in reality it is not. This is, because, though one of the four vents has been, with a view to make the structure boat- friendly, constructed wider in size, excessive head difference between upstream and downstream impede the passage of the boats.

As a mitigation measure, the CPP has, for the facility of movement of other traffics and the pedestrians, constructed a 3.5 km link road near Jugni. The mitigation measures obviously apply to traffic and pedestrians movement only. With this, the problem of movement of boats form Jugni regulator point to further downstream of Lohagong river has not at all been mitigated and consequently the boatmen community is financially suffering.

b) Suggestions

The CPP, in realization to the problem, should develop measures such as credit facilities/soft-loan to the boatmen so as to enable them to switchover to other professions.

6.3 Redundancy of Structures

a) Findings

The structures in CPP were claimed to be constructed on due consultation with the beneficiaries. But the fact that a good number of structures got in operative within a short period of time. This indicates that either the structures were poorly planned or the people were not duly consulted out the planning and execution stage

b) Suggestions

More care in proper planning, wide public consultation and unprejudiced decisions be undertaken in order to make execution of structures effective.

6.4 NGOs

a) Findings

The non government organization in Bangladesh have become over the years, one of the most thriving sectors particularly in the area of working with the poor. In CPP mass participation and contribution of NGOs in different fields have accelerated the project planning and execution.

b) Suggestions

NGOs should be involved extensively for training related to water management, afforestation, social forestry, group formation both for routine and preventive maintenance etc.

6.5 Environmental Issues

6.5.1 Enhancement of Environment

a) Findings

The positive environmental impacts applicable to the project are as follows:

- Reduced flooding, in terms of level, timing, rate of rise, duration and extent of floods and consequent safety to private property and crops.
- Improved soil moisture status at critical periods through reduction of wetness in the monsoon and, in some cases, to irrigation or water retention for post-monsoon and dry-season use.
- Increased employment opportunity.
- Increased land availability by reduction of wetlands.
- Expansion of Transplanted Aman HYV area from 7 (1993) to 31 (1997) percent.
- Improved opportunities for culture fisheries and increase in aquaculture production.
- Increased rice production.
- Some improvement in human health and nutrition.
- Generally favourable social attitudes to the projects, despite many complaints.
- Increase in homestead forestry due to adequate flood protection measure.
- Environmental awareness, education and training to the beneficiaries.
- Secured environment for homestead.
- Composting of water hyacinth leading to use of more natural manure.
- Construction of drain in Tangail Town that reduces environmental hazards of Tangail Town.
- Stimulating farmers' group/OFD (training and demonstration).
- EMG formations have added to the development of women.

b) Suggestions

The observed environmental enhancements in the field of reduction of flood, agriculture, employment generation, fisheries, soil, socio-economy, afforestation etc. indicate that this project is environmentally acceptable. In order to make the environmental enhancement sustainable, monitoring and evaluation of these parameters should be continuously undertaken during the project period and even in the post project situation.

6.5.2 Environmental Degradation

a) Findings

The common negative environmental impacts observed in CPP include the following:

- cumulative influences in the external areas in increasing river flows, bank erosion and bed scouring, siltation, and flooding levels;
- reduced extent of wetlands, having ecologically adverse impacts;
- decline in soil fertility due to diminished aquatic vegetation and micro-biota;
- contribution to the general decline in fish ecology and capture fisheries;
- loss of land to the extent of 147 ha to embankments and other project works, often with inadequate compensation;
- hampering of free movement of boats due to gated control structures;
- intensive rice monoculture;
- increased use of agrochemical leading to degradation of soil fertility and adverse impact on surface and sub-surface water bodies;
- growth of insects causing more injury to crops;

b) Suggestions

Inspite of the fact that the project has created some additional environmental degradation to pre-project situation, it is required that the negative inputs should also be monitored so as to ensure that the degradations are kept well within the acceptable limit. Comparison between positive and negative impacts made by the author shows that the magnitude of the benefit of positive impact is higher than that of cumulative negative impact. This balance, it is recommended, should be maintained.

6.5.3 Social Impact

a) Findings

The project has stimulated employment, in both agricultural and non-farm activities, and all interventions provide substantial employment opportunities in construction. Such employment accrues for the most part to men and (even more to) women.

The benefits from the project are not, however, evenly spread. Capture fishermen and boatmen are usually the greatest losers, while agricultural production benefits tend to accrue particularly to the larger landowners.

Land acquisition processes have been a common source of dissatisfaction during execution. The complaints generally related to the process of land acquisition and the levels of payment.

The project has exacerbated social tensions in the impacted areas between insiders and outsiders, between farmers and fishermen, between farmers and boatmen and between farmers with different size of farms. In many cases these conflicts occur annually, and local conflict resolution arrangements are clearly inadequate.

b) Suggestions

Attempts should be taken to resolve the social issues of both the advantaged and disadvantaged groups through establishment of effective water management committees.

6.5.4 Mitigation Measures

a) Findings

A mitigation plan is under execution and measures have been formulated for the following sectors:

- CPP interventions caused some adverse impact on reduction of passenger trips and goods transportation along the navigational routes. Construction of embankments and bridges, and re-sectioning of various roads have improved the internal transportation of the area.
- To improve drainage of floodwater outside the project area, the Elanjani Loop cut has been created and Gala Khal has been re-excavated. For better communication in the adjacent areas, several roads and bridges have been constructed.
- CPP has started Integrated Pest management (IPM) training schools from 1995 onwards in collaboration with DAE and Food and Agricultural Organization (FAO) to raise public environmental awareness.
- Under EMP, monitoring of river flood sediments, biological diversity in ecological sensitive habitats, soil fertility changes, ground water table fluctuation, homestead forestry, water pollution in ground water wells, ponds, khals and some beels, disease incidences etc. are being done for possible remedial actions.

Flood preparedness training and involvement of landless and destitute have been made mandatory for EMG and LCS works undertaken by CPP.

b) Suggestions

The mitigation measures already undertaken have been found fruitful and effective. It is expected that the monitoring activities will continue during the remaining period and even in the post-post situation.

6.6 Open Water Fisheries

a) Findings

Before the CPP Project (no interventions, only a peripheral embankment), around 500 tonnes of fish was produced annually in the Tangail area, out of which 59 percent came from beels and floodplains. It is observed that the professional fishermen and subsistent fishermen who had, in pre-project situation, reasonable access to open water fisheries, but due to the project this accessibility has been reduced appreciably and even in some cases it has been restricted. This situation has increasingly lowered their income and they are compelled to abandon their original profession.

Due to CPP interventions, the catch of open water fisheries has reduced. Aquaculture on the other hand, has improved a lot due to training facilities provided by CPP. Around 1800 fishpond owners, including 265 women, were trained by June 1998. The total number of ponds increased from 2953 (237ha) to 3101 (250 ha) between 1994 and 1998. The production level has increased from 1.2 to 2.7 tonnes/ha/year.

b) Suggestions

It is recommended to undertake a comprehensive survey work for assessment of the socio-economic condition of the professional and subsistent fishermen. Appropriate measures related to resettlement of the affected fishermen should be undertaken.

6.7 Groundwater Availability Monitoring

a) Findings

The importance of groundwater availability cannot be overemphasized and considering this CPP has undertaken monthly data collection of Tubewells. The data indicate that there is no fluctuation of water levels in the area though the extraction of groundwater has been increased considerably.

b) Suggestions

The process of monitoring activities with respect to ground water exploration and recharge should continue.

6.8 Agriculture

6.8.1 Cropping Pattern and Landuse

a) Findings

Landuse survey was conducted for Kharif-II season in 1993. The main objective of the survey is to obtain detailed scenario of landuse in the project area thus depicting crop production, cropping patterns, crop diversification & intensification, inundated areas, water congestion and fallow areas.

The total areas (Lohajong Flood Plain, Adjacent area) of different monsoon crops of 1993, 1995 and 1997 are shown below. The data are from CPP source.

Description of crops	Year	1993	1996	1997
T-Aman(LV)		1982	2706	2583
T-Aman(HYV)		588	1326	2634
DW-Aman		2980	1921	1682
Total Aman		5550	5953	6899
Water bodies		1747	1024	639
Upland fallow		545	929	635

Area in ha.

The recent increase in the area under HYV T. aman varieties is spectacular from 1982 ha to 2583 ha and so is the increase of total t. aman area in lieu of DW-aman and water bodies.

Agriculture in the project area is obviously, dominated by rice crops. Due to CPP interventions, land use has changed in monsoon season as follows:

Crops	**1993 (base year)**	**1997**	**Increase/Decrease**
Transplanted Aman (HYV)	7%	31%	(+) 24%
Transplanted Aman (Local)	23%	30%	(+) 7%
Deep Water Aman	34%	20%	(-) 14%
Sugarcane	9%	5%	(-) 4%
Fallow	27%	14%	(-) 13%

b) Suggestions

The cropping pattern and land use in the project area have changed positively contributing to net agricultural production. Care should be taken to monitor that this increased production does not cause any environmental imbalance with respect to land use.

6.8.2 Irrigation

a) Findings

Due to the project the following benefits with respect to irrigation have resulted in.

- boro rice in lower areas is protected from damage caused by early rain either at the maturing stage or at the harvesting time.
- decrease of flooding depth as well as frequency of occurrence on cultivated land thus making more favorable conditions for planting and transplanting the kharif amon crop which results in increased production during the monsoon season in CPP; and
- early evacuation of water in October/November allows farmers to grow one early rabi crop like mustard, potatoes etc. before plantation of boro rice.

The number of different types of equipment for the year 1993, 1995 and 1997 is shown below:

Equipment	1993	1995	1997
STW	774	619	881
DTW	78	85	81
LLP	3	4	2
Traditional	1	1	1
Total	855	708	964

The area-wise irrigation achievement is furnished below:

NCA	1991		1995		1997	
	ha	% of NCA	ha	% of NCA	ha	% of NCA
8595 ha	3962	46	3681	43	4465	52

b) Suggestions

The gradual increase in number of STWs and DTWs and irrigation area may change water quality and soil fertility adversely. This should be monitored.

6.9 Pesticides

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a) Findings

Pesticides are extensively used for crops' pest control mainly for boro and irrigation. Pesticides are toxic to frogs, spiders, earth worms and few other kinds of species. The long term ecological effect of insecticide application has not been studied and could be potentially significant.

b) Suggestions

It is recommended that the effect should be studied thoroughly and to be monitored not only during the project but also after the end of the project period i.e. after June 2000.

6.10 Project Externalities

6.10.1 Dhaleswari Closure

a) Findings

The Dhaleswari river is the main source of water for a large area approximately 65,000 ha including the project. After the closure of Dhaleswari in 1994, for the construction of Jamuna bridge, the supply of water to Dhaleswari and Pungli rivers become uncertain and the required water levels as well as discharge would certainly not been reached. A link canal was proposed as an alternative.

At the beginning of 1996, the JMBA carried out some dredging work in spill channel to bring the level to 9.00 m PWD. In 1996, when the project was preparing for operating and testing the water management system, the supply of

water from Dhaleswari was again threatened because of putting earthen cross bund by the people living adjacent to the area. With the rising of water, the earthen cross bund was completely washed away, as a result, water level in rivers and khals in and around Tangail Compartment have been restored fully.

b) Suggestions

As such it is recommended that the channel has to be further monitored and stabilized to prevent siltation and / or runaway river bank erosion in future failing which the existence of the whole project will be at stake.

6.10.2 Replicability of Compartmentalization in the National Level

a) Findings

"Living with floods" is more traditional way of dealing with floods whereas **"Controlled flooding", "Controlled drainage"** and **"Water management"** are also tools for water resources planning and development. Hence the concept "Compartmentalization" crept in.

To overcome the damage caused due to severe flooding along the major rivers of Bangladesh, it was realised that "series of compartments" could be developed over the flood prone zones in the respective flood plain of the individual river. Such compartments would contribute reduction of flooding by

- Slowing down the runoff
- Letting in water of the attuned peaks likely to exceed optimum levels.

Has it ever been tested in FAP 20, Tangail? The reply is a great "No". Surely, it would be never possible as the people within the compartment would not allow any storage beyond their requirements or for no immediate benefit. How many of these compartments would be needed to have an noticeable impact on the peaks of major rivers like the Dhaleswari or the Jamuna? The CPP cannot answer this question at the moment and will never be able to say in the coming years. As such the concept of compartmentalization is at stake.

b) Suggestions

The project is still ongoing. Unless the same is complete and tested fully with respect to the projected benefits, the replicability of the project at the national level cannot be meaningfully ascertained.

Chapter 7
Conclusion and Recommendations

7.1 Conclusion

1 In achieving controlled flooding and drainage in the CPP area, the compartmentalization concept is found to be partially effective. Full effectiveness could not be achieved due to inadequate institutional arrangements and non -completion of drainage facilities which could not be executed mainly due to land acquisition problem. CPP being a pilot project, full development of the concept in respect of controlled flooding and drainage could not be possible at this stage. This is a process and full achievement is time dependent. But it is encouraging to observe that the beneficiaries' response towards the project is positive.

2. The study on evaluation of environment impacts of the project reveals that environmental and social benefits are greater in magnitude than disbenefits. The usual negative impacts of a flood control project could not be eliminated by controlled flooding.

3. Different mitigation measures have been adopted for elimination and reduction of adverse environmental impacts due to implementation of CPP. The assessment of effectiveness of the measures so adopted could not be made fully because of the fact that the results of the measures are yet to be accrued.

4. Peoples' attitude, acceptability and participation towards implementation, operation and maintenance of the project are favourable. Chawk Water Management Committee (ChWMC) and Sub-compartment Water Management Committee (SCWMC) have already been formed and they have been working for last two years on minor works. The quality of the works undertaken by SCWMC is satisfactory. This indicates that the committees would be in a position to carry out the O&M of minors works even after the completion of the project. As such it can be inferred that stakeholders attitude and acceptability towards O&M are also favourable.

5. The study reveals that the conflict between farmers and fishermen, conflict between low and high land farmers have not been resolved. So long as the compartment level committee is not in place and functional, it is premature to conclude to what extent the projects concept is applicable in sustainable water management in this country.

7.2 Recommendations for Further Study

The present study by no means can be considered as a comprehensive and complete one covering all environmental aspects of the project. There are some areas requiring further study. The details of the requirement of the further study are furnished below:

- The study shows that open water fishery in the project area has been declined appreciably due to the project. Further study should be carried out to identify the reasons for such declination of open water fisheries and find appropriate measures for improvement.

- In the case of mitigating measures which are found to be less or in effective in mitigating adverse environmental impacts, further study should be carried out to devise proper and effective solutions.

- If is apprehended that due the project, soil fertility will decrease. At present monitoring of the same is going on without any clear result. Further study should be carried out in this area.

- The use of agrochemical has been increased substantially leading to possible adverse effects on soil and water quality. Further study in monitoring the situation and suggesting appropriate mitigating measures is recommended.

Appendix-A

Water Pollution Monitoring Data

WATER POLLUTION MONITORING DATA FOR THE SELECTED LOCATIONS OF TANGAIL CPP

A.1 : Temperature of Recreational Waters (River/Khal/Beel), °C

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Lohajang River	8	X	X	25.0	29.0	31.0	29.0	30.0	27.0	18.0	18.0	25.0	X	29.0	32.0	29.0	24.0	31.0	X	29.0	21.8	15.0	16.2	21.2	26.0	26.5	29.5	30.1			
Lohajang River	15	29.5	29.0	26.0	29.0	30.0	29.0	26.0	24.0	21.0	20.0	22.0	X	29.0	34.0	23.0	25.0	32.0	X	29.0	23.0	21.2	19.0	21.0	24.5	24.8	27.0	29.8			
Bara Beel	6	33.0	28.0	26.0	30.0	32.0	31.0	32.0	26.0	17.0	19.0	25.0	X	27.0	33.0	30.0	24.0	34.0	X	30.0	20.5	23.2	17.2	25.0	25.5	27.0	27.0	30.0			
Baruha Khal	10	X	X	27.0	27.0	31.0	27.0	26.0	24.0	18.0	19.0	21.0	X	28.0	33.0	24.0	25.0	32.0	X	26.5	19.5	16.0	14.5	18.5	23.0	26.5	30.5	29.5			
Atia Kumari Beel	11	33.0	31.0	27.0	29.0	32.0	29.0	29.0	27.0	19.0	19.0	21.0	X	30.0	32.0	23.0	26.0	32.0	X	29.0	22.0	19.0	15.5	17.0	25.0	25.0	27.0	29.5			
Tangail Khal	13	29.0	28.0	25.0	28.0	29.0	28.0	28.0	23.0	18.0	16.0	22.0	X	33.0	29.0	23.0	25.0	31.0	X	29.0	21.5	20.0	16.2	18.0	X	X	X	X			
Darun Beel	2	28.0	28.0	26.0	28.0	30.0	28.0	29.0	26.0	21.0	18.0	21.0	X	35.0	36.0	23.0	25.0	33.0	X	28.7	22.0	19.5	16.0	20.5	24.0	26.0	27.0	29.5			
Rasulpur Khal	3	X	X	25.0	28.0	30.0	28.0	28.0	26.0	21.0	19.0	26.5	X	34.0	31.0	30.0	26.0	34.0	X	29.6	22.8	22.0	17.0	23.0	29.0	28.0	31.5	29.3			

Location/ Source	Site Code	1997			1998												1999											2000		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Lohajang River	8		26.5	18.0	18.0																										
Lohajang River	15		28.0	17.0	18.0																										
Bara Beel	6		28.0	19.0	19.0																										
Baruha Khal	10		25.0	17.0	17.0																										
Atia Kumari Beel	11		26.0	19.0	17.0																										
Tangail Khal	13		X	X	X																										
Darun Beel	2		24.0	17.0	17.0																										
Rasulpur Khal	3		24.0	16.0	17.0																										

Note: Recreational Water Quality Standard for Bangladesh 20°C-30°C

A.2 : pH of Recreational Waters (River/Khal/Beel)

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Lohajang River	8	X	X	8.3	8.0	8.0	8.3	8.1	8.5	8.6	9.0	8.5	X	8.3	8.2	9.3	6.8	9.4	X	8.0	8.0	8.3	8.5	8.0	8.5	8.5	8.2	8.0	8.5	7.9	
Lohajang River	15	7.9	8.0	7.8	7.5	7.4	7.9	7.8	8.0	8.1	8.1	8.0	X	8.2	8.3	7.7	7.8	7.8	X	7.8	7.5	7.8	7.5	7.5	7.5	7.5	7.5	8.5	8.5	8.0	
Bara Beel	6	8.2	8.0	7.4	8.0	7.5	9.3	9.5	8.6	8.3	8.3	9.0	X	7.7	8.6	8.5	10.2	8.7	X	7.8	8.2	8.6	9.0	8.0	7.2	7.3	7.8	8.0	7.0	7.3	
Baruha Khal	10	X	X	7.3	7.7	8.3	7.6	7.3	8.2	8.0	8.5	8.4	X	8.7	9.5	8.0	8.6	8.1	X	6.4	7.3	7.5	7.7	7.5	8.2	8.5	8.8	7.2	7.5	7.3	
Atia Kumari Beel	11	7.5	7.2	7.4	7.7	7.3	7.5	8.1	8.0	8.1	8.5	8.3	X	8.1	7.0	8.0	8.0	8.2	X	7.2	7.0	7.2	7.0	6.7	7.0	7.0	6.8	7.0	7.5	7.8	
Tangail Khal	13	8.4	8.3	7.8	8.0	7.7	7.8	7.8	7.8	7.7	7.6	7.8	X	8.2	7.6	7.6	7.1	7.5	X	7.9	8.0	8.5	8.0	7.8	X	X	X	X	X	X	
Darun Beel	2	7.7	7.2	7.0	7.5	7.3	7.5	7.7	7.2	8.2	8.0	7.8	X	8.3	8.3	7.6	6.9	7.9	X	7.0	7.0	7.3	7.5	8.0	7.5	7.5	7.2	7.2	7.7	8.6	
Rasulpur Khal	3	X	X	7.4	7.8	7.5	7.5	7.5	8.3	8.6	8.4	8.4	X	8.4	9.7	9.0	7.2	8.7	X	7.4	7.5	8.1	7.8	7.8	8.0	7.5	8.5	8.5	8.0	7.8	

Source: CPP-EMP Final Phase, February 1997

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Lohajang River	8		7.4	8.2	8.1																										
Lohajang River	15		7.0	7.3	7.4																										
Bara Beel	6		7.8	7.8	7.5																										
Baruha Khal	10		7.5	7.3	7.4																										
Atia Kumari Beel	11		7.1	7.1	7.2																										
Tangail Khal	13		X	X	X																										
Darun Beel	2		7.1	7.3	7.2																										
Rasulpur Khal	3		8.0	8.2	8.2																										

Note: Recreational Water Quality Standard for Bangladesh 6.0-9.5

A.3 : Ammonia in Recreational Waters (River/Khal/Beel), mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Lohajang River	8	X	X	0.5	2.9	0.8	0.7	0.6	0.5	0.5	0.5	0.5	X	9.6	2.2	0.7	0.6	0.7	X	0.6	0.4	0.8	1.0	1.6	11.2	8.0	7.2	1.2	1.3	1.4	
Lohajang River	15	0.2	1.9	1.0	0.5	0.8	1.0	0.7	0.5	1.2	0.5	0.5	X	0.5	0.6	0.7	0.7	0.5	X	0.6	1.1	0.8	1.2	0.8	1.0	1.2	0.9	1.1	1.4	1.1	
Bara Beel	6	0.6	1.2	0.7	1.2	0.8	0.4	0.6	0.5	1.9	1.2	1.4	X	0.5	0.5	0.9	0.8	0.7	X	1.0	0.7	1.3	1.4	0.9	1.2	1.1	1.4	1.4	1.5	0.9	
Baruha Khal	10	X	X	1.6	0.6	0.6	0.7	0.8	0.8	0.8	0.5	0.6	X	6.7	1.2	0.9	0.8	1.0	X	1.6	1.3	0.6	1.3	1.8	15.0	11.2	4.8	1.6	1.6	2.4	
Atia Kumari Beel	11	0.5	0.6	1.1	0.5	0.7	0.6	0.5	0.6	1.0	0.7	0.5	X	0.6	1.0	0.5	0.8	0.6	X	0.6	0.7	0.5	0.5	1.2	1.0	1.2	1.5	1.3	1.5	1.3	
Tangail Khal	13	7.1	7.0	9.6	10.2	9.6	10.2	10.3	9.6	2.3	0.7	0.6	X	10.2	0.5	44.0	17.0	15.6	X	16.0	10.6	30.0	48.0	70.0	ND	ND	X	X	X	X	
Darun Beel	2	0.5	1.1	1.4	0.9	0.7	1.4	1.0	1.0	0.6	3.4	2.1	X	0.7	0.5	0.6	0.5	0.5	X	1.0	0.8	0.7	0.7	0.6	1.1	1.2	0.9	1.8	1.5	1.8	
Rasulpur Khal	3	X	X	0.6	0.5	0.9	1.2	0.8	0.7	0.5	0.7	0.6	X	1.0	0.6	0.7	0.7	0.6	X	0.6	0.6	1.4	1.5	2.0	7.5	2.4	1.0	1.0	1.6	1.1	

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Lohajang River	8		0.6	0.6																											
Lohajang River	15		0.6	0.8																											
Bara Beel	6		0.4	1.6																											
Baruha Khal	10		0.1	1.2																											
Atia Kumari Beel	11		0.4	0.6																											
Tangail Khal	13		X	X																											
Darun Beel	2		1.0	3.0																											
Rasulpur Khal	3		1.2	1.4																											

Note: Recreational Water Quality Standard for Bangladesh 2.0mg/L.

A.4 : Chemical Oxygen Demand (COD) in Recreational Waters (River/Khal/Beel), mg/L

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Lohajang River	8	X	X	10	8	10	13	2	4	5	10	15	X	10	5	16	35	35	X	38	2	6	8	30	33	41	18	41	2.4	X	
Lohajang River	15	18	18	12	10	9	4	52	45	10	40	30	X	39	10	2	21	12	X	29	6	6	2	32	15	9	16	22	6.0	X	
Bara Beel	6	8	10	20	12	22	40	60	30	30	28	30	X	29	54	12	32	70	X	43	28	24	26	36	32	9	10	18	184	X	
Baruha Khal	10	X	X	20	22	12	52	60	70	32	50	65	X	74	49	55	23	13	X	195	26	27	60	76		139	150	60	24.0	X	
Atia Kumari Beel	11	60	50	18	20	15	12	20	22	30	28	30	X	15	5	8	18	55	X	24	10	8	7	12	21	29	32	42	13.6	X	
Tangail Khal	13	150	50	35	120	50	30	20	30	30	10	15	X	20	59	31	59	86	X	35	26	35	48	51	ND	ND	X	X	X	X	
Darun Beel	2	29	10	12	20	30	40	15	68	20	20	15	X	39	30	7	59	22	X	34	11	7	12	16	25	10	13	11	5.6	X	
Rasulpur Khal	3	X	X	18	18	16	20	5	20	30	14	18	X	29	50	6	41	13	X	35	13	10	12	35	48	24	45	24	9.2	X	

Location/ Source	Site Code	1997			1998												1999												2000		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Lohajang River	8																														
Lohajang River	15																														
Bara Beel	6																														
Baruha Khal	10																														
Atia Kumari Beel	11																														
Tangail Khal	13																														
Darun Beel	2																														
Rasulpur Khal	3																														

Note: Recreational Water Quality Standard for Bangladesh 4.0 mg/L

A.5 : Iron in Recreational Waters (River/Khal/Beel), mg/L

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Tangail Khal	13	3.0	2.0	2.0	4.0	3.5	3.0	2.4	3.0	4.0	3.5	4.5	X	4.0	5.0	4.0	3.5	3.5	X	0.25	0.30	0.15	0.30	0.20	X	X	X	X	X	X	X

Location/ Source	Site Code	1997			1998												1999												2000		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Tangail Khal	13	X	X	X	X																										

Note: Recreational Water Quality Standard for Bangladesh NYS

A.6 : Zinc in Recreational Waters (River/Khal/Beel), mg/L

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Lohajang River	8	X	X	0.16	0.18	0.10	0.9	0.3	0.1	0.8	0.6	0.5	X	0.05	0.04	0.03	0.09	0.04	X	0.06	X	X	X	X	X	X	X	X	X	X	
Lohajang River	15	0.05	0.00	0.15	0.8	0.9	0.1	0.4	0.2	0.9	0.8	0.6	X	0.07	0.08	0.05	0.05	0.05		0.18											
Atia Kumari Beel	11	0.08	0.06	0.03	0.3	0.13	0.14	0.8	0.6	0.7	0.5	0.6	X	0.04	0.05	0.04	0.04	0.05		0.15											
Darun Beel	2	0.15	0.12	0.00	0.0	0.9	0.8	0.6	0.4	0.6	0.4	0.2	X	0.03	0.02	0.02	0.05	0.03		0.23											

Location/ Source	Site Code	1997			1998												1999												2000		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Lohajang River	8	X	X	X	X																										
Lohajang River	15																														
Atia Kumari Beel	11																														
Darun Beel	2																														

Note: Recreational Water Quality Standard for Bangladesh NYS

A.7: Faecal Coliform Bacteria in Recreational Waters (River/Khal/Beel), 1000 per 100 ml sample

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Lohajang River	8	X	X	6	5	6	3	0.27	0.8	4.6	0.1	0.5	X	14	5	3	2.4	1	X	2.8	0.2	1.7	0.8	1.4	4.9	28.0	22.0	11.0	9.0	1.1	
Lohajang River	15	28	16	26	5	14	20	4	3.1	1.4	0.7	0.2	X	35	2	1	4.6	11	X	1.8	4.0	2.6	1.5	0.2	1.4	15.0	24.0	15.0	8.0	0.5	
Baruha Khal	10	X	X	220	1,040	2	43	6	11	2.2	12.9	9	X	40	10	48	5.0	6	X	8.8	0.8	1.7	14.0	8.0	47.0	117.0	###	105	51.0	11.0	
Atia Kumari Beel	11	1	1	5	3	7	6	1	1.9	2.8	1.2	7.1	X	2.7	2	13	28	0.01	X	4.5	0.1	2.1	0.1	0.85	5.6	19.0	32.0	5.0	24.0	5.0	
Tangail Khal	13	25	120	260	30	15	1,000	10	2	0.7	4.2	3.5	X	65	10	32	51	2	X	24	2.0	3.0	6.9	###	X	X	X	X	X	X	
Darun Beel	2	1	4	34	2	2	1	2	3.8	0.5	0.4	1	X	4	4	7	2.0	4	X	5.3	0.5	0.5	1.0	0.2	0.3	4.7	5.0	0.8	4.2	0.1	
Rasulpur Khal	3	X	X	30	0.8	2	17	7	0.12	1.7	0.3	0.7	X	10.5	30	0.13	9.0	1	X	0.2	0.2	0.9	0.1	0.5	4.8	20.0	14.0	1.0	4.4	0.1	

Location/ Source	Site Code	1997			1998												1999												2000		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Lohajang River	8		0.9	0.42																											
Lohajang River	15		7.0	1.0																											
Bara Beel	6		X	X																											
Baruha Khal	10		11.0	1.0																											
Atia Kumari Beel	11		21.0	0.43																											
Tangail Khal	13		X	X																											
Darun Beel	2		2.0	0.3																											
Rasulpur Khal	3		0.5	0.3																											

Note: Recreational Water Quality Standard for Bangladesh NYS

A.8 : Temperature of Drinking Waters, °C

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Hand Tubewell	7	25.2	26.0	25.0	27.0	28.0	25.0	26.0	24.0	23.0	20.0	22.0	X	26.0	27.0	25.0	18.0	27.0	X	26	24.5	15.6	22.0	24.0	24.0	26.0	25.8	27.0	X	X	
Hand Tubewell	14	24.0	26.0	25.0	25.0	26.0	25.0	24.0	23.0	22.0	20.0	23.0	X	25.0	27.0	19.0	13.0	27.0	X	26	24.0	24.0	24.0	24.0	24.8	24.0	25.0	26.1	X	X	

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	7		26.0	23.0	22.0																										
Hand Tubewell	14		26.0	22.0	22.0																										

Note: Drinking Water Quality Standard for Bangladesh 20°C-30°C

A.9 : pH of Temperature of Drinking Waters

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Hand Tubewell	7	6.8	7.0	7.0	7.0	7.0	7.2	7.3	7.3	7.4	7.4	7.4	X	7.2	7.4	7.5	9.2	7.8	X	6.9	6.8	7.0	7.0	7.0	7.0	7.2	7.0	7.0	7.0	7.0	
Hand Tubewell	14	7.3	7.0	7.2	7.2	6.8	7.2	7.3	7.4	7.4	7.5	7.4	X	7.3	7.4	7.4	7.1	7.5	X	6.8	6.8	7.1	7.0	7.0	7.0	8.4	7.0	7.0	7.0	7.0	

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	7		6.7	6.7	6.7																										
Hand Tubewell	14		6.7	6.6	6.6																										

Note: Drinking Water Quality Standard for Bangladesh 6.5-8.5

A.10 : Electrical Conductivity (EC) in Drinking Waters, mS/cm

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Hand Tubewell	7	440	460	460	450	440	430	450	440	450	420	420	X	420	390	450	420	450	X	430	410	###	420	470	###	490	420	410	410	450	X
Hand Tubewell	14	460	480	450	470	480	490	470	450	420	420	430	X	420	420	410	430	380	X	390	350	###	360	350	###	380	380	370	370	390	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	7	X	460	450	440																										
Hand Tubewell	14	X	300	480	410																										

Note: Drinking Water Quality Standard for Bangladesh NHY

A.11 : Ammonia in Drinking Waters, mg/L

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Hand Tubewell	7	1.5	2.0	1.7	1.9	1.9	1.9	1.9	1.8	2.2	1.9	2.0	X	1.2	1.9	1.8	1.8	1.7	X	1.4	1.6	1.3	7.0	5.6	7.0	8.0	6.4	5.0	7.7	6.5	
Hand Tubewell	14	2.4	4.2	2.4	2.0	3.6	2.6	3.2	2.8	3.1	2.6	2.4	X	6.0	3.0	2.2	2.2	3.4	X	3.5	3.0	3.2	3.0	6.4	6.0	11.0	6.0	4.0	7.8	7.2	

Location/ Source	Site Code	1997			1998												1999												2000		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	7		1.6	1.4	1.2																										
Hand Tubewell	14		3.2	3.0	3.8																										

Note: Drinking Water Quality Standard for Bangladesh 0.5 mg/L.

A.12 : Iron in Drinking Waters, mg/L

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Hand Tubewell	7	5.0	8.0	7.0	8.5	9.0	8.5	8.0	6.0	7.0	7.0	7.0	X	6.5	7.0	6.0	7.0	7.0	X	7.2	4.0	7.0	16.0	9.0	15.0	9.0	15.0	X	X	X	X
Hand Tubewell	14	6.0	10.0	11.0	11.0	12.0	11.0	12.2	11.0	10.0	11.0	10.0	X	12.0	11.0	12.0	11.0	11.0	X	10.5	7.5	10.0	15.0	34.5	15.0	16.0	15.0	X	X	X	X

Location/ Source	Site Code	1997			1998												1999												2000		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	7		16.0	15.0	10.0																										
Hand Tubewell	14		20.0	16.0	15.0																										

Note: Drinking Water Quality Standard for Bangladesh 0.3 mg/L-1.0 mg/L.

A.13 : Chemical Oxygen Demand (COD) in Drinking Waters, mg/L

Location/ Source	Site Code	1995									1996												1997								
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Hand Tubewell	7	15	20	9	10	10	20	20	65	10	10	12	X	3	10	8	47	28	X	19	18	2	0.8	8.0	0.0	2.0	2.4	0.4	0.0	X	
Hand Tubewell	14	26	5	10	10	20	10	10	10	28	10	12	X	5	5	2	15	50	X	14	8	4	1.6	4.0	1.0	3.6	4.4	0.0	0.0	X	

Location/ Source	Site Code	1997			1998												1999												2000		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	7																														
Hand Tubewell	14																														

Note: Drinking Water Quality Standard for Bangladesh 4.0 mg/L.

A.14 : Faecal Coliform Bacteria in Drinking Waters, 1000 per 100 ml sample

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Hand Tubewell	7	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0.003	0.002	0	X	0	0	0	0	0	0	0	0	0	0	0	X
Hand Tubewell	14	0	0	0	0	0	0	0	0	0	0	0	X	0	0.05	0	0	0	X	0	0	0	0	0	0	0	###[	0	0.29	0	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	7	X	0	0																											
Hand Tubewell	14	X	0	0																											

Note: Drinking Water Quality Standard for Bangladesh 0 per 100 ml sample

A.15 : Temperature of Irrigation Waters, °C

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Shallow Tubewell	4	25.5	X	X	X	X	X	X	X	X	X	X	X	28.0	X	X	X	X	X	X	X	X	X	25.0	25.3	ND	X	X	X	X	X
Deep Tubewell	1	26.0	X	X	X	X	X	X	X	X	22.0	24.0	X	28.0	X	X	X	X	X	X	X	X	X	X	26.0	ND	X	X	X	X	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Shallow Tubewell	4	X	X	X	X																										
Deep Tubewell	1	X	X	X	X																										

Note: Drinking Water Quality Standard for Bangladesh 20°C-30°C

A.16 : pH of Irrigation Waters

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Shallow Tubewell	4	7.3	X	X	X	X	X	X	X	X	X	X	X	7.7	X	X	X	X	X	X	X	X	X	7.2	7.3	X	X	X	X	X	X
Deep Tubewell	1	7.2	X	X	X	X	X	X	X	X	8.2	7.5	X	7.6	X	X	X	X	X	X	X	X	X	X	7.2	X	X	X	X	X	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	4	X	X	X	X																										
Hand Tubewell	1	X	X	X	X																										

Note: Drinking Water Quality Standard for Bangladesh 6.0-8.5

A.17: Electrical Conductivity (EC) in Irrigation Waters, mS/cm

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Shallow Tubewell	4	470	X	X	X	X	X	X	X	X	X	X	X	420	X	X	X	X	X	X	X	X	X	420	###	X	X	X	X	X	X
Deep Tubewell	1	440	X	X	X	X	X	X	X	X	410	430	X	380	X	X	X	X	X	X	X	X	X	X	###	X	X	X	X	X	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	4	X	X	X	X																										
Hand Tubewell	1	X	X	X	X																										

Note: Drinking Water Quality Standard for Bangladesh 750 mS/cm

A.18 : Iron in Irrigation Waters, mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Shallow Tubewell	4	2.5	X	X	X	X	X	X	X	X	X	X	X	5.0	X	X	X	X	X	X	X	X	X	14	9.0	X			X	X	X
Deep Tubewell	1	8.0	X	X	X	X	X	X	X	X	9.0	8.0	X	8.0	X	X	X	X	X	X	X	X	X	X	12.0	X			X	X	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	4	X	X	X	X																										
Hand Tubewell	1	X	X	X	X																										

Note: Drinking Water Quality Standard for Bangladesh NYS

A.19 : Chemical Oxygen Demand (COD) in Irrigation Waters, mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Shallow Tubewell	4	20	X	X	X	X	X	X	X	X	X	X	X	20	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Deep Tubewell	1	10	X	X	X	X	X	X	X	X	32	32	X	29	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Hand Tubewell	4	X	X	X	X																										
Hand Tubewell	1	X	X	X	X																										

Note: Drinking Water Quality Standard for Bangladesh NYS

A.20 : Temperature of Fishing Waters (Beel and Dighi),°C

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Jugini Beel	5	33.5	29.0	26.0	30.0	33.0	31.0	30.0	27.0	19.0	19.0	28.0	X	29.0	32.0	30.0	24.0	32.0	X	30.5	22.0	22.8	17.5	24.8	29.0	27.2	28.0	30.5	X	X	X
Santosh Dighi	9	33.5	31.0	26.0	31.0	31.0	30.0	29.0	27.0	21.0	21.0	25.0	X	30.0	33.0	29.0	26.0	30.0	X	32.0	19.2	22.6	19.0	26.0	28.5	29.2	30.0	31.0	X	X	X

Location/	Site	1997			1998												1999											2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Jugini Beel	5	X	28.5	21.0	19.0																										
Santosh Dighi	9	X	27.0	19.0	18.0																										

Note: Drinking Water Quality Standard for Bangladesh 20°C-30°C

A.21 : pH of Fishing Waters (Beel and Dighi)

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Jugini Beel	5	8.0	7.5	7.5	7.5	7.5	8.2	8.2	8.0	8.1	8.3	8.6	X	9.4	9.1	9.4	10.5	9.2	X	8.3	8.3	9	8.5	8.5	9	9.4	8.0	8.0	8.5	8.0	X
Santosh Dighi	9	8.3	7.8	7.2	8.0	7.2	7.6	7.9	8.4	8.2	8.7	9.2	X	8.4	8.3	8.7	8.4	8.5	X	8.4	8.1	9	8.5	8.7	9	8.3	9.2	8.5	9.0	X	X

Location/	Site	1997			1998												1999											2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Jugini Beel	5		8.6	8.2																											
Santosh Dighi	9		7.8	7.5																											

Note: Fishing Water Quality Standard for Bangladesh 6.5-8.5

A.22 : Dissolved Oxygen (DO) in Fishing Waters (Beel and Dighi), mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Jugini Beel	5	8.6	8.5	9.0	9.0	10.0	9.0	9.0	9.0	9.7	9.5	9.9	X	10.2	10.0	9.8	9.9	9.1	X	9.0	X	13.9	11.4	10.6	9.1	8.5	7.9	X	X	X	X
Santosh Dighi	9	9.1	9.0	9.0	8.5	8.5	9.0	9.0	9.5	9.7	9.6	9.9	X	9.7	10.0	10.1	9.9	10.0	X	8.1	X	13.1	11.1	10.1	8.7	8.1	7.3	X	X		

Location/	Site	1997			1998												1999											2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Jugini Beel	5	X	8.0	6.0	5.0																										
Santosh Dighi	9		4.0	4.0	4.0																										

Note: Fishing Water Quality Standard for Bangladesh 4 mg/L-6 mg/L

A.23: Total Hardness (CaCO3) in Fishing Waters (Beel and Dighi), mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Jugini Beel	5	68.4	68.4	51.3	68.4	85.5	102	85.5	68.4	85.5	85.5	85.5	X	102	85.5	68.4	68.4	68.4	X	68.0	68.0	51.3	51.3	68.4	68.4	51.3	51.3	51.3	51.3	51.3	X
Santosh Dighi	9	51.3	34.2	34.2	51.3	68.4	68.4	68.4	51.3	68.4	68.4	68.4	X	51.3	68.4	51.3	51.3	68.4	X	68.0	68.0	68.0	68.4	68.4	68.4	68.4	68.4	68.4	68.4		X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Jugini Beel	5	X	68.4	51.3	85.5																										
Santosh Dighi	9	X	68.4	68.4	102.6																										

Note: Fishing Water Quality Standard for Bangladesh 80 mg/L-120 mg/L

A.24 : Ammonia in Fishing Waters (Beel and Dighi), mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Jugini Beel	5	1.2	1.7	2.1	1.5	0.4	1.0	0.7	1.1	1.0	1.4	1.7	X	2.2	0.2	0.3	1.5	0.5	X	0.7	0.6	1.2	1.6	1.4	2.5	1.8	1.8	2.2	2	1	X
Santosh Dighi	9	0.2	0.7	1.1	0.8	0.1	0.5	0.4	0.6	0.5	0.6	0.7	X	0.5	0.5	1.0	1.0	1.0	X	0.5	0.5	1.4	1.2	1.4	1.1	1.5	0.6	0.5	1	X	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Jugini Beel	5	X	0.2	1.0	1.2																										
Santosh Dighi	9	X	0.2	1.0	0.8																										

Note: Fishing Water Quality Standard for Bangladesh 0.075 mg/L

A.25 : Electrical Conductivity (EC) in Fishing Waters (Beel and Dighi), mS/cm

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Jugini Beel	5	230	230	230	160	180	200	200	210	190	200	200	X	240	190	290	170	240	X	220	190	###	150	170	###	160	230	160	120	150	X
Santosh Dighi	9	120	130	120	150	140	160	160	160	150	150	180	X	160	140	190	190	190	X	220	170	###	200	210	###	230	220	220	230	X	X

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Jugini Beel	5	X	170	150	180																										
Santosh Dighi	9	X	170	160	230																										

Note: Fishing Water Quality Standard for Bangladesh 800 mS/cm-1000 mS/cm

A.26 : Temperature in Industrial Effluent Water (Handloom Waste),°C

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Handloom Factory	12A	X	29.0	25.0	30.0	28.0	25.0	25.0	21.0	17.0	X	X	X	X	X	X	X	X													
Handloom Factory	12B	X	25.0	26.5	29.0	28.0	33.0	29.0	21.0	X	X	X	X	X	X	X	X	X													

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Handloom Factory	12A																														
Handloom Factory	12B																														

Note: Industrial Effluent Quality Standard for Bangladesh 6.0-9.0

A.27 : pH of Industrial Effluent Water (Handloom Waste)

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Handloom Factory	12A	X	8.3	7.5	8.5	9.5	8.5	8.8	8.2	9.0	X	X	X	X	X	X	X	X													
Handloom Factory	12B	X	8.2	8.5	8.4	10.6	9.0	7.8	8.3	X	X	X	X	X	X	X	X	X													

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Handloom Factory	12A																														
Handloom Factory	12B																														

Note: Industrial Effluent Quality Standard for Bangladesh 6.0-9.0

A.28 : Ammonia in Industrial Effluent Water (Handloom Waste), mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Handloom Factory	12A	X	0.4	2.3	0.8	10.7	2.4	2.9	3.0	1.0	X	X	X	X	X	X	X	X													
Handloom Factory	12B	X	0.4	2.2	0.7	4.3	1.9	2.4	3.4	X	X	X	X	X	X	X	X	X													

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Handloom Factory	12A																														
Handloom Factory	12B																														

Note: Industrial Effluent Quality Standard for Bangladesh 5 mg/L

A.29 : Chemical Oxygen Demand (COD) in Industrial Effluent Water (Handloom Waste), mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Handloom Factory	12A	X	150	38	180	230	120	130	130	170	X	X	X	X	X	X	X	X													
Handloom Factory	12B	X	184	80	240	180	130	80	102	X	X	X	X	X	X	X	X	X													

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Handloom Factory	12A																														
Handloom Factory	12B																														

Note: Industrial Effluent Quality Standard for Bangladesh 200 mg/L

A.30 : Chromium (+VI) in Industrial Effluent Water (Handloom Waste), mg/L

Location/	Site	1995									1996												1997								
Source	Code	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Handloom Factory	12A	X	0.52	0.12	0.09	0.08	0.07	0.14	0.2	0.2	X	X	X	X	X	X	X	X													
Handloom Factory	12B	X	0.44	0.16	0.20	0.25	0.2	0.18	0.30	X	X	X	X	X	X	X	X	X													

Location/	Site	1997			1998												1999												2000		
Source	Code	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Handloom Factory	12A																														
Handloom Factory	12B																														

Note: Industrial Effluent Quality Standard for Bangladesh 0.1 mg/L

Legend : X Not Available/Sampled; NYS Not Yet Settled

REFERENCES

Compartmentalization Pilot Project (CPP), 1995. "Draft Final report, Homestead & Road Embankment Plantation Survey".

Compartmentalization Pilot Project (CPP), 1998. "CPP 1st Phase-An Overview of the 1996 & 1997 Monsoon Experiences for CPP".

Compartmentalization Pilot Project (CPP), 1999. "CPP Workshop, 9-10 February, 1999".

Compartmentalization Pilot Project (FAP-2), 1993. "Sirajgonj CPP Interim Report, Annex 6: Final Report, Environmental Issues".

Compartmentalization Pilot Project (FAP-20), 1992. "Tangail CPP Interim Report, Main Volume".

Compartmentalization Pilot Project (FAP-20), 1994. "Draft Final Report on Special Fisheries Study".

CPP, 1994. "Draft Final Report, Environmental Pollution Survey".

CPP, 1996. "Draft Final Report, "Fish Culture in CPP- An Analysis of 1992-95 Results".

CPP, 1996. "Social Forestry in the CPP, Tangail, Working Paper (upto 96/01)".

CPP, Tangail, 1996. "Draft Final Report, Fish Catch in the CPP- An Analysis of 1992-95 results".

CPP, Tangail, 1996. "The Completion Report of the 1st Phase (October 1991 to September 1996)".

CPP, Tangail, 1996. "Work Plan on Monitoring & Evaluation".

CPP/FAP-19, 1992. "Geographic Information System, EIA Case Study".

FAP 3.1, 1997. "Jamalpur Project Refinement Study, Draft Project Refinement and EIA Reprot-R3".

ISAPN, 1992. "Compartmentalization Pilot Project, Bangladesh Flood Action Plan, FAP-16, Environmental Study- Environmental Impact Assessment Case Study".

Pandey, C.N., Garney, G.C. "Environmental Engineering".

Trivedi, R. N. "A Text Book of Environmental Sciences".

World Bank, "Environmental Assessment Source Book, Volume I, Policies, Procedures and Cross-Sectoral Issues, Environmental Department".