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The People's Republic of Bangladesh

Ministry of Irrigation, Water Development and Flood Control

BANGLADESH FLOOD ACTION PLAN

FAP 16 Environmental Study

FAP 19 Geographic Information System

Environmental Impact Assessment Case Study

COMPARTMENTALIZATION PILOT PROJECT

December 1992

ISPAN IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

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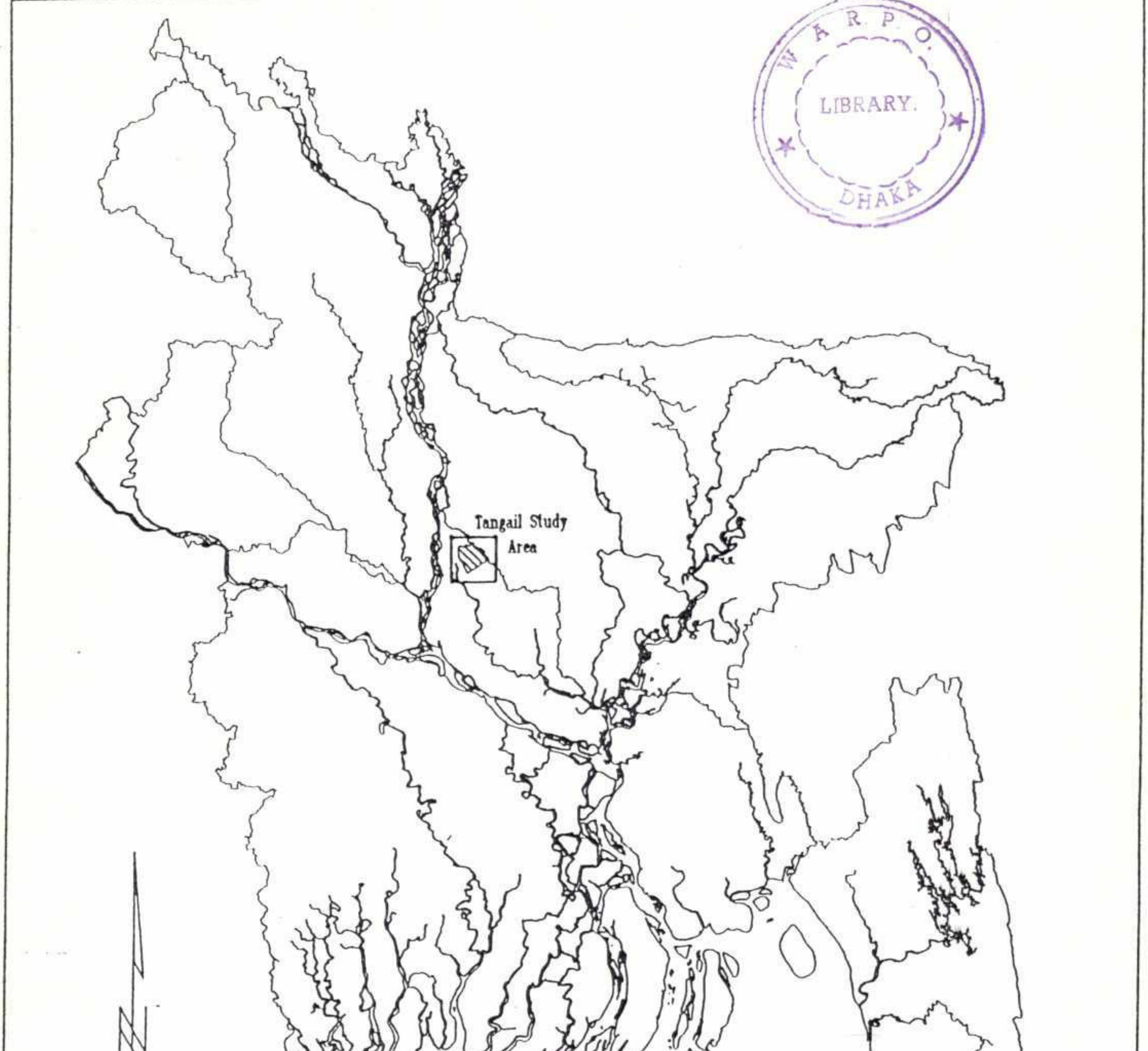

ISPAN

Map of Bangladesh and Location of Tangail Study Area

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EXECUTIVE SUMMARY

This report presents an Environmental Impact Assessment (EIA) of the proposed Compartmentalization Pilot Project (CPP) at Tangail. The assessment was undertaken by the FAP 16 Environmental Study component of the Bangladesh Flood Action Plan (FAP) as a case study in undertaking EIAs of typical FAP projects. The main objectives of the case study were to apply the EIA process as specified in the FAP EIA Guidelines, to develop appropriate experience amongst local EIA practitioners, and to test the practical application of a Geographic Information System (GIS) to a typical EIA.

The CPP study area is located in the north-central region of Bangladesh, close to the left bank of the Jamuna River, and bounded by the Dhaleswari and Pungli rivers, and transected by the Lohajang River. Total area of the project is approximately 13,000 ha.

The CPP project is a flexible plan comprising compartmentalization of the area with provision for flow control and water management. For the purpose of the case study, the project was taken to be the implementation of the full program intended to bring about the maximum amount of flow control in the area; this comprised a horse-shoe embankment and closure embankment on the southern side, various emergency spillways, main and medium size inlet regulators, a main outlet regulator or control structure along the Lohajang River, erosion protection along rivers, and drainage improvements. Water management within the subcompartments of the CPP area is a long-term objective but was not specifically assessed in this case study because of a lack of specific information on future water levels under such management regimes.

The EIA study process followed that defined in the FAP EIA guidelines and consisted of the major steps of project design and description, environmental baseline description, scoping, bounding, major field investigations, impact assessment, evaluation of impacts , development of recommendations for an environmental management plan, feedback to improve project design, and preparation of the EIA report. Some work on people's participation was undertaken to supplement the extensive program undertaken by FAP 20. Close collaboration was maintained throughout the study with FAP 20 (CPP) and FAP 19 (GIS).

The environmental impacts predicted for the CPP are summarized in Table 1. The main beneficial impacts of the project would include increases in irrigated area, improvement in agricultural production, reduction in crop damage losses, improvements 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, e.g. incomes and cereal-based nutrition. Negative impacts would include a reduction in agricultural crop diversity, marked declines in capture fish production and harvests, reductions in aquatic habitats and in wildlife species dependent on such habitats, reduction in water-based transportation, decreases in socio-economic parameters related to fish and fishing, e.g. subsistence fishing income and fish-based nutrition, and an increase in environmental contamination with pesticides and other agricultural chemicals.

Mitigation of negative environmental impacts would be possible for some impacts, but not all. A relatively large number of impacts would not be adequately mitigated by presently available and practical mitigation measures - these are listed in Table 2.

The economic benefits of the project appear to exceed the costs by a small margin. Increased employment in project construction and in the agricultural sector account for most of the benefits, while the largest environmental cost is in the loss of capture fisheries production and employment. Some significant environmental and social impacts were not included in the economic evaluation due to a lack of specific information, these include increased pesticide and pollution damage, the loss of wetland species and general biological diversity, and the costs of dealing with potential disease epidemics related to project development.

Table 1. Summary List of Environmental Impacts, CPP Area.

Important Environmental Components	Present Amounts	Impact of CPP	Type of Impact[*1]	Impact Rating[*2]
Land Types				
F_0	576 ha	+1896 ha	SM/HM	+2.5
F_1	1821 ha	+1085 ha	SM/HM	+2.5
F_2	4248 ha	-787 ha	SM/LM	+1.0
F_3	2552 ha	-2194 ha	SM/HM	+2.5
Drainage Congested Areas	1549 ha	Decrease	SM/LM	+1.5
Ground Water	Adequate	Decrease in dry years	RM/LM	-0.5
Annual Crop Production				
Total area irrigated	5398 ha	+376 ha	SM/LM	+1.5
Total potential paddy production	37,551 tonnes	+3276 tonnes	SM/LM	+0.5
Total paddy production	34,376 tonnes	+8077 tonnes	SM/HM	+3.0
Total production lost to crop damage	-3175 tonnes	+4801 tonnes	SM/HM	+3.0
Total rabi production	7751 tonnes	+1579 tonnes	SM/HM	+1.5
Total jute production	2947 tonnes	+1920 tonnes	SM/HM	+1.5
Crop diversity	1:2.1	Decrease	RM/LM	-1.5
Cropping intensity	196%	+18%	SM/LM	+0.5
Total farm labor	3,011,000 person/-days	+292,000 person/days	SM/HM	+1.5
Homesteads				
Housing	1751 ha	+175 ha	SM/LM	+0.5
Garden crops	875 ha	+87 ha	SM/LM	+0.5
Tree crops	875 ha	+87 ha	SM/LM	+0.5
Homestead vegetation damage	-20%	+20%	SM/HM	+3.0
Biomass Energy Shortage	-52%	+50%	SM/HM	+3.0

*1 SM = sustainable with mitigation, S = sustainable, RM = reversible with mitigation, IR = irreversible; HM = high magnitude, LM = low magnitude

*2 Highest beneficial impact = +5.0, maximum negative impact = -5.0

Continued

Table 1. Continued

Important Environmental Components	Present Amounts	Impact of CPP	Type of Impact[*1]	Impact Rating[*2]
Capture Fisheries				
Annual production	380 tonnes	-32 tonnes	IR/LM	-3.5
Professional fisherman household production	720 kg/year	Decrease	IR/LM	-3.5
Subsistence fisherman household production	8 kg/year	Decrease	IR/LM	-3.5
Fish diversity	56 species	-23 species	IR/HM	-5.0
Culture Fisheries		0		
Annual Production	49 tonnes	+16 tonnes	SM/HM	+1.5
Total employment	NQ	Larger increase	SM/LM	+1.5
Aquatic Habitat				
Pre-monsoon	322 ha	+1875	SM/HM	+1.5
Monsoon	7138 ha	-1130	RM/HM	-1.5
Post-monsoon with drainage congestion	8145 ha	-1521	RM/HM	-1.5
Post-monsoon without drainage congestion	697 ha	+118	SM/LM	+1.0
Terrestrial Habitat				
Pre-monsoon	12,678 ha	-1875	RM/HM	-1.5
Monsoon	5862 ha	+1130	SM/HM	+1.5
Post-monsoon with drainage congestion	4855 ha	+1521	SM/HM	+1.5
Post-monsoon without drainage congestion	12,303 ha	-118	RM/LM	-0.5
Wildlife		0		
Presently endangered	7 species	2 species will become extinct	IR/HM	-5.0
Presently threatened	10 species	4 species will decline	RM/HM	-3.0
Presently common	29 species	13 species will decline	RM/HM	-3.0
Pesticide contamination	Prevalent	Increase	RM/HM	-3.0

Continued

Table 1. Continued

Important Environmental Components	Present Amounts	Impact of CPP	Type of Impact[*1]	Impact Rating[*2]
Road communication	262 km	Improved	S/LM	+0.5
Navigation				
Passengers	245,000 annual trips	Likely decrease	RM/HM	-2.5
Goods	900 tonnes annually	Small decrease	RM/LM	-0.5
Socio-economic				
Subsistence fishing	2.6 - 3.5 kg/hh/-year	Decrease	IR/LM	-3.5
Crop production, annual wages				
Peak season	135.5 million taka	+44 million taka	SM/HM	+3.0
Lean season	90.3 million taka	+29 million taka	SM/HM	+3.0
Construction employment	Nil	+9533 person/years	NS/HM	+2.0
O&M employment	Nil	+580 jobs	SM/LM	+1.5
Quality of Life				
Gender issues	NQ	Improved	SM/LM	+1.0
General Health	NQ	Improved	SM/HM	+3.0
Nutrition - crop based	NQ	Improved	SM/HM	+1.5
Nutrition - fish based	NQ	Decrease	IR/HM	-3.5
Vector-borne disease incidence	NQ	Increase	RM/HM	-1.5
Tangail Town		0		
Drinking water	High iron and manganese	Deteriorates	RM/LM	-0.5
Groundwater depletion	0.25 m/yr	Decrease	IR/LM	-1.5
Flooding hazard	High risk	Decrease	SM/HM	+3.0
Drainage problems	Prevalent	Decrease	SM/LM	+1.0
Rural flooding hazards	Prevalent	Decrease	SM/LM	+2.5

Table 2. Residual Impacts Expected after CPP Implementation and Application of Practical Mitigation Measures

Important Environmental Components	Present Amounts	Assessed Impacts	Impact Magnitude	Reversibility
Fisheries and Aquatic Habitats				
Aquatic habitat: monsoon	7138 ha	-1130 ha	High	Reversible
Aquatic habitat: post-monsoon	8145 ha	-1521 ha	High	Reversible
Fish diversity	56 species	-23 species	High	Irreversible
Capture fishery production	380 tons/year	-32 tons/- year	Low	Irreversible
Professional fishing production	720 kg/hh/year	Decrease	Low	Irreversible
Subsistence fishermen	8 kg/hh/year	Decrease	Low	Irreversible
Agriculture				
Crop diversity ratio	1:2.1	Decrease	Low	Reversible
Terrestrial Habitats				
Terrestrial habitat: pre-monsoon	12678 ha	-1875 ha	High	Reversible
Terrestrial habitat: post-monsoon	12303 ha	-118 ha	Low	Reversible
Ecosystems				
Pesticide contamination	Prevalent	Increase	High	Reversible
Navigation				
Boat use of waterways	245000 pass./year	Likely decrease	High	Reversible
Cargo use of waterways	900 tons/year	Small decrease	Low	Reversible
Public Health Concerns				
Household subsistence fishing	2.6 - 3.5	Decrease	Low	Irreversible
Nutritional use of fish	NQ	Further decrease	High	Irreversible
Vector-borne disease incidence	NQ	Increase	High	Reversible
Tangail town drinking water	High Fe & Mn	Deteriorates	Low	Reversible
Tangail town groundwater depletion	0.25 m/yr	Decrease	Low	Irreversible

*T Assuming practical application of mitigation measures (see text)

Table 3. Main Recommendations for the Environmental Management Plan

Community Participation

- Ongoing liaison with all communities and resource user groups in the CPP area.

Project Operation and Maintenance

- Cuts and breaches to the embankments to be inventoried and a detailed maintenance plan established.
- Preparation of a flood preparedness plan for the area

Hydrology

- Ongoing testing and development of surface water models for use in water management and impact assessment.
- Low cost drainage improvement methods to be developed and applied

Groundwater

- Systematic study on groundwater recharge under project conditions.

Fisheries

- Study and design of an effective fish pass on the Lohajang River
- Maintain high water levels after 15 July each year to maintain beel recharging
- Develop and refine the beel concept of fisheries management
- Promote integrated rice-fish culture

Navigation

- Develop boat locks on Lohajang River and other important waterways

Infrastructure

- Improve road network to facilitate transportation of goods to markets
- Establish a tree plantation program for roads and embankments.

Health and Welfare

- Educational and clinical programs to safeguard against malaria.
- Monitor the incidence of kala azar.
- Establish health education programs on water borne diseases.
- Minimize the effects of jute retting on water quality.
- Replace lost capture fish protein sources.

Institutions

- Comparative assessment of impacts on socioeconomic groups
- Development of a strategy for beneficiary participation
- Define the roles and coordination requirements of NGOs in project implementation
- Develop training programs for project beneficiaries
- Facilitation of credit delivery systems to landless groups and women.
- Enhance agricultural extension services int he area,
- Enhance development of small industries in the area.
- Preparation of a detailed compensation plan.

Impacts beyond the boundaries of the CPP would occur due to backwater effects and to flow regulation downstream of the CPP area. These impacts would be limited to the immediate downstream areas bounded by the Dhaleswari and Pungli rivers and to the sub-compartments immediately north of the CPP. These impacts were not assessed in detail in this case study, but are considered to be potentially small.

Cumulative environmental impacts might occur in the area south of the CPP due to the synergistic effects of flow regulation by the CPP and the hydrological effects of closure of the northern intake of the Dhaleswari River. These cumulative effects would be relatively very small and difficult to quantify in terms of land type changes. In the areas north of the CPP the effects of the Dhaleswari closure would negate any backwater effects of the CPP during the monsoon season, and overall water levels and the extent of flooding would decrease.

Recommendations for an Environmental Management Plan are made in the report; these are summarized in Table 3 above.

ACKNOWLEDGEMENTS

The FAP 16 team members gratefully acknowledge the sincere cooperation and assistance received from the villagers and elites of the Compartmentalization Pilot Project area, Tangail, during field work on the EIA case study. Numerous government and nongovernmental agencies and individual officials provided information and assistance, which is thankfully acknowledged. The team acknowledges, in particular, the Deputy Commissioner of Tangail; the CPP Project Director, Bangladesh Water Development Board (BWDB); the thana Nirbahi officers and their associates, and the thana and union council chairmen and their associates; directors and other officials of the Geological Survey of Bangladesh, Dhaka; the Dhaka Meteorological Department and the Soil Resources Development Institute.

The assistance and cooperation of the entire FAP 20 study team is gratefully acknowledged, in particular Paul Zijderveld, Hans Visser, Dirk Frans, Golam Kibria, Egbert Hamel and Gertjan de Graaff.

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ABBREVIATIONS AND ACRONYMS

BBS - Bangladesh Bureau of Statistics
BKB - Bangladesh Krishi Bank
BRDB - Bangladesh Rural Development Board
BWDB - Bangladesh Water Development Board
cm - centimeters
CPP - Compartmentalization Pilot Project
DEM - Digital elevation model
DOF - Directorate of Fisheries
DPHE - Department of Public Health Engineering
DTW - Deep tube well
EMP - Environmental management plan
ERDAS - Digital image processing software
FAP - Flood Action Plan
FCD/I - Flood Control Drainage and Irrigation
FPCO - Flood Plan Coordination Organization
g - grams
GIS - Geographical Information System
GR - Gini ratio
h - hours
ha - hectares
HTW - Hand tube well
HYV - High yielding variety
IEC - Important Environmental Component
ISPAN - Irrigation Support Project for Asia and the Near East
IUCN - International Union for Conservation of Nature and Natural Resources
km - kilometers
LGED - Local Government Engineering Department
m - meters
m^3/s - cubic meters per second
mg/l - milligrams per liter
mm - millimeters
MCHFP - Medical care, health and family planning
MP - muriate of potash
mt - metric tonne

NCRM	-	North Central Regional Model
NCS	-	National Conservation Strategy
O&M	-	Operation and Maintenance
pc ARC/INFO		GIS application software
ppm	-	parts per million
PRA	-	Participatory rural appraisal
PWD	-	Public Works datum
RMP	-	Rural Maintenance Program
ROL	-	Rate of literacy
RRA	-	Rapid rural appraisal
SCWC	-	Subcompartmental Water Committee
STW	-	Shallow tube well
SWMC	-	Surface Water Modelling Centre
T. aman	-	Transplanted aman
TD aman		Transplanted deep water aman
Tk.	-	Taka
TSP	-	Triple Super Phosphate
USU	-	Ultimate sampling unit

GLOSSARY

Aman	-	Rice grown during *kharif-2* season with the exception of broadcast aman which is sown in the *kharif-1* season and harvested in the *kharif-2* season
Aus	-	Rice grown during the *kharif-1* season
B. aman	-	Broadcast aman
Bandalling	-	Low-cost dredging method applied to small channels involving bamboo mat panels which create spiral currents
Beel	-	A natural depression, the bottom of which normally remains wet throughout the year
Boro	-	Rice grown during *rabi* season
Bandhak	-	Mortgage
Barga	-	Share cropping
Barsha	-	Normal seasonal flooding
Biri	-	Local cigarette
Conch	-	A variety of shell
Dhenki	-	Traditional foot-operated paddy dehusking device
District	-	An administrative unit comprising a number of thanas under the charge of a Deputy Commissioner
Khal	-	Natural channel
Kharif-1	-	Early summer (March through June)
Kharif-2	-	Late summer and fall (July through October)
Khasland	-	State owned land
Macha	-	A high platform, usually made of bamboo
Matabbar	-	Informal village leader
Maund	-	A local unit of measurement (1 maund=37.3 kg)
Monsoon	-	Rainy season starting in June and ending in September
Mouza	-	The smallest revenue unit
Nikari	-	Middlemen in fish trading
Pagar	-	A small waterbody adjacent to the homestead and under individual ownership
Palan	-	Extension of homestead land, used for vegetable gardening

Rabi	-	Winter cropping season (November through February)
Sairat mahal	-	Places of public use given on annual or short term lease by the government
Salish	-	Village court
Taka	-	Name of Bangladesh currency
Thana	-	Administrative unit (division of a district)
Union	-	Smallest administrative unit of the local government (division of a thana)
Upazila	-	Term previously used for thana

Chapter One

INTRODUCTION

1.1 Environmental Impact Assessment within the Flood Action Plan

During the past two decades, Environmental Impact Assessment (EIA) has become an integral component of the feasibility plans prepared for development projects in many countries. The Flood Action Plan (FAP) in Bangladesh is no exception. Subsequent to the 1988 flood, a wide range of flood control-related development plans have been proposed, ranging from major river training and embankment construction to community-based flood-proofing. The fragile nature of the environment in Bangladesh combined with the delicate adjustments that rural people have historically established with the realities of flooding has necessitated a careful review of the proposed plans in the context of their social and environmental impact. EIA's overall purpose is to assist the planning and decision making processes. EIAs are used as action driven force to foster environmentally sound decisions on the proposed project and to aid in the development of an Environmental Management Plan (EMP) for the respective project(s).

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

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

1.2 Objectives of EIA Case Studies

The purpose of the EIA case studies is to:

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

1.3 Selection of EIA Case Studies

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

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

ronmental baseline conditions.

The first EIA case study was carried out by FAP 16 in the Surma-Kushiyara area (ISPAN 1992b). The present study represents the second EIA case study, and has been implemented in close collaboration with FAP 19 (Geographic Information Systems - GIS) and FAP 20 (Compartmentalization Pilot Project - CPP).

1.4 Compartmentalization Pilot Project

Tangail is located in the north central region and is the site of the CPP being undertaken by FAP 20. Tangail is also the site of a FAP 19 Geographic Information Systems (GIS) pilot study. FAP 16 selected this site and the CPP for the EIA case study for the following reasons:

- The CPP site comprises diverse and important land uses including intensive cropping (rainfed and irrigated), fisheries and urban development, and thus provides opportunities to assess a wide range of environmental concerns related to FCD/I.
- The CPP proposals cover an array of interventions pertinent to FAP, including flood control, irrigation, drainage improvement and water management.
- The CPP is a FAP 19 GIS pilot study area and provides opportunities for EIA professionals to utilize this technology in conducting a typical EIA.
- CPP has adopted a participatory approach in the planning, designing and implementation of the proposed actions, providing an opportunity for EIA to be conducted along the same philosophical approach.

The Guidelines for Project Assessment (FPCO 1992b) require that project impact be evaluated at one or more of three levels - economic, quantitative and/or descriptive evaluation. Economic and financial evaluation of impacts and resource losses is typically performed in a separate cost-benefit analysis, but the basic information is provided from the EIA. The case study presented herein has assessed the impacts as far as possible in a quantitative manner, and an preliminary economic analysis of these has been included for input to a feasibility report.

The EIA team performed this assessment in collaboration with the FAP 20 social and agricultural scientists and engineers. In a feasibility study, this interaction is essential in order to develop an efficient and acceptable project design and EMP. This EIA report details the major environmental and social impacts that would normally link to the main project feasibility report. The EIA report provides initial mitigation recommendations for use in the EMP but does not produce a detailed EMP that would normally require more extensive interactions between design engineers, the EIA team, pertinent government ministries and local communities, as well as provision of detailed budgets and schedules.

Chapter 2

PROJECT DEFINITION

2.1 The CPP Concept

Understanding the concept of compartmentalization is key to successful environmental assessment of the CPP. The concept has evolved in the Flood Action Plan to provide water management in protected areas and to contain the extent of flooding in case of an embankment breach. A compartment is an area in which effective water management, controlled flooding and controlled drainage is made possible through structural and institutional arrangements. Over time, and in pace with development of institutional capacities, compartments will build up into continuous water management systems along the main rivers (FAP 20 1992a) with intended benefits which will include flood control structures, increased crop production and crop diversification. The compartmentalization concept will be demonstrated in pilot areas to test its operational feasibility and institutional viability. The CPP is the first scheme for implementation and, if proved effective, will be adopted in future FCD/I projects.

2.2 Project Area

The CPP area is located in the north-central region, several km east of the left bank of the Jamuna River (see *frontispiece*). As defined by FAP 20, the western boundary of the CPP area (Map 2.1) 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 River 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 Floodplain. The overall drainage is toward low-lying land in a southeasterly direction. Total area of the project is approximately 13,000 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 are operated with wooden fallboards 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 (Map 2.1).

The CPP or '*project*' area, as defined by FAP 20 for the purpose of developing the compartmentalization project, does not precisely define the required study area for an EIA of the project. Areas up- and downstream of the CPP area would potentially be affected by backwater and downstream flow effects, and there could potentially be socio-economic impacts outside of the CPP boundaries. The overall area to be considered in the EIA is termed the '*impact*' area. These issues are described further in section 3.2.

2.3 An Overview of Flood Related Problems in the Project Area

According to the surveys conducted by FAP 16 (Annex 1) and FAP 20 (1992b, 1992c), the people in the project area perceive drainage congestion, siltation, flooding, and erosion as the major water-related problems. These are directly related to the heavy monsoon season rainfall and the morphology of the river and land systems. People in the project area have made impressive efforts, including development of multiple cropping and intercropping patterns according to seasonal hydrological changes, in order to adapt their resource use practices to the realities of the natural setting.

Early floods occur due to heavy rain in April and May. Most of the khals connecting the low-lands and beels to the river system are normally silted and unable to carry the required discharge. In other areas, there is no defined channel to connect the beels to the river. Consequently, proper drainage does not take place, leading to inundation of the floodplain and depressions. Inundation during this period adversely affects crops, particularly boro rice, and local accessibility to croplands.

During the monsoon season the flooding condition worsens due to increases in water levels in rivers and khals as well as overbank flow. Floods during this period damage high yielding varieties (HYVs) of transplanted aman (T. aman) and seedlings of deep water rice planted in low-lying areas. Excessive flooding may occasionally inundate fields, homesteads and the road network.

In late September and October, khals drain the water from the floodplain to the rivers. In some cases because of inadequate capacity of khals and heavy siltation, insufficient discharge takes place and the beels and other depressions remain inundated, either for prolonged periods of time or else permanently, e.g. Dharun Beel. Inadequate drainage and stagnant flood water prohibit the planting of boro rice.

Drainage congestion during premonsoon periods obstructs fish migration. During the dry period, irrigation reduces the wetland areas, promoting overfishing and rapid depletion of this important resource.

Bank erosion occurs during monsoon flooding due to current velocities and wave action, and again during flood recession because of bank loosening and drawdown effects. Bank erosion is a prominent problem along the Pungli and Elanjani rivers. Villages affected each year by land and homestead loss due to bank erosion include Salina, Panchbethoir, Rupshijatra, Pichuria and Haludbari.

2.4 CPP Development Options

2.4.1 Objectives of the CPP

The overall objectives of the CPP are "*to establish appropriate water management systems for the development of protected areas so that criteria and principles for design, implementation and operation can be made available for the Action Plan*" (FAP 20 1992a). Specifically, this entails "*testing of the compartmentalization concept in the field under real operating conditions, addressing all the relevant socioeconomic, institutional and environmental issues, and trying out water control work and water management systems*" (FAP 20 1992a). Water management is defined as "*the controlled usage of water, including early, late, and deep flooding, irrigation and drainage, surface and ground water quantity and quality, and water use for agricultural, fisheries, transport, sanitation and domestic and industrial purposes*". The CPP, therefore, is a pilot scheme to test the adaptability of compartmentalization and water control in Tangail in the realms of technical and institutional feasibility, social acceptance and overall sustainability.

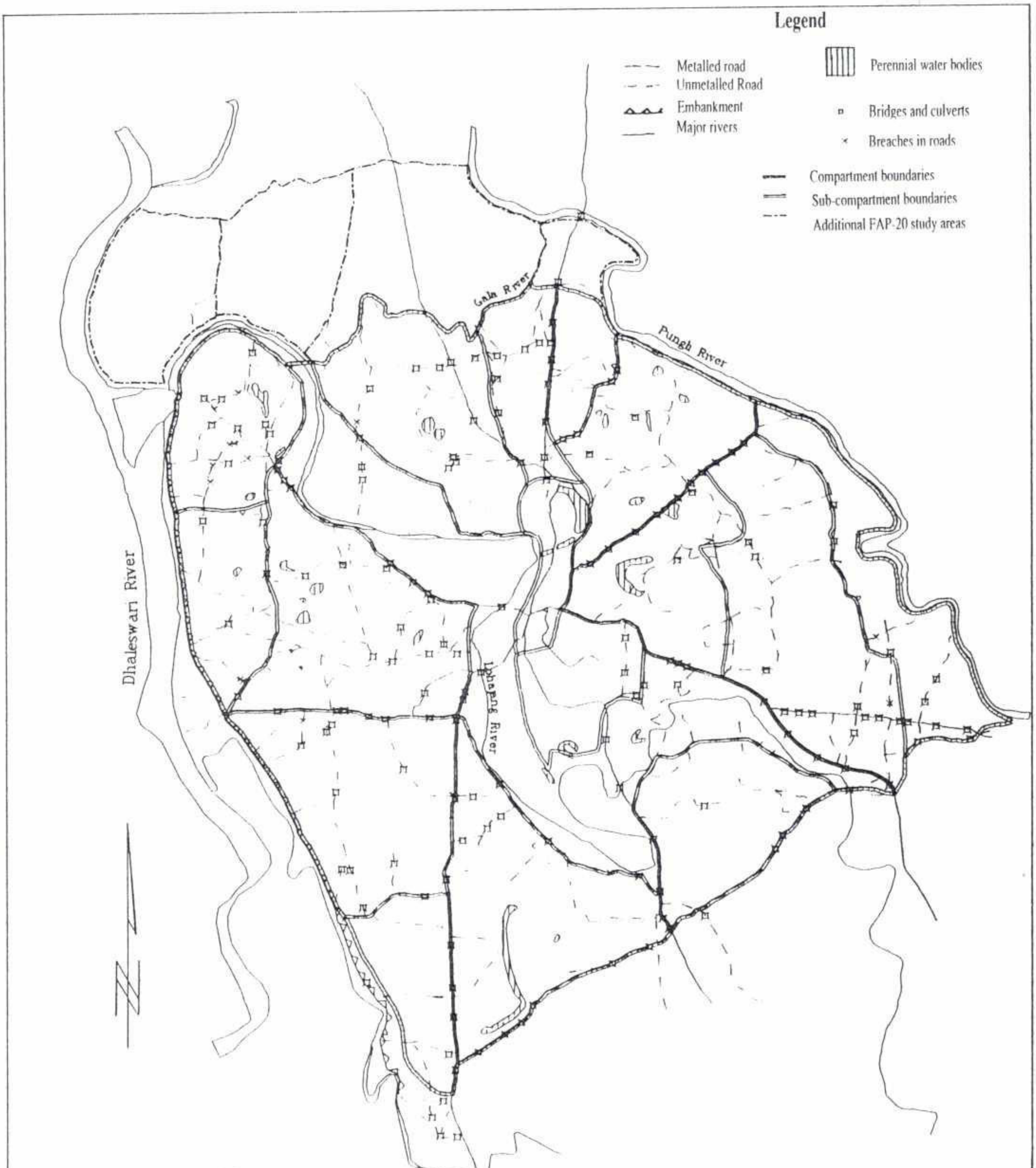
2.4.2 Proposed Project Options

FAP 20 is in the process of fine tuning the alternatives actions for implementation of the CPP (FAP 20 1992d). The project alternative actions described here are based on the FAP 20 revised Inception Report of April 1992 (FAP 20 1992a), the Interim Report of September 1992 (FAP 20 1992d), and several discussions and interactions between FAPs 16 and 20 from April through December 1992.

Six implementation alternatives are currently being considered (FAP 20 1992d).

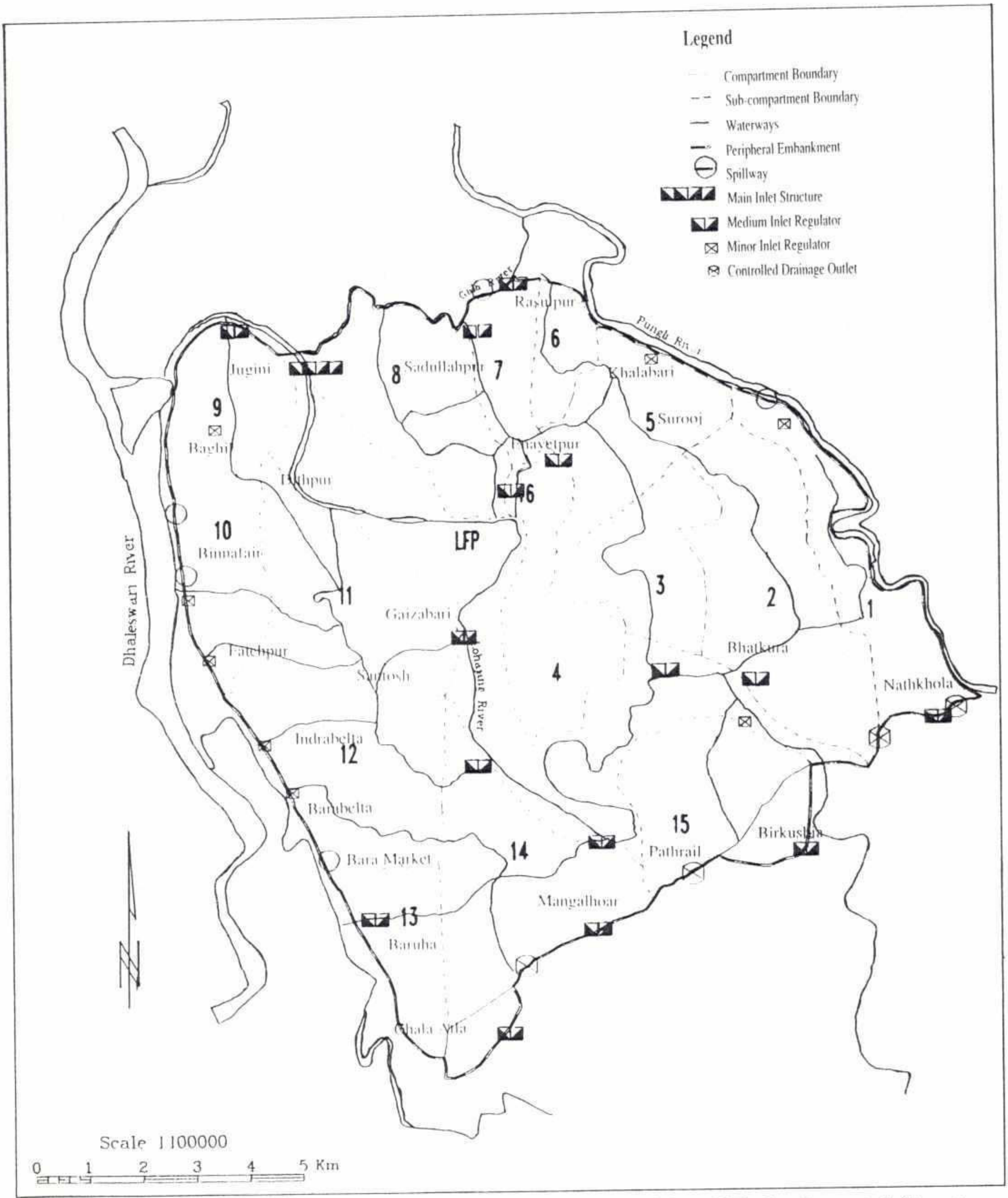
- Option IA - full compartmentalization (Map 2.2 and 2.3). All peripheral structures gated with the exception of the ungated or partly gated navigable inlet structures at Lohajang and Sadulla-

Map 2.1



Infrastructure

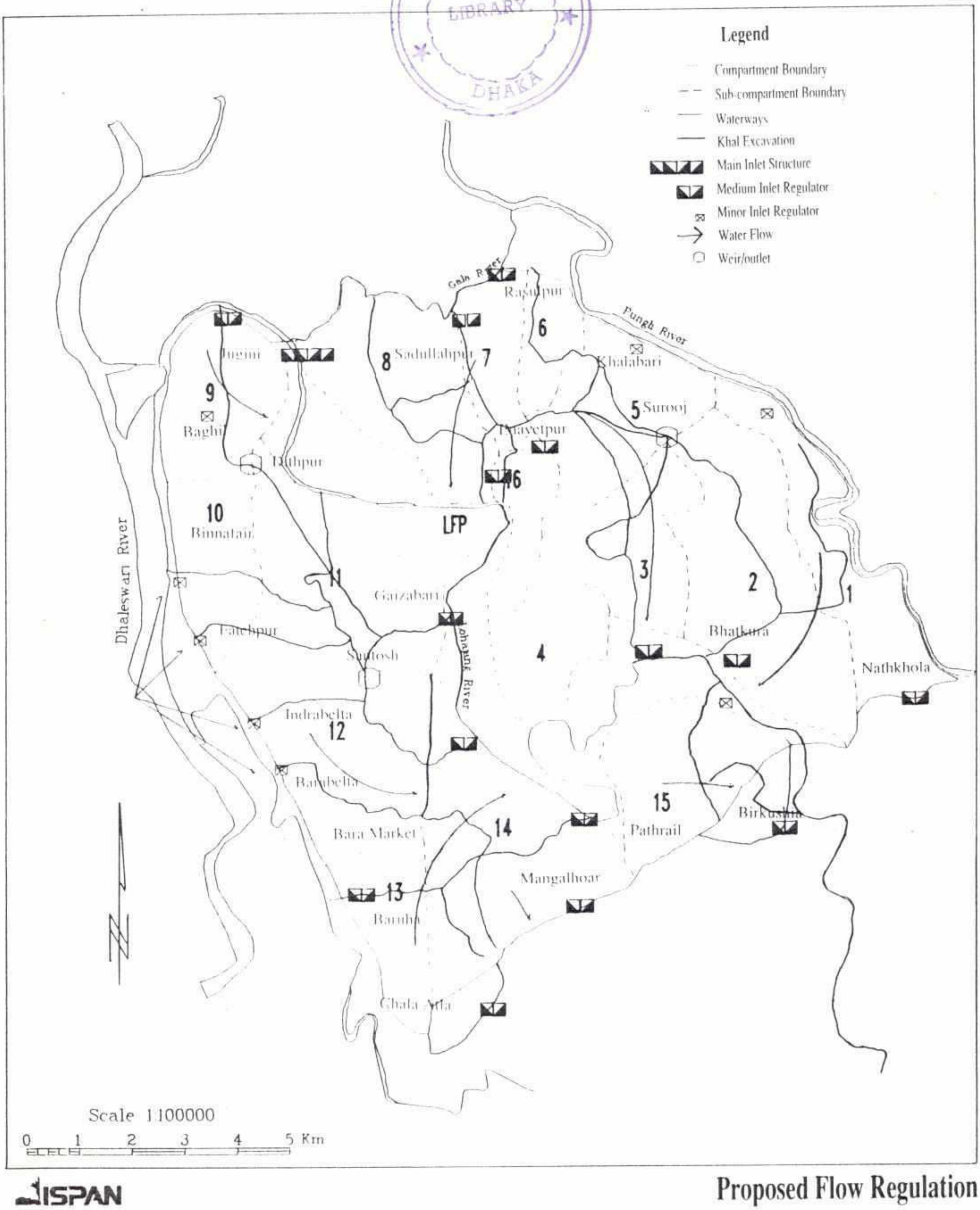
Map 2.2



ISPAN

Proposed Peripheral Embankment & Structures

Map 2.3



Proposed Flow Regulation

pur; limited peripheral road (20 km); southern embankment as feeder road with bridges/ungated structures; flow regulators between Lohajang and subcompartments 9, 10 and 11 only.
- Option IB - same as IA but also gated and unnavigable inlet structures at Lohajang and Sadullapur including mooring facilities (or lock).
- Option IIA - same as IA but also including flow regulators between Lohajang and remaining subcompartments.
- Option IIB - same as IB but also including flow regulators between Lohajang and remaining subcompartments.
- Option IIIA - same as IIB but with closed/regulated structures along southern embankment with the exception of the open Lohajang outlet.
- Option IIIB - same as IIIA but with complete peripheral road (60 km).

One of these options will be implemented in several phases in accordance with the principles of community participation, institutional development and results of testing various water management techniques. The project options are all of a phased nature, with possible "*go*" or "*no go*" decisions in-between steps. The aim of the peripheral control at compartmental level is to permit normal (or "semi-controlled") flooding but to keep out major floods (gated structures) or reduce them (partly ungated structures). Peripheral control is a prerequisite for controlled drainage from the compartment into the Lohajang River.

2.4.3 Construction Elements

Each implementation alternative includes most of the following construction elements:

- horseshoe embankment and closure embankment on the southern side;
- emergency spillways;
- main and medium size inlet regulators;
- main outlet regulator or control structures along the Lohajang River and medium and small size outlet regulators;
- erosion protection along rivers; and
- drainage improvement.

Maps 2.2 and 2.3 indicate the location and type of structures proposed by the project. More detailed descriptions of specific structures are presented in FAP 20 (1992d).

Horseshoe Embankment or the Peripheral Embankment

The embankment will function as a multipurpose structure. It will accommodate road transport and construction of emergency "bulge" along the riverside to accommodate people and livestock from outside during high flood periods. The existing embankment will be upgraded to prevent a 1988 flood with a 30cm freeboard. This level corresponds with a 1:7 year return period flood with a 90cm freeboard. Sections along the 1988 flood level will not be upgraded unless required for improving the multi-purpose use of the embankment. Sections that are in imminent danger from river erosion will be upgraded. Sections that are above design level will be maintained. It is assumed that the total width of the embankment, as per Bangladesh Water Development Board (BWDB) standard, provides sufficient stability and protection against seepage, and permits road transport without weakening of the embankment. The new sections of the embankment will follow standard design criteria.

Emergency Spillways

Emergency spillways will be integrated in the peripheral embankment to help control the water level within the river during an extreme flood event with a probability that is close to the design event. It will also help provide a higher downstream water level when overtopping of the embankment occurs during an above design flood. During extreme floods all planned and new inlet structures (Lohajang main inlet; Jugni, Rasulpur, Sadullapur and Baruha medium inlet regulators; and four existing structures) will be opened. The flow in the Lohajang River will be controlled by a main inlet regulator which will also provide spilling capacity for the Dhaleswari during extreme floods.

Main Inlet Regulator

The main inlet regulator will be located 4.5 km downstream from the mouth of the Lohajang River and immediately downstream of the Gala Khal inlet. It will be a 5-vent structure with three 3m x 3m and two 1.5m x 3.0m vents. This will give a head loss of 0.7m for an estimated peak typical discharge of 80 m^3/sec. The sill level has been assessed at 9.5m + PWD (Public Works Datum), corresponding with the bottom level of the Lohajang river at the site. The top level of the structure is based on a 1:50 year return period. The freeboard will probably follow the BWDB standard of 1m.

Medium Inlet Regulators

Four new inlet regulators are proposed for peripheral control at Khorda Jugni, 250m from the mouth of the khal; at Rasulpur, 25m from the mouth of the khal; at Sadullapur, 350m from the mouth of the khal, and at Baruha, 100m from the mouth of the khal. The function of these inlet regulators is to secure the water level inside the compartment and, by maintaining an appropriate water level in the major khals, facilitate controlled flooding and drainage in the compartment. It is proposed that the vents are run as free surface vents and that flow should be controlled by two partial gates.

Existing Inlet Regulators

There are four existing inlet regulators located at Bannafor, Fatehpur, Indra Belta, and Belta Sarai. All the existing regulators will be upgraded as appropriate to increase their efficiency.

Southern Closure Embankment

The southern embankment is the unmetalled road between Nathkhola, Karotia, Puthrail and Silimpur. It will include Birkushia Chak to control both Kumuli and the Birkushia khals at the confluence with the Lohajang River in order to improve water level in subcompartment 15. At Atia village three breaches have been repaired with new alignment and new section. It is proposed to follow this new alignment. At Silimpur it is proposed to change the alignment in a southern direction to include the Atia Hinganagar Khal.

Outlet Regulators

A series of medium size outlet regulators has been proposed between the Lohajang River and the adjacent subcompartments. The embankment along the Lohajang downstream of the inlet regulator will be partially upgraded. Outlet regulators of various sizes, some with gates and some without, and bridges and culverts are being considered along subcompartments 1, 14, and 15.

Erosion Protection Measures

Erosion protection work will be implemented at the Dhaleswari River (Sibpur), at the Elanjani River (Guni Kishore, Baruha, and Bara Belta), and at the Pungli River (Salina, Panchbethoir, Khalat Bari and Birnahali).

Subcompartmental Water Management Structures

A number of structural measures including various size inlet and outlet flow regulators for water control and management within and between subcompartments are included in the project design.

Water Management in Tangail Town

A number of actions have been recommended to control flooding and erosion in Tangail town. Flooding can be prevented by operating the main inlet for all flood events with a frequency up to 1:20 years. To improve drainage the central drain, 2.6 km long, should be re-excavated to an appropriate capacity. Erosion protection work will be required at five sites. Protection measures are being designed by the BWDB Design Office.

2.4.4 Construction Phases

The following schedules for implementation of the construction phases have been proposed (FAP 20 1992d).

Construction Period 1992/93

This phase will include peripheral control by strengthening the horseshoe embankment, including erosion protection work; internal water control in subcompartments 9, 10, 11 (including the adjacent Lohajang floodplain); initial work in subcompartments 1 to 8, and 15 and E1; and implementation of mitigation measures for floodplain fisheries. During this phase a decision will be made concerning gated structures at Lohajang/Sadullapur and between Lohajang and subcompartments 1 to 8.

Construction Period 1993/94

This phase will include completion of the construction work of phase 1 and development of internal water control of subcompartments 1 to 8, E1 and 15, and associated Lohajang floodplain; initial work in subcompartments 12, 13, and 14; implementation of upstream mitigation measures; urban development; and completion of bank protection and river training. During this phase a decision will be made regarding the closure of the southern embankment.

Construction Period 1994/95

This phase includes completion of construction work of phase 2, a decision on construction of the peripheral road, and completion of peripheral control at the southern embankment.

Operation and Maintenance Phase

Activities pertaining to this phase will include operation of gates, maintenance of roads and embankments and drainage channels, development of local institutions for water management, and implementation of an environmental monitoring and management plan.

2.4.5 Developmental Options for EIA

The CPP, as described above, is a deliberately flexible plan of development with several options and courses of action involving both construction of structures and their mode of operation. The project is likely to be developed over a time period spanning several years. From the environmental perspective, this is an excellent mode of development since it provides opportunities to measure the effects of development and to take constructive action to mitigate or eliminate negative impacts before further development is undertaken.

For the EIA case study, which has specific goals related to testing of EIA methods and approaches, the approach presents problems of open-endedness and a lack of clear definition of project actions which can be assessed. To overcome this problem, the FAP 16 team defined two options for the purpose of the case study.

- No intervention (termed "*future without project*") - since conditions in the CPP area are not static and many environmental components and resources are likely to undergo changes over the forthcoming years, whether the CPP is developed or not, it is necessary to assess these changes and to attempt to quantify them to the extent possible. The differences between the *future-without-project* conditions and the *future-with-project* conditions constitute the defined impacts due to the project (ISPAN 1992a).
- Controlled flooding and water management (termed "*future with project*") - the case study considers all the alternatives as components of one option, i.e. the EIA assumes that all the structures proposed by the CPP for alternative IIIA (full river flood control and drainage improvement) will be implemented in a phase-in arrangement. This represents a scenario of maximum likely flow control (and correspondingly maximum likely impact).

A third option was initially considered for inclusion in the case study, i.e. a case of intensive water management which would follow implementation of the controlled flooding development described above and would assume full use of water control and institutional arrangements. Assessment of this option required detailed prediction (through hydrological modelling) of future water levels in each CPP subcompartment. FAP 20, because of the phased nature and uncertainty of actual developments, were not in position to provide this information to meet the schedule of the EIA case study and the option was accordingly dropped from consideration in the case study.

2.4.6 Development of Local Institutions for Water Management

The CPP will initiate a process of consultation with communities and training and development of local institutions. The efforts will include:

- formation of landless contracting societies for re-excavation of khals, construction and maintenance work;
- gradual establishment of water users groups at field level;
- establishment of subcompartmental water committees, composed of representatives of different categories of farmers, fishermen, landless people, women and urban dwellers, as well as pertinent ministries and local governments; these committees in due course will become responsible for operation and maintenance of all water regulating structures in each subcompartment.
- establishment of a CPP Executive Committee composed of district and thana staff of pertinent government departments, local government officials, Tangail town representatives, and representatives of interest groups and non-governmental organizations (NGOs); this committee will be responsible for coordination of CPP implementation activities; the Executive Committee will become the Compartment Water Management Board once a full representation of all the interest group has been achieved (estimated mid 1994); the board will be responsible for the maintenance and operation of all the structures, will guide the project, and will assume the responsibility for comprehensive water management, cost recovery, and future planning when the project is phased out.

It is expected that field level organization of beneficiaries and the establishment of water users groups and subcompartment water committees will be undertaken by the Bangladesh Rural Development Board (BRDB), Department of Agricultural Extension (DAE) and a selected NGO. The project intends to implement a series of training programs for the members of the named local institutions and conduct studies pertaining to institutional arrangement and technical issues.

2.5 Assumptions and Limitations

In the development of both baseline information and quantified projections and predictions, the outputs from hydrological models and GIS processing were extensively utilized. The hydrological models have limitations in that they are based on assumptions such as selective model inputs (against a much wider spectrum of inputs entering into a hydrological process under natural conditions), and calculated, controlled, and predictable model outputs (against a complicated chain of reactions operating under natural condition that often result in unpredictable outputs). In the absence of long term water level data in the project area, a significant level of extrapolation, simulation and correlation has been employed in applying the models for water level projections. The GIS output depends largely on the quality and reliability of the input data. Lack of long term and reliable data on major resources in the project area has been a limitation. This EIA represents the first attempt in Bangladesh on application of combined hydrological modelling and GIS techniques in baseline studies and project impact predictions. As such, several problems pertaining to selection of flood depth data (year, duration and frequency of occurrence) were encountered. These issues are discussed further in Chapter 9.

The EIA's quantified assessment has been primarily based on changes in land types and water level between the baseline condition (1 in 5 year water level, rainfall + river flood) and full flood control (using an approximation to a 1:5 year flood depth under project conditions). Both the baseline data and the projected data used for depicting and computing the changes in land types inevitably carry certain assumptions. A detailed discussion on the concept of 1:5 year land type is provided in Chapter 9.

FAP 20 conducted an extensive socio-economic and field inventory in the project area. These data were made available to, and were used by the EIA team. The team also conducted their own limited data collection. In certain cases reviewers may find differences in baseline and projected data between the FAP 16 and FAP 20 teams. The most important difference is the baseline flood depth computation. This is discussed in Chapter 9.

Chapter 3

METHODOLOGY

The EIA team undertook extensive literature reviews and field investigations, aerial photo interpretation in collaboration with FAP 19, and interacted with FAP 20 engineers and project managers. This chapter briefly describes the methodology used for data collection and tabulation on various resources and issues impacted by the CPP.

3.1 Environmental Baseline Description and Field Investigations

3.1.1 Field Data Collection

The EIA team conducted a reconnaissance field visit to the CPP site in March 1992 to tour the project site and the adjacent areas beyond the project's northern and southern boundaries. Initial field data were collected using the Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA) techniques. PRA is a development of the RRA approach in which the communities become involved in investigation and analysis of local issues and problems and how problems could be resolved.

The EIA team undertook field data collection during April and May 1992. Each subcompartment was visited and individual professionals collected data and information concerning their respective discipline. This was achieved through observations as well as discussions with individuals - key informants and knowledgeable persons - and groups of people - households and communities. The team completed data collection for most resources in the entire CPP area within a month. Field data collection on fish production, navigation and Tangail town continued beyond May 1992.

During field work, the team made extensive use of aerial photographs (1:20,000 of 1990 and 1:50,000 of 1983), Spot imagery, BWDB maps, and maps prepared by FAP 20. During field data collection the EIA team met frequently with FAP 20 professionals to exchange and compare information.

Water Resources

Field data on water resources was collected by visiting the rivers, khals and beels. Data gathered from secondary sources was supplemented with information from local sources regarding the depth and direction of flow in different seasons. Emphasis was laid on problems of flooding, drainage congestion, siltation and erosion. Field data were complemented by aerial photo interpretation.

Land Resources and Land Use

A semi-detailed land use survey was carried out to map land use and the cropping patterns of the project area. Physiographic units were delineated from aerial photo interpretation. Traverse lines 1 km apart were identified and which cut across all the major physiographic units in the project area. The land use surveyors proceeded along the traverse lines and filled in a structured questionnaire on land use practices, either by direct observation or from information supplied by local farmers. Mapping unit boundaries for major cropping patterns and infrastructure features were delineated in the field on overlays over the aerial photographs. Complementary data were collected on agricultural practices by interviewing groups of farmers from different land types regarding cropping patterns, crop damage, crop yields, and human and animal labor requirements.

For homestead production, the team used questionnaires divided into two sections. The first section was filled in by field assistants during land use mapping, while the second set of information was collected through RRA. Homestead vegetation data along the rivers and the perennial water bodies (beels) and in urban settlements was collected.

Fish and Wildlife Habitats

For *terrestrial habitats* an ecological area sampling technique was employed. This involved multi-stage stratification of the project area and delineation of sampling units to obtain the maximum possible representation of ecological factors.

- Stage 1 - on the basis of reconnaissance visits and reference to remote sensing imagery, the project area was classified into seven ecological zones (EZ): (a) river banks (b) shorelines of perennial water bodies (beels) (c) areas between a and b (d) urban areas (e) agricultural land (f) roadside vegetation and (g) fallow land.
- Stage 2 - ecological subzones (ESZ) were delineated within the homogeneous parts of each ecological zone according to vegetation and species composition, based on land use survey findings, aerial photographs and the agroecological zone (AEZ) maps (FAO 1988).
- Stage 3 - ultimate sampling units (-USU), ranging from 0.08 to 0.7 ha in size were selected for in-depth investigation of wildlife and their habitat.

For identification of *aquatic habitats* aerial photo interpretation was followed by field checks. Depending on seasonality, wetland habitats were broadly classified into two groups: perennial waterbodies that remain inundated throughout the year, and seasonal waterbodies that are inundated for less than a full year. Using the hydrological model, water level maps and data were produced for selected dates to compare the changes in inundations between baseline and "with project" conditions.

Limno-biological tests were conducted in river points and in six beels during the dry months (April-May), and water quality parameters were tested in segments of the Dhaleswari, Pungli, Lohajang and Elanjani rivers. A Hach portable water testing kit was used to test the following parameters: dissolved oxygen, carbon dioxide, alkalinity, hardness, chloride, ammonia, nitrite nitrogen and pH. Surface water samples were taken at a distance of 1-2 meters from the bank. Plankton samples were collected using a plankton net. Ten liters of water were filtered through the plankton net at two points at each of the selected wetland. Plankton samples were preserved in 5 percent formalin and later examined under a compound microscope using a plankton identification key (Alfred *et. al.* 19-73). Benthos samples were collected along the shorelines from two points in each of the selected wetlands using an Ekmann grab. Benthic invertebrates were identified alive. Aquatic macrophytes were identified through direct observation. Macrophytes were classified into four major groups: marginal, submerged, emergent and floating.

Fisheries

Open water capture fisheries: the team studied the fish community and population by observing fish markets and fish catches at different fishing sites during April-May, 1992. Fish communities of the area were classified into four groups: carps, catfishes, snakeheads and small fishes. Possible fish migration routes, including canals and rivers, were observed during the same period. Information on fish movement through canals and rivers was collected through interviews with fishermen and local villagers living around the canals and rivers. Information on fishing gear, catch per unit effort and fish production was collected directly from the field by observing the gears and catches as well as by interviewing fishermen. Data on beel, river and subsistence catches were collected from the FAP 16 special study (ISPAN 1992c) reports. Bangladesh Fisheries Resources Survey Systems (BFRSS) data on fish production in the Tangail area were also analyzed. Information on management aspects of wetland habitats i.e. ownership patterns, stocking and problems related to disease, siltation, closing of khals and sluice gates was collected by observation and interviewing people, including fishermen. Additional data on fisheries management and problems were provided by FAP 20 (1992d) reports.

Closed water culture fisheries: information on culture fisheries was collected directly from the field by observing ponds, interviewing the pond owners in each subcompartment and from the Thana Fishery Officer. Relevant data were provided by BFRSS and FAP 20 (1992b) reports on number of ponds, number of ponds under fish culture, cultured species, sources of fish seed, production management, annual fish production, marketing, and constraints to culture fisheries.

Wildlife

Appropriate sites were visited at different times during the day and in specific locations within the terrestrial and aquatic EZs for identification of wildlife species. Numbers of individuals per species per unit area within each USU were estimated. Food consumption by each wildlife species was observed. Endangered and threatened wildlife species were identified, along with their critical habitats and potential causes of decline. Commercially important wildlife were identified and information on harvesting and hunting collected from knowledgeable local persons: hunting/trapping/harvest techniques, amount of harvest, seasonality, annual return for local consumption/export, and ecological gains or losses due to harvests in each EZ and in other selected locations.

Socioeconomic

The team collected primary data from 42 villages in the CPP area and in three adjacent areas. Villages within each subcompartment and the adjacent areas were selected according to hydrological features, key geographical locations and occupational groupings.

The team held informal discussions with individuals and groups from different social categories in the selected villages using an interview guide. The socioeconomic categories included :

- thana and union parishad chairmen and members, and local government officers;
- local NGO staff, and village and community leaders;
- college and school teachers;
- doctors;
- large, medium, small and marginal farmers, and landless laborers;
- fishermen, boatmen and boat builders;
- home based producers, such as weavers and potters; and
- women from the above social categories, including female heads of households.

Information collected covered a wide range of social and economic factors including occupation, income, employment, perception of flood related problems and remedies, gender issues, education, health, land tenure and the like. The data complemented the socioeconomic survey data collected FAP 20 (1992b, 1992c) and published government statistics.

Hazards and Risks

The team collected information concerning sedimentation, bank erosion, waterlogging, embankment breaching, floods and health hazards through field visits and observations, group discussions and interviews with local government officials, the thana health complex and pertinent NGO officers.

3.1.2 Application of GIS and Modelling

Geographic Information System (GIS)

GIS technology was provided by the FAP 19 team to establish an environmental profile for the project area and to develop data sets for prediction of the project impacts. Maps used in this report were produced in pcARC/INFO on ERDAS software and the tabulations provided were calculated using ERDAS software. Spatial data from the EIA field studies were traced onto a stable film base at a scale of 1:50,000. Tracing was done from field interpreted and/or aerial photo/satellite overlays by either the FAP 16 EIA team or the FAP 20 CPP team. After digitizing each film overlay, a plot was prepared at 1:50,000 scale for comparison with the overlay provided. Mouza boundaries were digitized from the Small Area Atlas (SAA) published by the BBS at a nominal scale of 150,000. Digitizing was accurate to approximately 30 to 40m for all digital themes except for mouza mapping, where the error was about

100m. The area of roads and similar features has not been calculated accurately due to lack of specific information. Figures provided for cultivated land include a portion of land that is actually unavailable because of roads or borrow pits.

Hydrological Models

A mathematical model was used by FAP 20 to develop flood water levels under various scenarios for assessment purpose. This model is based on MIKE 11 software and was upgraded by FAP 20 specifically for the Tangail area. The CPP model consists of two modules: the hydrological NAM and the hydrodynamic module. The outputs of the model are volume and water elevations at river cross sections and flooded areas. The GIS was used to create a digital elevation model (DEM) for the CPP. To develop the baseline (existing conditions) land type, a 1:5 year flood level (rain and river flood) was calculated by FAP 20 for each subcompartment, based on historic water level data collected at the Jugni gauging station and correlated to points within each subcompartment. For the "with-project" land type, the 1:5 flooding level proved very difficult to compute through standard means and, following extensive discussion with FAP 20 and careful review of water level hydrographs of different years and seasons, the modelled water level of July 16, 1991 was used to approximate the 1:5 water flooding level.

3.2 Scoping, Bounding and Selection of Important Environmental Components

Following the field reconnaissance, the EIA team began the process of scoping, bounding and selection of a set of Important Environmental Components (IECs). During the scoping those IECs pertinent to the CPP were identified for more detailed study. The IECs were ecological components and processes that were responsible for the maintenance and functioning of such components and/or resources of particular value to communities within the project area. IECs pertaining to water, land and biological resources and uses, and to relevant socio-economic issues were selected. IECs relevant to potential impact of the project in the urban areas were later identified as pertaining to drinking water/groundwater sources, flooding hazard and associated health issues in Tangail town, the main settlement in the project area. The list of IECs and the quantified impact assessment are presented in chapters 6 and 7, respectively.

The EIA deals primarily with the area within the CPP boundary as defined by FAP 20. It is recognized that the impact of the CPP will probably extend beyond the boundary of the project area in respect of the following.

- Areas up- and downstream of the CPP will be affected by backwater and flow changes as a result of water regulation through the CPP. This may caused sequential changes in water-dependent resources and activities such a fisheries and navigation.
- There may be shifts of people, goods and services beyond the CPP boundaries which are affected by the CPP itself, e.g. movement of laborers in to seek employment or movement of landless and displaced people out.

The hydrological changes beyond the immediate CPP boundaries were investigated with the assistance of the Surface Water Modelling Centre (SWMC) who applied their existing North Central Regional Model (NCRM). The NCRM consists of two modules, east and west. For the CPP simulation, only the western submodel was required. The entire model was run with boundary conditions set as for the western portion of the North Central Region; the boundary thus extended all the way from the Futikjani River in the north and the Jamuna River to the west to the Bangshi River in the east and the Kaliganga River in the south. The model was run for three selected years - 1988/89 (high flood year), 1989/90 (low flood year) and 1991/92 (average year) for two scenarios - with- and without the CPP in place and operated as per described in Chapter 2. Differences between the two scenarios for 20 model nodes were plotted by SWMC, and interpreted by the EIA team in terms of potential impacts.

Socio-economic changes outside the CPP area were assessed on the basis of data and information received via the FAP 20 household surveys (FAP 20 1992c) and the EIA field RRA data.

3.3 Impact Assessment and Analysis

3.3.1 Approach

The team developed an environmental baseline description for the CPP area. Significant project actions were assessed using network analysis (ISPAN 1992a), the FAP 20 hydrological model and the relevant GIS output maps and tables. The assessment began with establishing an environmental trend under an assumed scenario of no intervention. In most cases the past trend was extrapolated as a basis for future predictions. The impacts of the project were predicted and assessed from consideration of GIS analyses, modelled water levels and consideration of the effects of other FCD/I projects in Bangladesh (e.g. FAP 12 1991). This was followed by development of a series of recommendations on mitigation, enhancement and monitoring for the environmental management plan. Economic indicators were identified for trend analysis and impact evaluation. Changes in various IECs under "with project" option were computed and assessed against the baseline condition and the future without project under the underlying assumption that the first phase of the project would be implemented in late 1992.

3.3.2 Assessment and Scoring

The case study has adopted the methodology described in the EIA Manual (ISPAN 1992a) for project impact assessment and predictions. The project assessment of specific IECs was carried out by individual EIA team members whose expertise was relevant to the IECs assessed. In order to perform the assessment within a uniform format and criteria, the concepts of sustainability and reversibility were defined clearly and the assessment scoring was allocated following a well defined and stepwise structure. Assessment and scoring were performed on predicted (quantified or subjective) impacts of the proposed project actions on specific and individual IECs.

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

The following procedure was used to quantify and assess the project impacts.

- IECs were grouped based on the type of resource, resource use and resource user.
- Impacts of project actions on the IEC(s) were assessed sequentially to differentiate between cause (project action) and effect (impact)
- Changes to IECs expected over time without the project were assessed, quantified where possible in terms of areas gained or lost, or tons/year yield gained or lost, and the changes converted into percentages.
- The gains or losses as a result of project impact(s) were assessed at two levels of comparison - against the pres-

ent baseline conditions, and against the future likely levels in the absence of the project. The latter comparison, i.e. between future-without-project and future-with-project, is the defined measure of impact (ISPAN 1992a).

- Mitigation measures were recommended to reduce the effects of the impact in the case of negative impacts, and enhancement measures were recommended to increase the benefits in the case of beneficial impacts on IECs.

The EIA guidelines (FPCO 1992a) require scoring the impacts. The scoring method described herein (Table 3.1) has been structured primarily along the same principles as outlined in the EIA Manual (ISPAN 1992a). The scoring was done within an 11 point scale from -5 to +5 depending on the type of impact.

The current EIA guidelines (FPCO 1992a) suggest weighting of the impacts as products of the relative importance of the environmental components and the relative magnitudes of the predicted impacts, and a summation of these products as a measure of the overall impact of the project. This exercise was not undertaken in the current case study. The EIA team's efforts were aimed at providing an unbiased assessment and scoring of specific IECs and presentation in the report for consideration by management and the decision makers. It is believed that the decision and determination as what resource or resource use is more important than others is up to the decision makers and not individuals in the EIA team. By definition, IECs are all important, and components and resources with low weights are automatically excluded in the scoping process.

3.3.3 Cumulative Impacts

Due to the complex and highly branched nature of rivers and distributaries in the north central region where the CPP is located, it would be expected that flow control in one area would affect hydrological conditions in adjacent areas, and consequential impacts might occur in such areas. Two specific projects might have interactive and potentially cumulative impacts with the CPP.

- Jamalpur Priority Project - located approximately 40km to the north of the CPP and would consist primarily of an embankment along the left bank of the Jamuna plus various water management and flood proofing works. The main linkage to the CPP would be via changes in the water levels in the Jamuna induced by the embankment, and consequential changes in water levels in the distributaries supplying the CPP, notably the Dhaleswari River. This possibility was noted, but not studied further following analysis of the potential interactions with the closing of the northern intake of the Dhaleswari River.
- Jamuna Bridge - a major bridge plus approach roads crossing the Jamuna River between Porabari and Sirajganj. The eastern approach road would block off the northern intake of the Dhaleswari River (Jamuna Bridge Authority, pers. comm.). The interaction between this and the CPP was studied with the use of the SWMC's NCRM (see section 3.2 above) by comparing water levels in the distributaries above and below the CPP under two scenarios - with the CPP only and with the CPP plus the Dhaleswari closure in effect.

3.3.4 Economic Evaluation

Changes in income and employment and the distribution of income are the primary economic measures of the impacts of the proposed project actions. This EIA assesses the economic impacts of the proposed CPP in terms of these measures through an assessment of the basic underlying factors that cause changes in them. For example, net farm income is not directly quantified in the EIA but can be estimated from changes in cropping patterns, yields, production inputs and crop flood losses that determine net farm income. Similarly, the EIA provides information on important inland waterway transpor-

Table 3.1 Criteria for Scoring Impacts on IECs

Positive (Beneficial) Impact	Negative Impact
Sustainable	**Irreversible**
Less Sensitive	*Less Sensitive*
High Magnitude and Immediate (+4)	High Magnitude and Immediate (-3.5)
High Magnitude and Gradual (+3.5)	High Magnitude and Gradual (-2.5)
Low Magnitude and Immediate (+2)	Low Magnitude and Immediate (-2)
Low Magnitude and Gradual (+0.5)	Low Magnitude and Gradual (-1.5)
Sensitive	*Sensitive*
High Magnitude and Immediate (+5)	High Magnitude and Immediate (-5)
High Magnitude and Gradual (+4)	High Magnitude and Gradual (-4)
Low Magnitude and Immediate (+3.5)	Low Magnitude and Immediate (-3.5)
Low Magnitude and Gradual (+1.5)	Low Magnitude and Gradual (-2.5)
Sustainable with Mitigation	**Reversible with Mitigation**
Less sensitive	*Less sensitive*
High Magnitude and Immediate (+2.5)	High Magnitude and Immediate (-2)
High Magnitude and Gradual (+1.5)	High Magnitude and Gradual (-1.5)
Low Magnitude and Immediate (+1)	Low Magnitude and Immediate (-1)
Low Magnitude and Gradual (+0.5)	Low Magnitude and Gradual (-0.5)
Sensitive	*Sensitive*
High Magnitude and Immediate (+4)	High Magnitude and Immediate (-3.5)
High Magnitude and Gradual (+3)	High Magnitude and Gradual (-2.5)
Low Magnitude and Immediate (+2.5)	Low Magnitude and Immediate (-2)
Low Magnitude and Gradual (+1.5)	Low Magnitude and Gradual (-1.5)
Non-Sustainable	**Reversible**
(Sensitivity does not apply)	*Less Sensitive*
High Magnitude and Immediate (+2)	High Magnitude and Immediate (-1.5)
High Magnitude and Gradual (+1.5)	High Magnitude and Gradual (-1)
Low Magnitude and Immediate (+1)	Low Magnitude and Immediate (-0.5)
Low Magnitude and Gradual (+0.5)	Low Magnitude and Gradual (-0.5)
	Sensitive
	High Magnitude and Immediate (-2.5)
	High Magnitude and Gradual (-1.5)
	Low Magnitude and Immediate (-1)
	Low Magnitude and Gradual (-0.5)

tation routes, markets and points of origin and destination, and this can be used to estimate changes in transportation costs, incomes and employment.

This EIA does not evaluate the economic feasibility of the CPP. That evaluation is part of the project feasibility study and follows the Guidelines for Project Assessment (FPCO 1992b). The EIA presents and assesses the basic underlying environmental resource determinants of income, employment, and the distribution of income under baseline and with-project conditions. The most significant factors included in the analysis of the CPP economic impacts for the three major sectors affected by the project are as follows:

- Agriculture
  - production of crops and gross value of crop production
  - hired farm labor; total, peak-season, and off-season
  - wages of hired farm laborers, peak-season, and off-season
  - land tenure (ownership, farm size, and terms of sharecropping)
- Fisheries
  - total production
  - direct consumption by catching (households)
  - quantity marketed and value at market prices
  - employment (total and seasonal)

- Navigation
  - routes and points of origin-/destination
  - large markets
  - types and numbers of boats
  - kinds and quantities of goods

The magnitude of costs are also a consideration for evaluation of potential measures for environmental enhancement and for the mitigation and/or compensation of harmful environmental impacts.

Chapter 4

PEOPLE'S PARTICIPATION AND SCOPING OF PUBLIC OPINION

4.1 Background

Historically the participation of local people in FCD and FCD/I projects in Bangladesh has been limited. Local views were sought on a random basis during reconnaissance studies at the project identification stage. Feasibility studies were conducted without popular involvement, with the result that local environmental knowledge was not incorporated into project design, local needs and likely project impacts were not properly assessed, and potential social conflicts over operation and maintenance were not identified. Since they had not been consulted, local people evinced no interest in the success of projects and often took individual and collective action to overcome detrimental project planning and design deficiencies (FAP 12 1991).

More recently, pre-project meetings and local project committees have proved useful in encouraging beneficiary and local government interest in small-scale flood control projects. However, since these meetings and committees remain dominated by the rich and powerful, the aim of popular participation in planning and design has not been fulfilled. The participation of local people in the planning and design of water management projects is increasingly being recognized as the key to their sustainability. The Government of Bangladesh in its Fourth Five Year Plan has laid down a policy of a "bottom up" planning process for projects, including large multipurpose projects such as the FAP.

The basis has been laid in the CPP for a two-way flow of information between the multi-disciplinary team and the target population. The FAP 20 team has undertaken a comprehensive survey of people's views in the project area on water management problems and measures for their alleviation (FAP 20 1992b). Local and expert opinions have been integrated to formulate alternative project options. These options then will be taken back to the people for further discussion before finalization of the project plan.

4.2 Approach to Participation in the Case Study EIA

The aim of the FAP 16 field work was to complement FAP 20's efforts to involve local people in project planning. Informal group discussions were conducted with men and women from a range of social and occupational categories in 42 villages within 15 subcompartments (see Annex 1). Special attention was given to landless and marginal farmers, and to the various occupational groups such as fishermen, weavers and potters, who are most likely to be affected by project interventions. In three villages discussions were held both inside the embankment which marks the project boundary and immediately outside the embankment in the adjacent impact area. Discussions focused on villagers' occupations and livelihoods, the local agrarian structure, their perceptions of flooding and flood-related problems and their views on appropriate solutions.

4.3 Participation Context

Many of the villagers interviewed were illiterate, but were open, highly responsive and knowledgeable about their local environment. They understood their water management needs clearly and had concrete suggestions to make about measures to be adopted (Annex 1). Illiteracy is no barrier to participation in the CPP planning process. If discussions are held separately with groups of people from similar socio-economic and occupational backgrounds, and with women from these groups, then the poor will feel free to express their views.

Tangail has a history of political involvement, and people are more politically active and aware than in other parts of the country. Field work indicated that villagers had a clear understanding of social issues such as village power structures, concentration of wealth and the processes leading to landlessness. Although those villagers affected regarded the indebtedness resulting from severe flooding, drainage congestion, sand deposition and erosion as contributing to increased poverty and land loss, they still cited payment of dowry as one of the major reasons for landlessness. Death of the head of the household, household dependency ratios and unwillingness to migrate for work were also regarded as important factors.

In areas where people face severe flooding and flood-related problems, they expressed a willingness to take part in a water management program and offered to contribute their labor without payment. Mobilization of those who are not directly affected would be needed to gain their cooperation.

Although in most cases villagers expressed distrust of their elected representatives, they appeared to have confidence in their traditional village matabbars (informal leaders), whom they said represented their interests. Matabbars adjudicate divorce and abandonment cases and land disputes at the salish (village court). Matabbars are always male. Although some are leaders by virtue of their inherited status, the majority are educated medium farmers. The quality of judgement and freedom from bias is the main selection criterion.

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

The Bangla word "*barsha*" means normal seasonal inundation. This floods agricultural land but not homestead compounds. People in one-third of the 42 villages visited regard barsha as a problem. Most villages have not suffered severe flooding since 1988. Three villages - Pichuria, Dhalan and Rupshijatra span the project boundary: villagers inside the embankment said that they were not much affected by normal seasonal flooding, whilst those outside complained that their homesteads were flooded every year. In Rupshijatra village in subcompartment 13 the majority of households are not flood-affected, but the village is highly erosion-prone and agricultural land was subject to sand deposition during the 1988 flood. Villagers inside the road-cum-embankment believe that it should be raised by 0.5 - 1m as protection. However, a community of landless households live on low-lying land outside the embankment. Women indicated that every year homestead compounds are flooded to a depth of about 1m. They have to leave their houses for 15 days to one month and take shelter on the road, or build machas (high platforms) to live on. They drink river water as tubewells are submerged. Unlike the better-off, they cannot store food and fuel and remain in their homes.

Sand deposition affects agricultural production in eleven villages. Land is lost and households displaced due to river bank erosion in six villages. However, in the people's view, drainage congestion is the key problem in the case study area. This was the major finding of the FAP 20 Multi-Disciplinary Subcompartmental Survey (FAP 20 1992b) and confirmed by FAP 16 field work. Drainage congestion was cited as a problem in over three quarters of the discussions. Villagers realize that congestion is caused by siltation of rivers and khals and by man-made obstructions such as unplanned roads. Some khals, e.g. Dainna Chowdhury, Mirer Betka and Bartha khals, have been blocked because of excessive sand deposition on adjacent agricultural land.

Villagers are in favor of excavation and/or re-excavation of khals and, in some cases, the Lohajang River, as the solution to their drainage and communication problems. Drainage improvement was recommended in nearly three quarters of the villages. In one village in the Lohajang floodplain re-excavation of a beel was also recommended. Man-made breaching, particularly of roads, occurs both to drain water out and to let water in, and the lack of bridges and culverts was referred to in 13 villages in relation to poor water flows and communication in the monsoon season. Construction, raising and improvement of roads were proposed in a quarter of the discussions, and raising and construction of embankments in about one-eighth of the discussions.

Proper maintenance of existing sluice gates and construction of new ones were suggested in some discussions, although potters in Enayetpur village said that they would be adversely affected if navigation was obstructed by one of the sluice gates proposed on the Sadullapur Khal. Drying up of water bodies and scarcity of fish are of concern to the three fisherman communities visited. Fishermen said that improved drainage would mean a reduction in their fishing area and loss of livelihood; they would have to change their profession as a result.

4.5 Institutionalization of People's Participation

Impromptu informal discussion with groups of villagers during RRA surveys is an invaluable method for involving local people in the early stages of project identification and planning. The poor and women feel free to voice their opinions in this context. However, efforts to institutionalize participation, e.g. through project committees, run the risk of domination by local powerful political and economic interest groups. For this reason, long-term people's participation in the Tangail CPP should not be based solely on elected bodies such as union parishads. It would also require inputs from genuinely representative local people's organizations which would involve people from all socioeconomic groups and various occupational categories.

Tangail has a comparatively high level of social organization and NGO activity. Village leaders are said to generally represent the interests of all social classes. Participation efforts might benefit from the existing network of formal and informal institutions.

In the design and implementation of specific project interventions, particularly water management in subcompartments, it is recommended that the local knowledgeable people from the various social and occupational groups, including the landless, should be identified and developed as spokespersons. Women from all groups should be properly represented. Regular meetings with spokespersons and village leaders at selected sites, initially to discuss project plans and alternatives, should be the second step in the process of popular involvement through the various phases of the project. Large landowners and other members of the elite should be interviewed separately. In this context a high priority should be given to representation of the interests of those communities living outside the project boundary who may be adversely affected by the project. Meeting sites could be selected according to a range of project criteria, e.g. the degree to which they represent different hydrological features, different land elevations, different occupational groupings and key geographical locations in relation to project interventions. The EIA team believes that the approach described herein will make possible the establishment of representative structures whereby spokespersons are elected from village or mouza level to union or project level committees. During the construction, operation and maintenance phases, any funds allocated should be properly utilized, and committee members should be held accountable for funds dispersed. Success of people's participation in the FAP will depend to a great extent on the development of genuinely representative people's institutions, and the effectiveness of the interaction between these institutions and local elected bodies.

Chapter 5

ENVIRONMENTAL BASELINE DESCRIPTION

5.1 Hydrological Resources

5.1.1 Climate

Climate in Tangail is characterized by dry and mild winters and hot and wet summers. There are four distinctively identifiable seasons: winter (December to February), unstable pre-summer monsoon (March to May), summer monsoon (June to September), and retreating monsoon (October to November). Monthly data for a number of climatic factors in the project area are presented in Table 5.1.

The general trend of the spatial distribution pattern shows that rainfall gradually increases from west to east and from south to north. Average annual rainfall in and around the project area ranges from 1606mm at Atia to 1892mm at Mirzapur stations, respectively.

The three agroclimatic periods include the kharif 1 (March to May), kharif 2 (June to October) and rabi seasons (November to February). The extent of the kharif growing period is 210-220 days, from 9 May to 18 December. The humid period during kharif occurs between 20 May and mid-October with a rainfall of 700 to 1500mm (FAO 1988). The kharif 2 cropping season is most vulnerable to flood damage and insect attacks. The rabi season is most favorable for cropping because of cooler temperatures and absence of damage from flood. The highest potential for intensive cropping rests with the rabi season.

5.1.2 River System and Channel Network

The CPP area covers 16 subcompartments and the Lohajang floodplain (LFP), starting from the offtake of the Lohajang River at Ramdebpur in the NW corner of the project area to Karatia in the SE. The channels in the eastern part of the project area originate mainly from Gala Khal whereas those originating from the Lohajang and Elanjani rivers form the channel network system for the western part of the project (Map 5.1). Gala Khal, connecting the Lohajang River to the Pungli River, forms the northern boundary of the project. The two branches of Gala khal are Boilla (or Sadullapur)
Khal and Rasulpur Khal.

Boilla Khal, originating from Sadullapur, flows through Enayetpur village and enters subcompartment 5 via Sibpur. The Boilla Khal again subdivides into two branches at Kandila. One branch flows southward and enters subcompartment 3 and ends at Beel Gharinda. The other branch flows northward to Bamonkushia village and continues up to the southern end of Burai Beel. From Burai Beel this khal 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 Gugudao 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 through to the construction of a bridge.

The Rasulpur Khal flows southward along the borrow pit of Tangail-Jamalpur road. It flows through subcompartments 5 and 6. One branch of this khal flows through Sibpur village to Baroshila Beel and the other branch flows through Aagbethoir village to Burai Beel.

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

In addition to Gala Khal three khals - Bhatkura, Julfi and Tangail - form the channel network originating from the Lohajang River and running through subcompartments 1,2,3 and 4. Bhatkura Khal connects the low lying areas of subcompartments 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

Table 5.1 Climatological Data of the CPP Area (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 (1988)

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.

The channel system of the western part of the project consists of a number of khals - Jugni, Ghoramara, Kalibari, Gaizabari, Dighila, Sontosh, Deojan and Aloa-Tarini. All those khals originate from the Lohajang River. Within the same network there are Baro and Indrobelta khals, both originating from the Elanjani River. Jugni and Kalibari khals pass through subcompartment 9. The Goramara Khal passes through subcompartment 10. Gaizabari and Dighila khals flow through the southeast of subcompartment 11. Sontosh Khal passes through subcompartment 12 and 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 Birkushia khals, all originating from the Lohajang River make up the channel system of subcompartment 15.

5.1.3 Surface Water and Flood

The CPP area is under the influence of the Jamuna River system. Flood conditions in the Jamuna and its distributaries - Lohajang, Elanjani and Pungli rivers - determine the intensity of floods in the project area. Gala Khal and its branches play an important role in accelerating the flood in the area between the Lohajang and Pungli rivers. Early flood occurs due to rain in April and May. In the absence of proper drainage, the depressions and low-lying areas receive the runoff and remain inundated. During the monsoon, the water level in the area increases as a result of rain/runoff and riverbank overflow. Figure 5.1 presents water level hydrographs of the Lohajang River for selected recent years to illustrate the pattern and variations in water levels.

Water levels in the Dhaleswari River rises towards the end of June when water enters Gala Khal through the 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 flowing east from Gharinda to Suruj market along a road and borrow pit enter the agricultural land (chak) around Parkushia village. From this point, the flood water enters subcompartment 2 through Gugodao bridge and continues toward Hatila Beel through Suruj Khal and floods the areas across its path. Subcompartments 1,2,3 and 4 become flooded as a result of the flood flow through Bhatkura and Julfi khals.

There is no direct flood water flow from the Pungli River into the project area since the Bartha and Suruj khals are closed at their offtake. Similarly, the existing embankment along the Dhaleswari/Elanjani rivers prevents the

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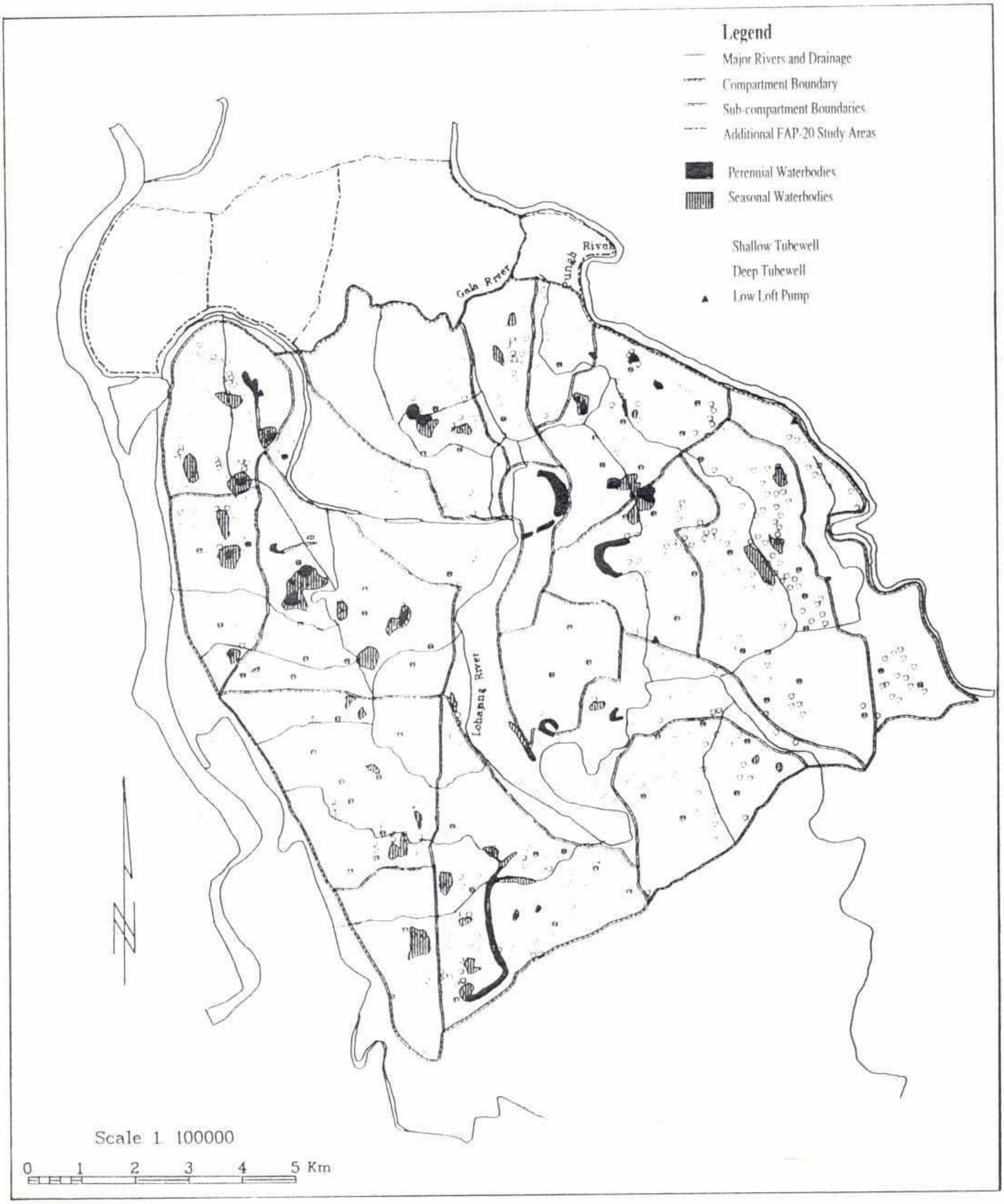
Map 5.1



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Waterbodies and Distribution of Wells

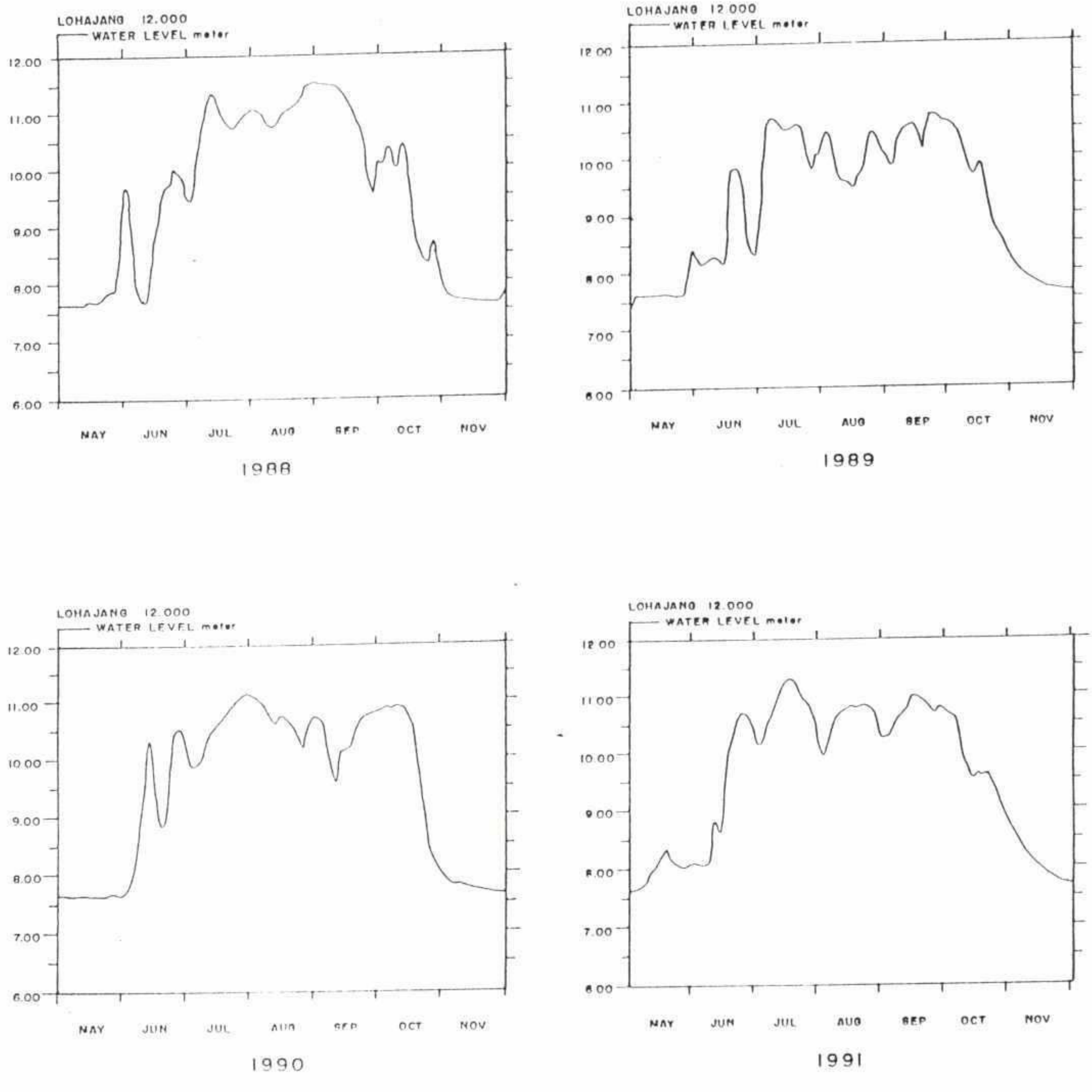


Figure 5·1 Water Level Hydrographs For Selected Years entry of flood water to the project area from those sources.

Flood water enters the areas between the Lohajang and Dhaleswari/Elanjani rivers through the canals and khals originating from the Lohajang. Flood enters subcompartment 9 through Jugni and Kalibari khals. Ghoramara Khal is the entry route of flood water to subcompartment 10 where it spreads over the entire southern part. Sontosh Khal is the flood water entry route to subcompartment 12 and spreads over subcompartment 14 through Aloa-Tarini Khal. Flood water enters subcompartment 15 through Pathrail, Kumuli and Birkushia khals.

5.1.4 Drainage

Drainage congestion has reportedly been the main problem in the CPP area. The existing channel network does not permit adequate drainage. The farmlands located in the low-lying plain are normally inundated by early rainfall in April, May and June. Pre-monsoon drainage does not take place properly because the main channels are either silted up or do not have the capacity to handle the required volumes of water. Poor drainage during this season damages the boro crop at harvesting stage and damages T.aman seedlings. River water entry starts in late June during the high water stage and continues through August or September.

Drainage to rivers begins in and around October when flood waters start to recede. Drainage to the Pungli River does not take place because the khals originating from the river have been closed at their offtake. Two canals, Julfi and Bhatkura khals, function as the main drainage channel though which the flood water from the areas to the left of the Lohajang drains to the river. Julfi Khal connects the low-lying areas of subcompartments 3 and 4, and Bhatkura Khal connects subcompartments 1 and 2 to the Lohajang River. Gala Khal through its two main branches Sadullapur and Rasulpur khals and sub-branches connects subcompartment 7 to the low-lying areas of subcompartment 6 and to subcompartments 5, 3 and 2. As a result, the low-lying areas consisting of Gharinda, Burai, Hatila and Dharun beels, and other low pockets connect either Julfi Khal or Bhatkura Khal through the channel network described above. Pre-monsoon and post-monsoon drainage from this area occurs through these two khals to the Lohajang River when the water level in the river permits drainage.

The existing channels and khals through which flood water enters the area on the right bank of the Lohajang River also function as drainage channels. Drainage occurs through these channels to the Lohajang and Elanjani rivers. Kalibari Khal is the main drainage for subcompartments 9 and 10, and Ghoramara khal serves as the main drainage channel for subcompartments 10, 11, 12, and 14 to the Lohajang River. Barobelta and Indrobelta khals drain the water from subcompartment 12 to the Elanjani River. Birkushia Khal functions as the main drainage channel for subcompartment 15. Most of the drainage channels mentioned above have been either silted up or have inadequate capacity for proper drainage.

5.1.5 Groundwater

There are 616 shallow tube wells (STW) and 76 deep tube wells (DTW) recorded throughout the project area that are used for irrigating about 5500 ha of land (Map 5.1). Hand tubewells are also used for drinking water. The highest STW density (7.9/km^2) is found in subcompartment 9. Close to 50 percent of STWs have been concentrated in subcompartments 2, 8, 9, 11, 14 and the floodplain. DTWs are less frequent in the project area. The highest density of DTW (1/-km^2) is found in subcompartment 15. More than 50 percent of DTWs are concentrated in subcompartments 2, 11, 12 and 14.

Groundwater resources in the CPP are intensively used for irrigation and domestic purposes. Abstraction results in lowering of the groundwater table in the dry season. Ground water hydrographs for 1991 show that recharge during the wet season restores the groundwater table. According to the BWDB (cited by FAP 20 1992d) the highest level of groundwater recorded in the project area for the period 1987-1991 was 12.3m (PWD) and occurred on 22 August 1988. The lowest for the period was 7.0m (PWD) and occurred on 24 April 24 1989. The lowest levels for the period of record occurred between March and April, ranging from 7.0 to 7.9m. The highest levels for the same period occurred between August and October, ranging from 11.1 to 12.3m. The trend of the past five years does not indicate any significant reduction in the level of groundwater in the area as a result of increased number of tubewells and abstraction for increasing demand for irrigation. The fluctuation of the groundwater table in the area over the period 1987-1991 is shown in Figure 5.2.

5.2 Land Resources

5.2.1 Land Types and Land Use

Land types are flood depth phases of floodplain soils. Common practice in Bangladesh is to designate land types according to flood depths during the peak monsoon period are referred to the areas under different flood depth during the monsoon season computed as 1:5 year water levels. A 1:5 year frequency has been recommended by MPO to be used for assessing the agricultural uses (MPO 1986). The areas under various land types, generated through GIS by intersecting a 1:5 water level surface with a digital elevation model, is presented in Map 5.2 and the respective data summarized in Table 5.2. According to these data 71 percent of land (the total area of four land types) in the CPP area is available for cultivation. Actual area under cultivation changes annually and seasonally depending on the flood depth and inundation period. Settlements, including urban areas, account for 27 percent of the area. Water bodies are limited to only 1 percent and rivers occupy the remaining 1 percent of the area. More than 50 percent of the flood free land type (F_0) is found in subcompartments 1 and 14 and the subcompartment designated as Lohajang floodplain, whereas almost 50 percent of the flood prone land type (F_3) is found in subcompartments 10, 11 and 12. According to these figures only 4.4 percent of land in the CPP area is considered flood free (F_0).

5.2.2 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 5.3. These soil series are mapped in soil associations to show their relative distribution in the project area (Map 5.3).

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. Sabhar 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.

Most of the soils have good moisture holding capacity (high to moderate) and are moderately permeable except Sabhar Bazaar soils and silty alluvium which are slow and sandy alluvium which is rapid in permeability. The natural fertility of these soils is moderate to high. Presence of all essential soil nutrients except ammonium nitrogen is satisfactory for producing fair to good crops with minimal fertilizing (Table 5.4). However, for high level production these soils need fertilizer applications and modern soil and crop management techniques.

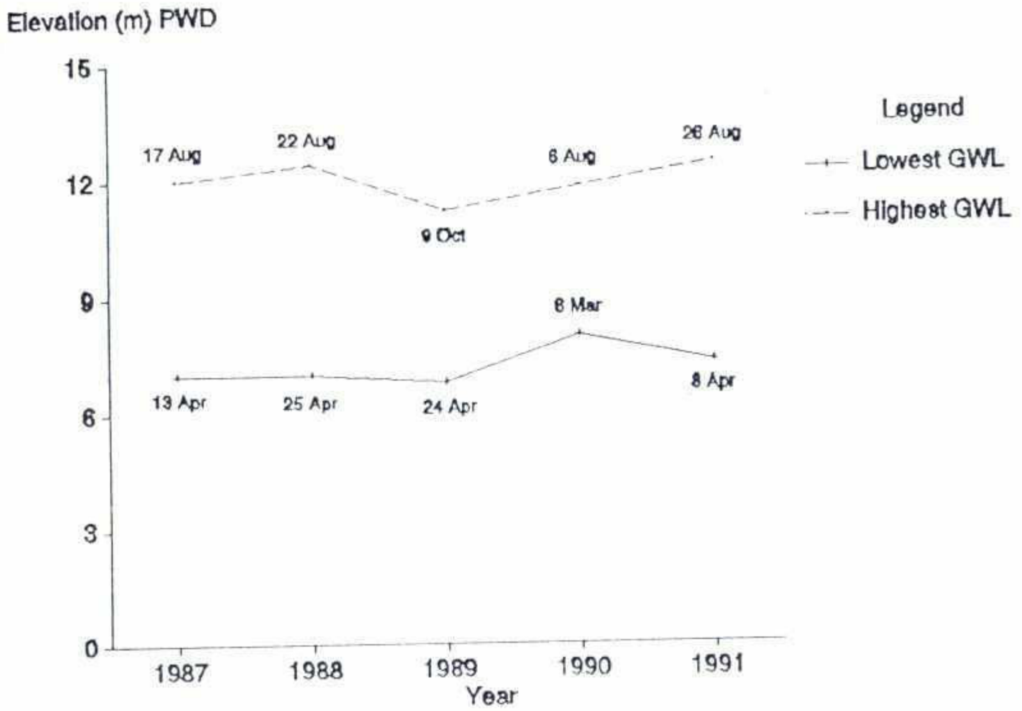


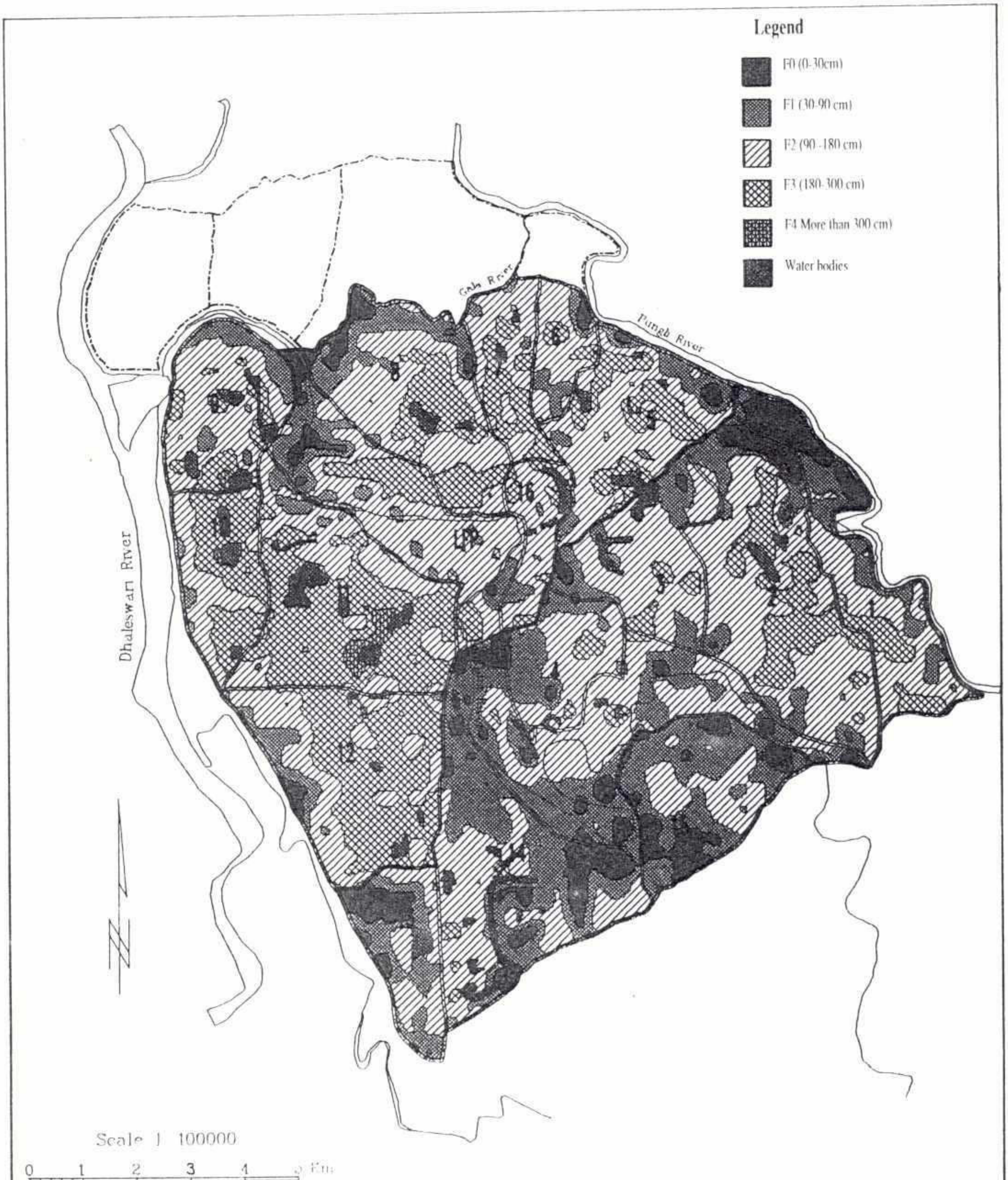
Figure 5.2 Recorded highest and lowest groundwater elevations, CPP study area, 1987-1991.

Table 5.2 Land Types in the CPP Area.

Land Type	Flood Depth (m)	Area (ha)	Area (%)
F_0 (highland)	0.0 to 0.3	576	4
F_1 (med. highland)	0.3 to 0.9	1821	14
F_2 (med. 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		167	1
Totals		13000	100

Source: GIS data base 1992

Map 5.2



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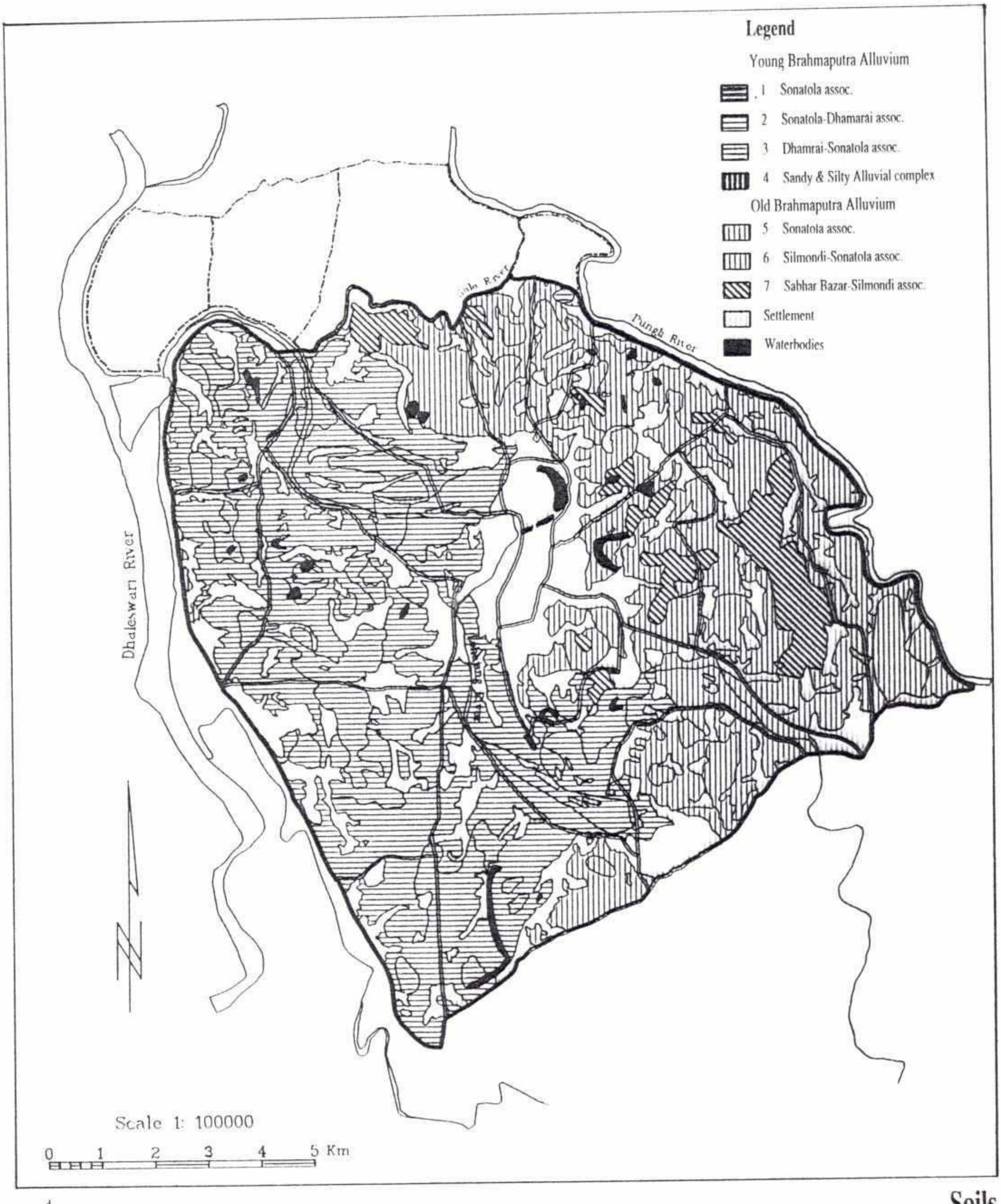
Land Type (1 in 5 Yr Flood)

Map 5.3



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Soils

Physical Limitations for Agricultural Production

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 Bazaar soil series are more deeply flooded and remain wet early in the dry season, thus limiting the growth of dryland 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 6.3 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.

5.2.3 Crops

Cropping Patterns

Cropping patterns in the project area are dictated by hydrologic regime and are essentially based on rice. Pre-monsoon cropping is constrained by drainage congestion, mostly from accumulation of rain runoff. This situation is aggravated in the monsoon season when flooding resulting from high water level in the Dhaleswari, Lohajang and Pungli rivers limits the crop choice. Post-monsoon drainage congestion also acts as a constraint against crop production. Irrigation using groundwater sources is extensively practiced for growing HYV boro rice in the winter season in sequence with high yielding and local varieties of T. aman on F_1 land type and transplanted deep water aman on F_2 land type. Non-rice crops are grown mostly in non-irrigated land in rotation with rainfed aus and aman rice varieties, depending on the land type. Winter crops are intercropped with sugarcane. Cropping patterns presently practiced by the farmers on different land types are summarized in Table 5.5. Maps 5.4, 5.5 and 5.6 depict the cropping patterns currently being practiced in the project area for three cropping seasons - kharif 1, kharif 2 and rabi. Data collected from the land use surveys in 1992 were used as a basis for preparing these cropping patterns.

Agricultural Inputs

Present levels of inputs, including human labor, animal power, seed, fertilizers and pesticides, are generally low. This is particularly true in case of crops that are vulnerable to damage by floods and drainage congestion. The highest quantity of inputs is used in irrigated HYV boro followed by HYV aman and wheat. Fair amounts of fertilizers are used in sugarcane and oilseeds. Pesticides are mostly used in HYV boro. Input use for different crops computed from the data collected in the field are presented in Tables 5.6 and 5.7.

Agricultural Production

Crop production in the CPP area is constrained by flooding and drainage. Pre-monsoon season transplanted deep water aman rice is damaged drainage congestion damages HYV boro and local varieties of aus rice. B. aman including by rapid accumulation of rain runoff in the pre-monsoon season and again by seasonal floods.

Post-monsoon drainage congestion results in delayed transplantation of HYV boro seedling that exposes the crop to damage by early floods.

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 5.8. It appears that a total of 36,356 tons of cereal including 34,376 tons of

Table 5.3 Soil Associations and Soil Series of the CPP Area.

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

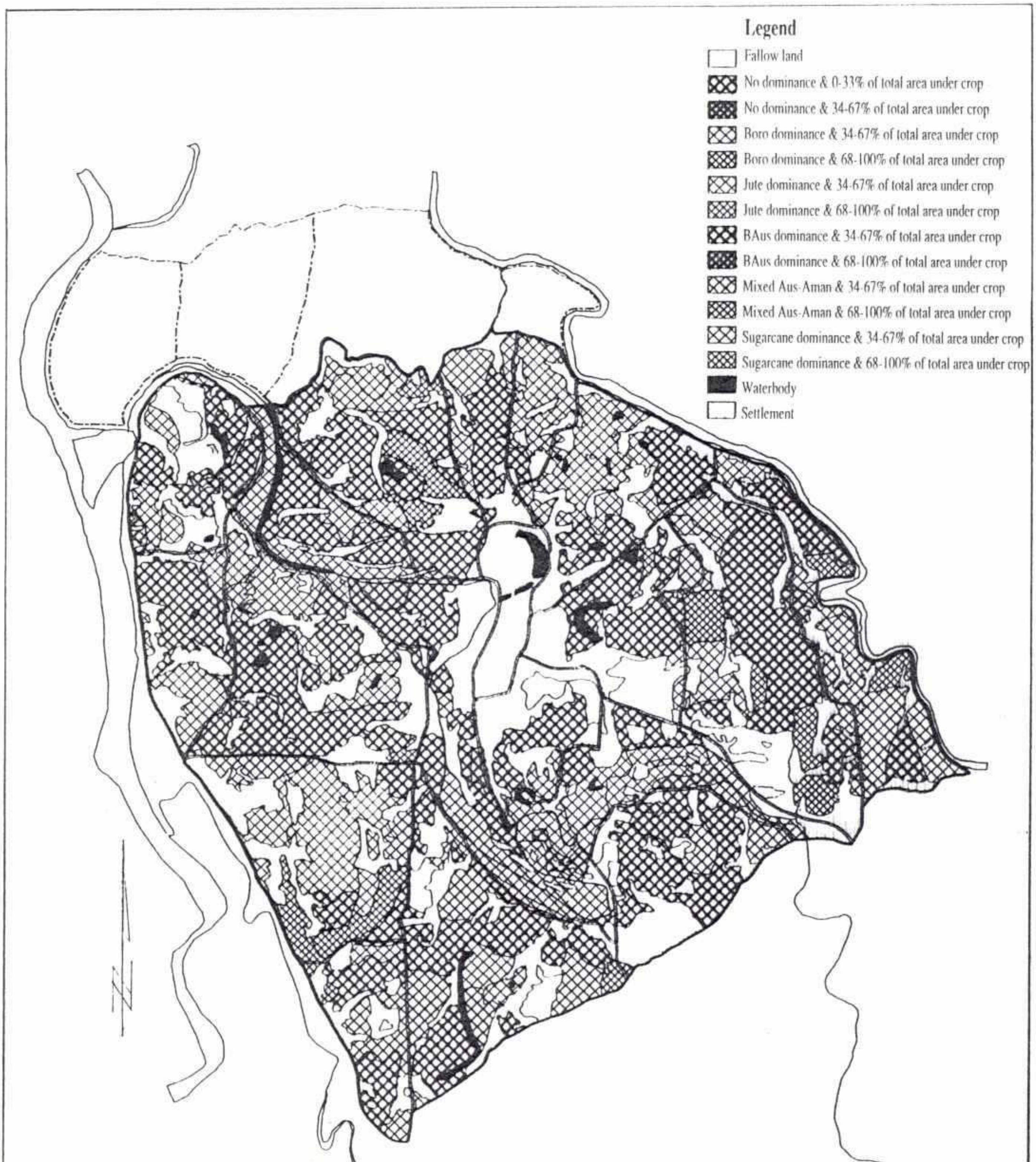
Source: GIS data base 1992

Table 5.4 Fertility Status of the Topsoils of Soils in the CPP area

Series	Land Type	pH	OM %	Ca	Mg	K	N	P	S	B	Cu	Fe	Mn	Zn
				- Me/100 ml -			µg/100 ml							
Sonatola	Medium Highland	5.1-7.9	2.7	6.1	1.9	0.33	25	15	54	0.5	23	213	34	3.2
Silmondi	Medium Lowland	5.6-6.6	3.1	3.7	0.7	0.44	30	12	54	0.7	83	1185	41	3.4
Dhamrai	Medium Lowland	7.2-7.7	2.9	8.0	3.2	0.40	26	16	37	0.35	15	233	25	3.5
Sabhar Bazaar	Lowland	7.8	2.1	7.6	2.1	0.31	25	23	18	0.1	12	39	11	3.0
Silty alluvium	Med. highland	7.6-7.8	2.6	8.9	3.1	0.31	24	13	83	0.8	17	47	28	2.8
	Med. Lowland	7.6	1.2	10.0	3.4	0.38	24	13	130	1.2	10	67	1	3.5
Sandy alluvium	Med. highland	7.7-8.0	1.0	6.4	1.7	0.41	24	13	10	1.2	5	15	4	2.0

Source:SRDI (1990)

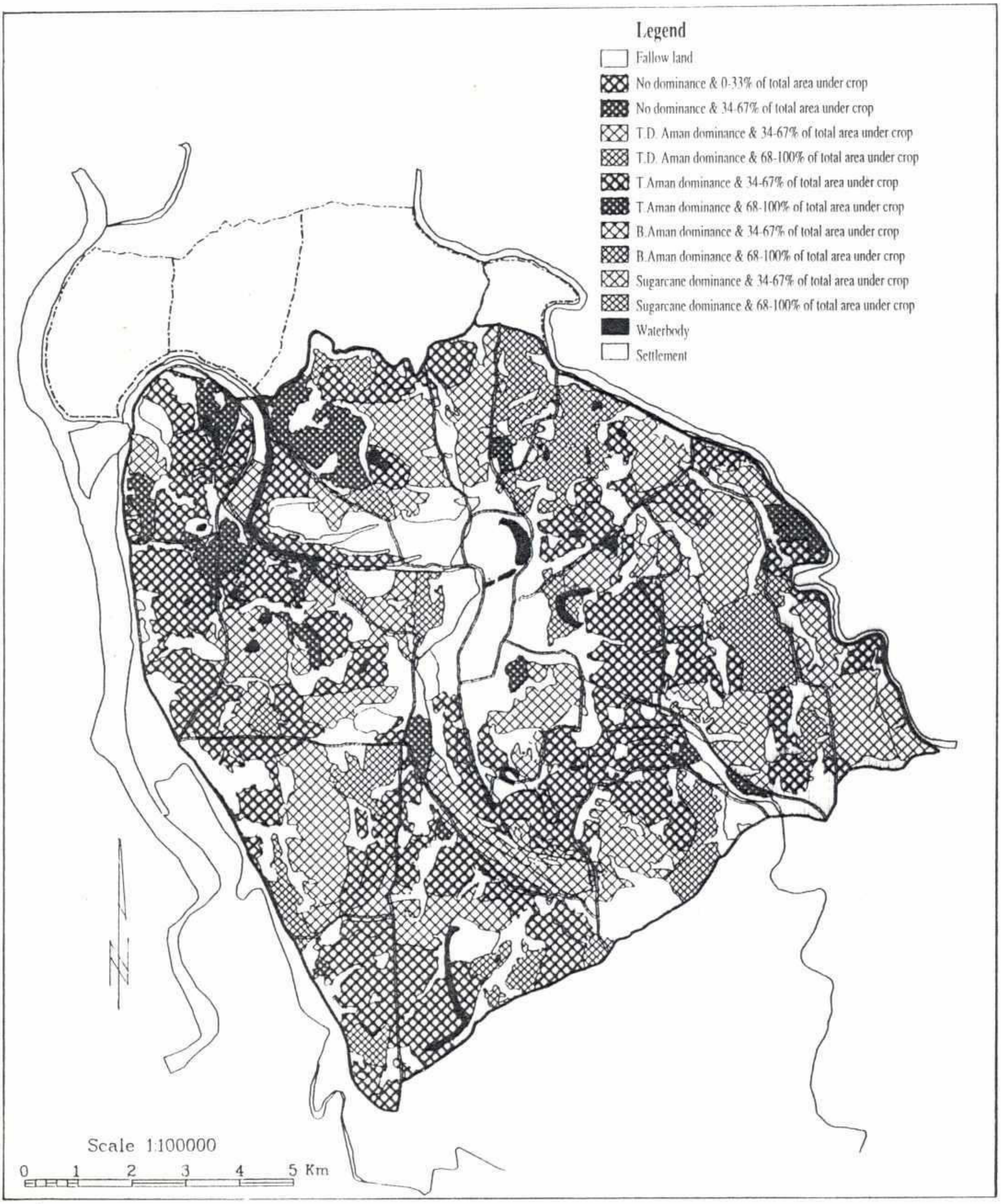
Map 5.4



ISPAN

Kharif 1 Crops

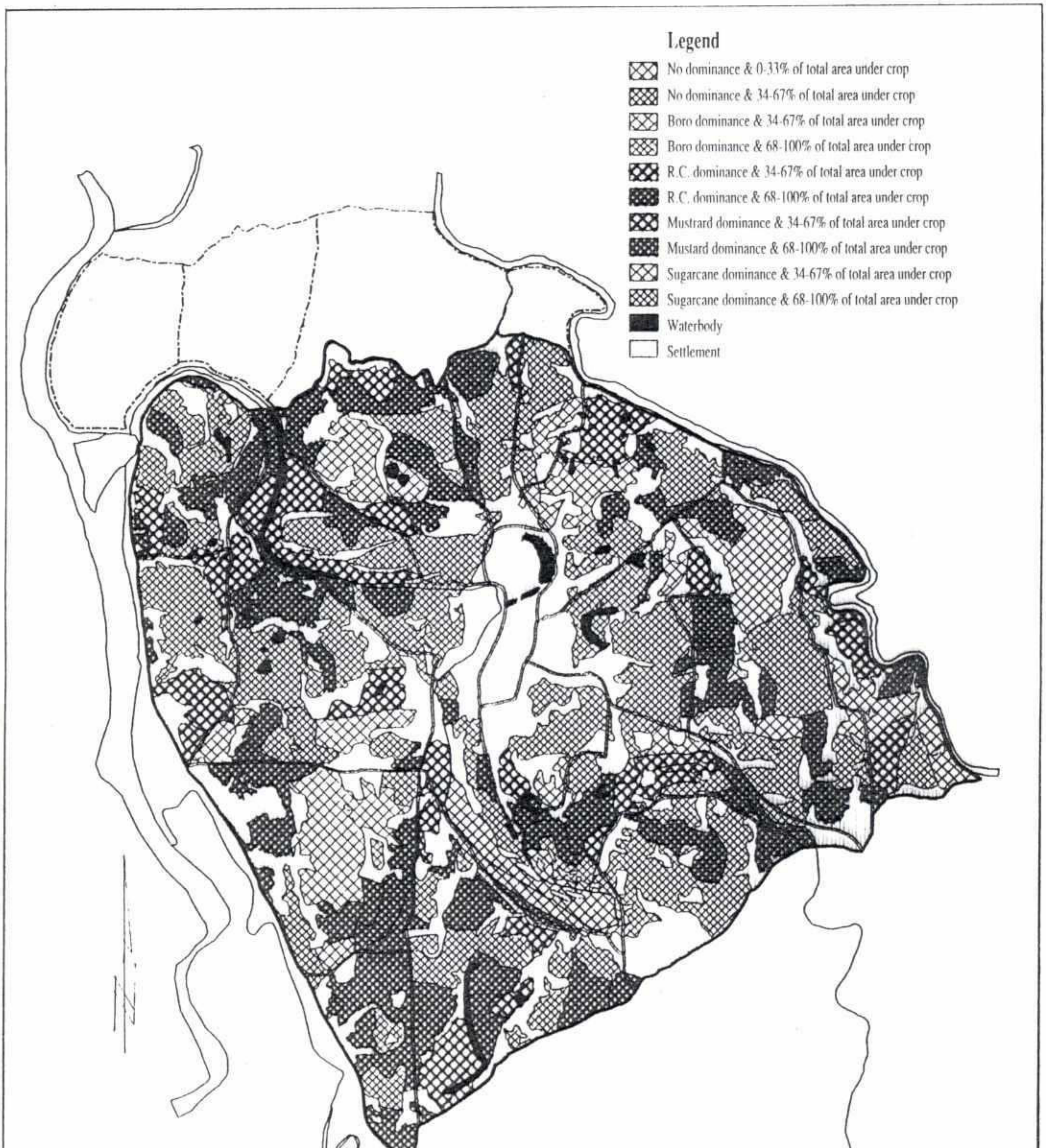
Map 5.5



ISPAN

Kharif 2 Crops

Map 5.6



ISPAN

Rabi Crops

Table 5.5 Cropping Patterns on Land Types in the CPP Area.

Cropping Pattern	Area under Cropping Pattern (ha) F_0	F_1	F_2	F_3	Totals
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 - 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 - Boro(L)	-	-	-	104	104
Mustard - Boro(H)	-	-	268	-	268
Totals	576	1821	4248	2552	9197

Table 5.6 Level of Production Inputs under Current Cropping Systems

Crop	Person-Days	Pair Oxen days	Seed (kg)	Fertilizers (kg) Urea	TSP	MP	Pesticides (kg)
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	-	-	-	-	-

Table 5.7 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)		395	378	182	305	374	250	238	166	55	47	298	363	3051

paddy is currently produced annually in the project area. Farmers lost an estimated 3175 tons of paddy because of flood damage and drainage congestion.

5.2.4 Forest and Homestead Vegetation

Forest and homestead vegetation comprises natural vegetation, plantations and homestead groves and kitchen gardens. Annex 2 presents a list of all trees, shrubs and herbs found in the project area.

Natural Vegetation

The project area does not have any public land for forests. Some naturally grown trees e.g. kharazora, kadam, koroi and chambal, shrubs e.g. kash, dholkalmi, beth and patipata, and herbs e.g. kalmegh, thankuni and kantanotey are found along the marginal lands of roads and embankments, field strips, canal banks and homesteads. These species are economically important because of their role in providing fuel, timber and herbal medicine. They also play an important role in erosion control and serve as windbreaks. Depletion of natural vegetation occurs due to flood damage of young seedlings during excessive flooding and by overconsumption for fuel.

Plantations

Of the 262km of existing roads in the CPP, about 18km have been planted by Upazila Banayan Prokalpa of the Forest Department since 1989 (FAP 20 1992b). Fast growing exotic tree species such as Akashmani, mahogany, eucalyptus and epil-epil have been planted in recent years. Older trees such as babla, mahogany, 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.

Table 5.8 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	406	1.5	78	0.5	648	78
Mix Aus and 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	

L = Local variety H = High yield variety

Homestead Groves and Kitchen Gardens

About 27 percent of the project area is occupied by homesteads. 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 for 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. This land is locally referred to as *palan* and is generally used for vegetable gardening for household consumption and/or marketing. Among the homestead groves betelnut, mangoes, jackfruit, citrus species, bamboos and bananas are the dominant trees found in abundance in the elevated areas. Debdaru is dominant in low-lying areas.

Among the vegetable species brinjal is an important cash vegetable grown in the palans of elevated areas. Cabbage and cauliflower are widely grown in the palans of subcompartments 5 and 6. Arum is an important cash vegetable grown in low-laying palans of subcompartments 1, 2, and 3. Sweetgourd, cucumber and chili are grown in abundance in subcompartments 3 and 4. Excessive rain in early monsoon prevents timely harvest of chili, cucumber and sweetgourd and creates storage and marketing problems.

During the years 1987, 1989 and 1990 flood water reached the homestead mounds and damaged kitchen garden crops in 3 to 10 percent of the farm households. The severe 1988 floods inundated 95 percent of the households. Villagers report that it is normally difficult to establish the saplings of jackfruit, mango, teak and betelnut as well as banana suckers and bamboo shoots in the margins of homestead mounds due to water seepage and waterlogging of the homestead margins.

Energy Use

The main sources of fuel for cooking in the rural parts of the project area are dried leaves, cow dung, jute sticks and crop residues. Tables 5.9 - 5.11 summarize available and collected information pertaining to biomass fuel energy sources, their extent of use, indigenous species, quantity and extent of local energy efficiency. Only about 20 percent of urban households use kerosene as a cooking energy source, while the remainder use fuelwood. Kerosene is used for lighting. Only 42 percent of rural households have electricity (FAP 20 1992d). Landless farmers use dung as their major fuel (85 percent) while the large farmers use dung as manure (67 percent). Any decrease in crop yield because of flood damage and depletion of vegetation due to human activities directly affects the availability of fuelwood. Existing fuel efficient trees such as neem and tetul, grown in and around the project area, are being exploited by ten brick field owners.

Livestock

Livestock are kept in most rural households in small numbers. Bullocks are kept mainly for draft purposes and transportation, and cows for milk. Goat, sheep, chickens and ducks are kept for cash income and as a source of protein. Cow dung is used as fuel in rural areas. Livestock holdings per household range between 0.2 and 2 animal units. Chicken and duck holdings range from 2.0 to 5.7 per household. There is a shortage of draft animals in the project area and farmers often use cows to plow their fields. Availability of draft power is only 1.9/ha in the project area, which is lower than 2.6/ha national average (FAP 20 1992d). The general health condition of the livestock in the area is poor due mostly to common shortages of feed and fodder, lack of grazing land, and diseases.

Feed and Fodder

The loss of natural fodder from low-lying areas due to water congestion causes deficiencies in livestock feed in the CPP area. Livestock is fed mainly on crop residues and by-products. However, the loss of crops due to flood often causes shortages of rice straw and rice bran. Feed deficiency is more pronounced during the months of February - April before the boro harvest, and again in the months of August - October, when aman crops remain in the field. During this period most of the farmers have to purchase high priced feed and fodder. They also feed their animals with crop weeds, grasses and water hyacinth. There is no specific grazing land in the CPP area except for a few parcels along roadsides and river banks. During the cropping and rainy season livestock are commonly confined in the homestead and stall fed. Few cattle and bullocks graze throughout the year.

5.3 Biological Resources

5.3.1 Aquatic Habitat

Wetlands

A variety of wetlands are found in the project area including beels, ponds, borrow pits, khals, rivers and seasonally flooded areas (Table 5.12). Using hydrological modelling the inundated areas for selected dates (May 15, July 30, September 30 and November 1) were computed, representing pre-monsoon, monsoon, post-monsoon (drainage conditions) and post-monsoon (drainage free conditions), respectively.

Table 5.9 Energy Use in the CPP Area

Sources	Percentage Contribution (%)	Dry Season Uses (%)	Wet Season Uses (%)
Cow Dung	20	20	80
Twigs	10	48	52
Leaves	8	95	5
Fuelwood	5	20	80
Husks	13	72	28
Crop Residues	15	73	27
Jute Stick	16	5	95
Straw (Wheat/Rice)	5	80	20
Bamboo	6	48	52
Water Hyacinth	2	80	20
Totals	100		

Source: Field Data

Table 5.10 Energy use in the CPP Area: Use of Indigenous Fuelwood Species

Species	Average Number Per household	Percentage of Households	Extent of Energy Efficiency
Kadam *(Authocephalus cadamba)*	0.2	10	Moderate
Krishnachura *(Delonix regia)*	0.3	20	Moderate
Tetul *(Tamarindus indica)*	0.2	10	High
Shaora *(Strebulus asper)*	0.2	10	Moderate
Kharazora *(Litsea spp.)*	0.2	20	High
Jarul *(Lagerstroemia speciosa)*	0.3	10	High
Debdaru *(Polyalthia longifolia)*	1.4	10	High
Bannay *(Crateavea religiosa)*	1.2	20	Low
Nishinda *(Vitex negundo)*	1.9	10	Moderate
Jiga *(Lannea grandis)*	1.4	50	Low
Neem *(Azadirachta indica)*	0.4	30	High
Pitraj *(Amoora rohitica)*	0.5	40	High

Source: Field Data

Table 5.11 Energy Use in CPP Area: Fuel Deficit and Use of Cow Dung as Fuel and Manure.

Farm Category	Average Family Size	Farmers Deficit in Fuel (%)	Cow Dung use(%) Fuel	Manure
Landless	6	100	85	15
Marginal	5	70	65	35
Small	7	60	57	43
Medium	8	30	55	44
Large	11	20	33	67
All Farms Average	7.4	52	59	41

Source: Field Data

There are 19 perennial beels in the Project area, covering an area of about 133 ha in April and 432 ha in Decèmber (Table 5.12). Of the perennial beels, Atia-Kumuria, Boro, Ghatak Bari, Jugnidaha, Batchanda, Gharinda, Dhurun and Chakran beels contain valuable aquatic habitat. The only river in the project area, Lohajang, 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.

Perennial water bodies in the project area increase gradually in size with the commencement of pre-monsoon 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 period (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.

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 Barobelta 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 Sadullapur 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 form 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

Water samples from rivers, beels and ponds were tested for a number of parameters from March through May (Annex 3). They were found to be generally suitable for fish and other aquatic biota. The overall quality of river and beel water was better than the pond water. The Dhaleswari, Lohajang, Pungli and Elanjani rivers are similar in their chemical composition. A slightly acidic pH was found in Atia (6.9) and Batchanda (6.7) beels that may have been due to the time of water sampling (0900 -0915 hrs). A pond at Kandua, near a Memorial Hospital, had a high concentration of chloride. Among all the beels sampled Jugnidoho currently has the best water quality and Dharun the worst.

The Jamuna Fertilizer Company is located approximately 20km upstream of the CPP area, and discharges factory waste directly to the Jamuna River. Two samples from Jamuna River water downstream of the fertilizer plant taken on 27 March 1992 showed high concentrations of nitrite, chloride and ammonia. According to local people, mass fish kills have occurred due to these discharges.

Plankton

Populations of zooplankton in all sampled beels were found to be higher than those of phytoplankton (Annex 3). 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 clams, 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 Baor,

Table 5.12 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 5.13 Perennial Beels within the CPP Area

SC No.	Name of Beel	Area (ha) December	Area (ha) April	Union	Ownership
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.	Sikdar 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
	Totals	222.3	77.7		

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.

Macrophytes

Overall macrophyte diversity in the CPP area is high. As many as 34 species of aquatic macrophytes were found in nine beel samples (Annex 3). Of the 34 species, 11 were marginal, 8 submergents, 11 floating and 3 emergent. Water hyacinth is the most abundant macrophyte covering, on average, more than 60 percent of the total surface area of the sampled beels. Many wetland bottoms are covered by water hyacinth roots and detritus.

Spirogyra spp.is the common algae noted in the area and 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 pagers 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 provides 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. Macrophytes provide shelter to waterfowl during the breeding season.

Pesticides

Pesticides are widely used in the CPP area for crop pest control. Insecticides are mostly applied in boro fields from mid-March to mid-May. The main agricultural pest is reportedly rice hispa *Diclohispa armigera* (locally known as "*Pamri*"). At least six different insecticides, five organophosphate and one pyrethroid, were observed to be in use by farmers to control rice hispa. Basudin is widely used. The 1992 sale target for Tangail area was 31,400 kg (Ciba-Geigy 1992). This pesticide reportedly is toxic to fish (Fisheries Research Institute 1991). Rice hispa in the area is resistant to pesticides and farmers use repetitive applications (as many as five observed in the area). Most insecticides are directly toxic to frogs, spiders, beneficial insects, earthworms and even mollusks in target fields and adjacent lands.

A number of samples of fish and cow's milk were collected in July 1992 and submitted for analysis by atomic absorption methods (Bangladesh Atomic Energy Commission). Despite being banned in Bangladesh, DDT was detected in pooled fish tissue samples, with residues measured at 21.5 ppb, and in fresh cow milk at 18.8 - 44.4 ppb. The pesticide is apparently in widespread illegal usage in the CPP area. Dieldrin concentrations in fish tissue were 87.9 ppb and 4.5 - 16.9 ppb in milk. Concentrations of endosulfans (71.4 - 201 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.

Wetland Utilization

Wetlands within the CPP are productive ecosystems serving the needs of a human population of more than 190,000 by providing water for drinking, washing and bathing, for irrigating rabi crops, and by supporting fish production. Of the 19 perennial beels in the area, only three are reported to be leased out partially every year by the government, the others remain as common property resources. Fishing by others in the leased wetlands is, apparently, permitted provided that only small gear is used. Children and women fish most of the wetlands in the project area and also collect mollusks for feeding ducks and for lime preparation. Aquatic macrophytes from the wetlands are used extensively as green manure and cattle feed. In nine wetlands sampled, aquatic macrophytes were estimated to provide sufficient fertilizer for 34 ha. In these areas the farmers were noted to use 25 percent less fertilizer than in other areas.

5.3.2 Open Water Capture Fisheries

Fish Diversity

As many as 50 species of freshwater fish and four species of small shrimp have been observed in different habitats inside the project area (Annex 3). An abundance of major carps is reported by fishermen/villagers in the area, and is possibly due to floods from the Jamuna River which is rich in major carp parent stock and fry (Tsai and Ali 1985).

Sensitivity of Fish to Changes in Hydrologic Cycle

The fishing communities in the project area are dependent on, and are strongly influenced by, the seasonal variations of the hydrologic cycle in the rivers and flood-plain of the Jamuna river basin. During the dry season fish fauna in the CPP area take shelter in the perennial beels and pools of the Lohajang River and become extremely vulnerable to overfishing, particularly in beels. At the onset of pre-monsoon rains early in March to May, water levels in rivers and beels increase. The increasing beel water inundates the nearby floodplains. The organic and inorganic matter/residues of dry season agricultural activities are flushed into the beels and provide nutrients essential for biological productivity of the aquatic ecosystem.

During the pre-monsoon period major carps (*Catla* sp., *Labeo rohita*, *Cirrhinus mrigala* and *Labeo calbasu*) from the lower reaches of the Jamuna River and its distributaries and beels begin to migrate upstream for spawning. In the CPP area, however, the major carps remain in the beels and segments of the Lohajang River. Carps cannot undertake spawning migrations due to delays in restoration of connections (through the khals) between water bodies inside the area and the rivers outside. Beel-dependent fishes *Channa*, *Puntius*, *Clarias*, *Heteropneustes*, *Colisa*, *Mastacembelus*, *Lepidocephalus* and *Anabas* spp. remain in beels throughout the dry period and start spawning as soon as the water levels and temperature rise. The early fry of those species use the newly inundated lowlands as their nursery ground. The adults of beel fishes also use the inundated lowlands as their feeding and spawning grounds.

In the early monsoon (May-June) major carps start spawning in the upper reaches of the Jamuna River and continue up to mid-monsoon (July-August). Their eggs, early fry and some adults flow downstream through the Jamuna River and its distributaries and eventually disperse laterally onto the floodplain in the project area through a number of open khals in late June through early August. They spend about 4 to 5 months in the floodplain of the project area (late June to early November) and feed on plankton, benthic invertebrates and detritus while growing into young/subadults. Other species of fish remain in beels within the project area and rivers and migrate laterally onto the floodplain for spawning and feeding. Lateral migration of fish in the early monsoon from rivers to the floodplain takes place mainly during the first few weeks of influx of water.

Monsoon is the peak period for major biological activities of freshwater fish species. Decomposition of plant and animal residues enhances the rapid growth of fish food organisms in the floodplain ecosystem which thus provides a suitable niche for floodplain and river breeding fish to accomplish such biological activities as spawning, nursing, feeding and growth. In the late monsoon (September onward) when floods start to recede, most fish species migrate back from the floodplain to the Lohajang and Pungli rivers through the same khals and perennial beels where they spend the entire dry period. Possibly the adults of riverine fish (major carps and some cat fishes) start emigration earlier than other species.

Migration Routes

Migration of fish, fish eggs and early fry takes place mainly through open khals and, on a smaller scale, through river bank spilling. Migration of fish from the Dhaleswari and Elanjani rivers is restricted because of sluice gates installed at Darjipara, Fatepur, Indrobelta and Barobelta, respectively. Fish from the Lohajang

River immigrate and emigrate mainly through Gaizabari, Aloa-Rajbari, Deojan, Bhatkura, Julfi and Jugni khals. Fish from the Pungli River migrate mostly through Sadullapur Khal and, in limited number, through Rasulpur Khal.

Impacts of Previous Developments

Construction of regulators in four khals at the western boundary of the project has hindered immigration of fish eggs, larvae and adult fish into the floodplain and beels within the project area. Closing of the khals in the northeastern part of the area has obstructed immigration of fish from the Elanjani, Lohajang and Pungli rivers. Construction of a diversion road by closing Boilla Khal on the Tangail-Madhupur road at Sibpur in early 1992 has stopped immigration of fish to the entire eastern part of the project area.

Fish Production

Reliable data on fish production from different open water habitats within the project area is not available. FAP 20 (1992d) has estimated the total open capture fisheries production in the project area at 380 tons/year (Table 5.14).

The overall national trend of fish in the country from the open water resources is declining. It is estimated that open water fishery production in the last 5 years (1983/84 to 1988/89) has declined by 12.8, 8.5 and 7.2 percent in rivers, beels and floodplains respectively. The total production has declined from 459,755 tons in 1983/4 to 414,285 tons in 1988/89 or a decline of 9.9 percent over the same period. The rate of reduction is about 2 percent per year (DOF 1983-89). The fishermen and villagers of the CPP area also reported a gradual decrease in fish production.

5.3.3 Closed Water Culture Fisheries

Culture (pond) fishery is not common in the CPP area. There are about 450 ponds (64 ha) in the area of which 187 (27 ha), 93 (19 ha) and 170 (18 ha) are cultured, culturable and derelict, respectively (DOF 1986).

The constraints facing the pond fishery practices include:

- inundation of ponds by flood water;
- good return from flood-fed derelict ponds stocked with wild fish;
- preference for fishing open water fisheries resources;
- lack of technical knowledge about fish culture;
- fear of fish disease (epizootic ulcerative syndrome) and poaching have made some pond owners reluctant to invest on pond aquaculture;
- lack of technical and financial support from the Department of Fisheries and other agencies.

Fish Culture Practices

The present status of fish culture is at a traditional level. Pond owners do not follow scientific methods of fish production management. They do not prepare the pond, e.g. by eradicating unwanted predator- and weed fishes, liming or manuring prior to stocking with fingerlings. As a result, predator fish feed on the stocked small carp fingerlings (2-5cm), leading to low survival of fish. Weed fishes, on the other hand, compete with carps for food and space resulting in slow growth rates and rendering productive fish vulnerable to various diseases.

The flood-free ponds are stocked in July through September with carp fingerlings. These are collected from fishermen and fish seed hawkers who bring fish seed from hatcheries as well as private nurseries from distant sources mostly outside the CPP area. In many cases, contract fishermen supply fingerlings free of charge on condition that they share 50 percent of the production. Ponds prone to flooding are stocked in October-November after the recession of floodwaters. Data obtained from 15 ponds in the CPP area revealed that the ponds are overstocked. This is a general trend with the other capture fisheries in the country. The stocking density varied from a minimum of 9,880 to a maximum of 54,340 fingerlings/ha with an average of 26,453/ha against the DOF recommended densi-

Table 5.14 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)

ty of 6,000 to 7,500/ha. The size of fingerlings varied from 2.5 to 7.5cm in 14 ponds, and in only one pond were 15 percent of the fingerlings larger in size (12-17cm). No definite stocking rate and ratio was maintained. *Catla* and *Rui* were found as the major species stocked in ponds. The stocked species are silver carp, common carp, *Catla, Rui, Mrigal* and *Tilapia*.

Most of the pond owners do not apply manure and feed for fish. Fish depend mainly on natural food growing in ponds. Some pond owners apply cow dung as manure and mustard oil cake and rice bran as fish feed on an irregular basis. Most of the pond owners do not monitor the growth, survival and health condition of fish. The survival rate of fish, as reported by the farmers, is about 50 percent in ponds infested with unwanted fishes while the same is around 60 percent in ponds that were dried out prior to stocking.

Production

Estimated annual production of fish from ponds varied from a minimum of 529 to a maximum of 1310 with an average of 910 kg/ha/yr. The average production of fish from ponds in the CPP area is lower than the national average (1,055 kg/ha/yr, DOF 1989), which may attributable to inappropriate management discussed above. The rate of production of fish in the CPP area was 1239, 851 and 682 kg/ha/yr in cultured, culturable and derelict ponds, respectively (DOF 1989). The figures for derelict ponds have been incorporated in total production under capture fisheries. The estimated annual total production of fish from ponds within the CPP area is 49 tons/year, which is 11.5 percent of the total fish production in the project 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 percent share or are paid on a daily wage rate basis.

5.3.4 Terrestrial Habitat

During the dry season, approximately 98 percent of the CPP area is available as terrestrial habitat. During the peak flooding period (September), about 63 percent of the area is flooded, and terrestrial habitat is limited to homestead and roadside vegetation and agricultural highlands. The terrestrial habitat of the project area, classified by location and dominant plant species composition, is summarized and shown in Table 5.15 and Map 5.7.

The CPP area provides 81 species of plants that are economically, socially and environmentally important. Among these plants 19 provide fruits, 14 timber, 15 fuelwood, 29 are vegetables and 4 species are shade trees. Bamboo is the dominant plant species in the project area and provides habitat to threatened and important wildlife species (Annex 2).

The abundance of bannay, son, bamboo, kharajora and debdaru is relatively higher in the project area compared to other parts in the country. A variety of bush plants, undergrowth species and climbers also provide habitat to wildlife.

The homestead vegetation areas within the project area are included in TEZ-1 to TEZ-4. Sampling locations for terrestrial habitat study in the project area are presented in Annex 3.

River levee vegetation grows in a linear pattern with Shimul trees occurring randomly along the river banks, while beel edge vegetation is situated in circular patterns. Vegetation close to wetland areas tends to be relatively luxurious in growth. These areas provide common plant species in moderate abundance. Most of the wetland-dependent birds take shelter in this habitat or use them as day/night resting place. Tall trees (e.g. Koroi) close to beels provide shelter to endangered and threatened bird species.

The Inland Densely Vegetated ecological zones are situated in the central part of the project area. These are areas of 5 to 20 ha each characterized by dense vegetation and diverse plant types. F_1 and F_2 land types around TEZ-3 have significant roles in vegetation succession and the number of dominant plant species is higher in TEZ-3. Older trees, situated in these areas, provide shelter to bat colonies and large numbers of other important wildlife species. Some exclusively Sal forest birds take shelter in these areas indicating that the habitat is in a high quality condition.

The urban area vegetation possesses the highest number of exotic plant species. Timber plants such as teak and mahogany have been planted by local people and by officials since the early part of the present century. Banyan trees within the town area are extensively used by bat colonies. House crows build their nests within trees in the town. Mango and litchi are common fruit plants in the urban areas. Unplanned urbanization is destroying other types of habitat in the project area, including the agricultural land habitat. Most of the roadside areas are without vegetation. These areas offer opportunities for plantations to provide food and shelter to wildlife and economic benefits to the rural communities. The agricultural land of the project area provides support to the granivorous and insectivorous wildlife.

5.3.5 Wildlife

The CPP area supports 177 species of wildlife including 5 amphibians, 17 reptiles, 140 birds and 15 mammals (field observations from April to May 1992, Annex 3). Important wildlife resource components within the project area consist of seven endangered and ten threatened wildlife species that directly or indirectly create benefits or disbenefits to human populations. These wildlife are sensitive to ecological changes caused by changes in the water regime. The important wildlife species are grouped according to their function vis-a-vis mankind. Endangered and threatened species have been identified from the National Conservation Strategy checklist (MOEF 1991).

Predators, Scavengers and Insectivorous Wildlife

Predatory and insectivorous wildlife help in vertebrate and insect pest control. Scavengers consume decomposing urban and rural wastes and domestic animal carcasses. Roadside banyan and shawra trees in the project area support 5 species of owl. Indian cobra and rat snake populations are low. These species as well as mongoose and fox play key roles in controlling rat populations. House crows, jungle crows and vultures are scavengers in the area. Vulture populations might decline due to cutting of large trees for the construction of the Tangail-Delduare road. There are four species of frogs, one species of toad, five species of lizards, four species of snakes, and a large variety of birds that consume agricultural pest insects. Bank mynas are important insectivorous birds, and their biological cycle is related to the life cycle of pest insects. Bank mynas consume brood insects during plowing operations. Since they breed in the eroded river banks, the late part of their breeding is affected by high river stage. *Pagers* provide habitat to frog populations.

Map 5.7

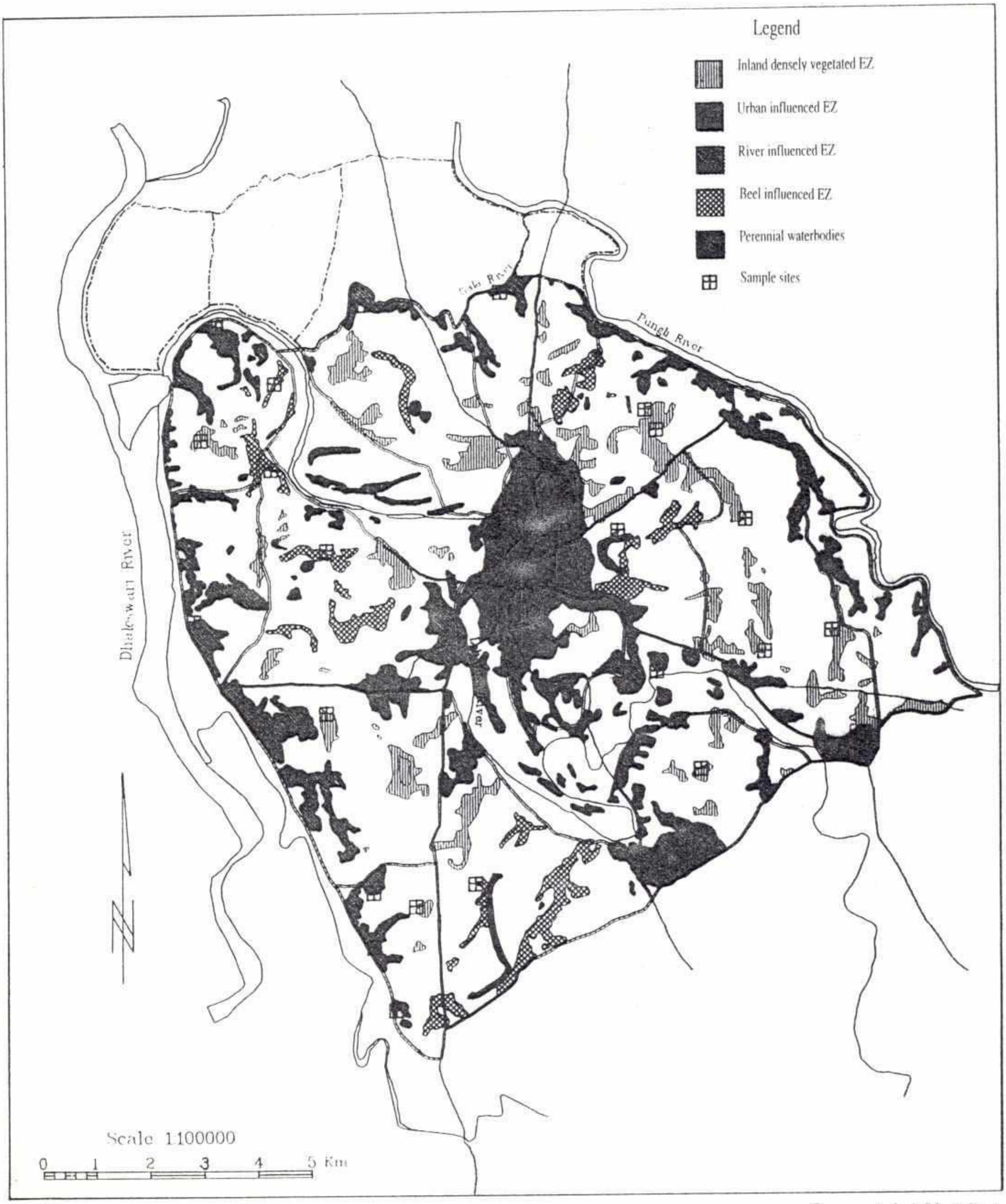

Legend
Inland densely vegetated EZ
Urban influenced EZ
River influenced EZ
Beel influenced EZ
Perennial waterbodies
Sample sites
Pungh River
Dhaleswari River
Scale 1:100000
0 1 2 3 4 5 Km

Table 5.15. Terrestrial Ecological Zones (TEZ) of the CPP Area

Code	Name of TEZ	Dominant Plant Species	Area/-Length	Area %
TEZ-1	River Levee Vegetation	Bamboo, Jackfruit, Banana, Shimul	1503 ha	11.6
TEZ-2	Beel Edge Vegetation	Banana, Koroi, Pitraj	453 ha	3.5
TEZ-3	Inland Densely Vegetated Areas	Bannay, Kharajora, Debdaru, Jackfruit, Mango, Pitraj	809 ha	6.2
TEZ-4	Urban Area Vegetation	Exotic & fruit plants	745 ha	5.7
TEZ-5	Roadside Vegetation	Son, Babla, Koroi, Shimul		
	- Metalled		59 km	
	- Unmetalled		193 km	
	- Embankment		10 km	
TEZ-6	Agricultural Land	Predominantly Paddy	9197 ha	70.8

Pest Wildlife

These are mainly granivorous wildlife species that damage and estimated 7-12 percent of total crop production. Populations of granivorous *Munia* spp. are increasing with the extension of roadsides and their associated grass verges. Among the four species of rats, two species cause significant crop damage. Rats are a problem all over the project area (FAP 20 1992b) and application of zinc poison of different types is a popular rat control measure in the area.

Commercially Important Wildlife

Some of the wildlife in the project area are commercially important for local consumption and export. People from Tangail town and outside Tangail hunt ducks, egrets, herons and other bird species in the wetlands. Atia Kumuria is a popular area with hunters. Most of the birds are hunted by air rifles which do not require licenses. Villagers trap pigeons, egrets, and water hens for consumption. Winter is the peak hunting season. Frogs, monitor lizards, snakes and turtles are the main export item from the project area. Since their export from Bangladesh is banned, frogs have not been extracted from the project area for the past 2-3 years.

Endangered Species

The project area supports a number of endangered wildlife species. With the exception of the large Indian civet, all endangered wildlife species are wetland-dependent. Pallas' fish eagle occurs in very small numbers. A shortage of water in beels during the breeding season is one of the main reasons for low populations. Openbill storks and large whistling teal are locally migrant species. Black winged kites and brown fish owls occur in moderately low numbers. The king vulture has been extinct from Bangladesh for the past 10 years, however local people reported its presence in the project area. Gangetic dolphins were observed in the Dhaleswari River adjacent to the project area. Siltation of river openings and high levels of river traffic do not allow dolphins to move into the project area.

Threatened Species

Among the ten threatened wildlife species in the project area, six are wetland-dependent. Shortage of water in beels during its breeding season is one of the main causes for low populations of pheasant tail jacanas. Flood water helps in the rearing and grazing of yellow monitor lizards. Large trees such as Koroi provide shelter for white backed vultures. Riverside bamboo provides habitat for paradise fly catchers. The Indian pita and the orange headed ground thrush are dependent on Sal (dry deciduous) forests of the Madhupur Tract, and sometimes seek shelter in homestead vegetation of the project area. Population expansion and increased demand for fuelwood consumption have led to extensive wildlife habitat conversion. Annex 3 provides more information on wildlife species in the CPP area.

5.4 Navigation

A combination of road network and navigation routes provides the communities in the CPP area with access to the outside, even during the flood season (except for the deeply flooded areas). The rural road network in the project area is extensive, with 224.8km of unmetalled road, 31.4km of major metalled roads and 6.1km of embankment-plus-road located along the western boundary of the project area. Most of the villages are connected by some form of rural road.

Water transport is commonly used for 3-4 months during the wet season. The Lohajang River passes through the middle of the project area and Tangail town. During the dry season, the northern part of the river becomes completely dry, and roads form the only network for communication, whereas water transport is used solely during the wet season. Map 5.8 shows the important navigation routes and the marketing networks.

5.4.1 Navigation Routes

Most of the eastern and western low-lying parts of the project area were at one time connected to the Pungli and Dhaleswari rivers through a number of khals. These khals used to be navigable and were used by the villagers as transportation routes. Construction of regulators on the western embankment closed off the navigation routes in the northeast of the project area.

Dhaleswari to Chillabari, Pungli to District Bazaar, and Pungli to Jugni Bazaar are the major existing navigation routes in the project area. For the first two routes, siltation of Gala Khal inlet at Jugni has made navigation possible only during high flood season. The longest and the most important route is from Chillabari to the char villages of the Dhaleswari River. This is the only navigation route connecting the project area with the outside for passenger and goods delivery.

5.4.2 Markets

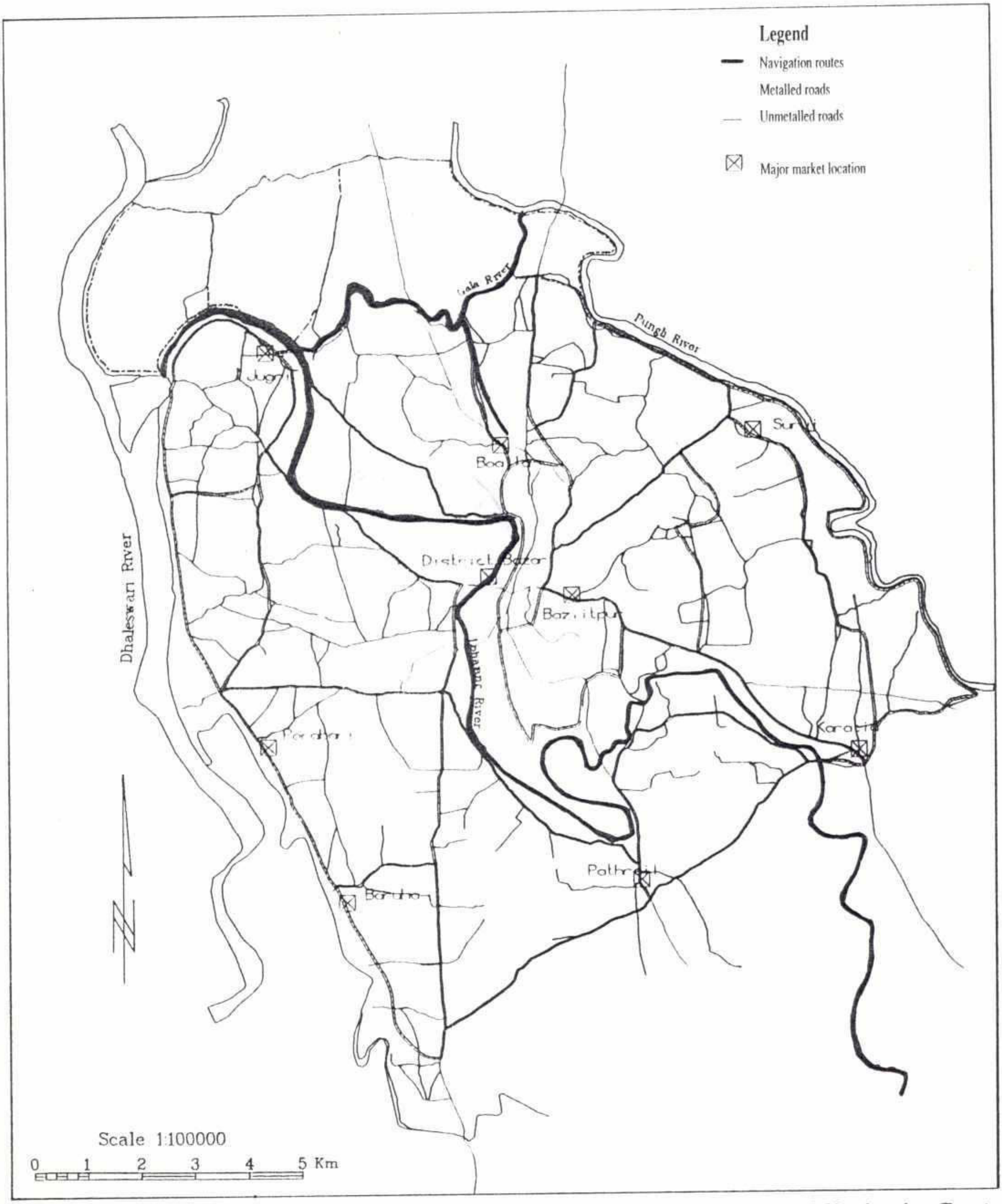
Jugni and Karatia are the two important markets located adjacent to the Lohajang River. A survey at the end of July 1992 showed that about 50 boats, both engined and non-engined, loaded and unloaded at the markets. Jugni is one of the busiest markets in the area and serves most of the Dhaleswari charlands. During the flooding season jute from the charlands is marketed in Jugni Bazaar and shipped to Charabari Ghat and on to Dhaka. Approximately 660 tons of jute, 120 tons of rice and 120 tons of sugar cane is delivered to Jugni of which 575 tons is shipped to Charabari (Table 5.16).

Most of the charlands people of the Dhaleswari River adjacent to northern part of the project area use the Lohajang River as their main route to reach Tangail town. Reasons for the journey are official activities in the District headquarters, access to medical facilities, marketing of goods, etc. During the four navigable months 75 percent of the people travelled by boat during the market day, the remaining 25 percent on the non-market day (Table 5.17).

Except for surrounding villages of Atia Beel, people living in the villages used small country boats for subsistence fishing and carrying goods. Average radius covered by small country boat is estimated at about 500m.

In summary, in spite of a reasonably good road network in the project area, watercourses play an important role in local economy during the monsoon season. Movement and marketing of agricultural goods, crops and fish harvested as well as locally-produced handicrafts and goods are dependent on watercourse transportation. Navigation is a source of whole or supplemental income for boatmen and boat owners in the project area and the neighboring areas. Naviga-

Map 5.8



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Market Locations and Navigation Route

tion is extremely sensitive to water level changes, flooding and siltation in the rivers and khals.

5.5 Human Resources

5.5.1 Population and Settlements

According to the 1981 census the population in the project area was 190,430 of which 97,988 were male and 92,442 female (Table 5.18). There is a large variation in population density between and/or among subcompartments due to the influence of Tangail town and other semi-urban areas (Map 5.9). The project area is densely populated with 1465 person/km^2 in 1981, compared to 605 persons/km^2 for the national average (BBS 1985a). Since the population census of 1991 for Tangail District was not available, an estimate of the 1991 population for the CPP area was made, based on the assumption of national exponential growth rate of 2.17 percent for 1981-91 (BBS 1991) at 236,580 persons. This figure suggests an increase in population density from 1465/km^2 in 1981 to 1820 persons/km^2 in 1991.

Muslims constitute nearly 89 percent of the total population (BBS 1984). Hindus, both caste and scheduled caste, constitute nearly 11 percent of the total population. Buddhist, Christian and tribal communities form an insignificant proportion of the population (BBS 1984).

Settlements are mostly concentrated along the riversides, khals and earthen roads in a linear linking pattern. Settlements in the highlands and beel areas are clustered. Homesteads or residential areas are generally located on higher land. In the low-lying areas they are constructed above the normal flood level.

The project area is connected to Tangail town by an extensive network of earthen and metalled roads including the Dhaka-Tangail, Tangail-Jamalpur, and Tangail-Delduar roads as well as many village paths that crisscross and intersect khals, beels and swamps. During the peak monsoon period, country boats of small and medium size are used for transporting people and freight.

Of the 27 market centers in the project area, Karatia, Pathrail, Bajitpur, Porabari, Jugni, Suruj, Baruha and District Bazaar are the largest. These large markets are effective meeting places. They are geographically central to some 60 to 70 villages and serve as important links between villages and Tangail town. The eight large markets meet daily, while smaller markets meet twice a week. The markets are accessible by major boat routes during the monsoon.

5.5.2 Livelihood and Subsistencee

The rural and household economy is mainly based on agriculture (Table 5.19). Agricultural activities are scheduled in accordance with the regular flooding pattern that is partly controlled by the existing embankments.

Rice is the staple food crop and is produced in more than 80 percent of the total cultivated area. Other important crops are jute, sugarcane, wheat, mustard, pulses and potato. Jute and sugarcane are the main cash crops. Service, business and transport constitute the main occupational sectors for a large number of households in the urban area, while only a few households in the rural area derive their livelihood from such occupations. Inherited community-based profession such as weaving, conch-making, pottery and carpentry is low in the urban area, while the percentage for such categories in the rural area is considerably higher. Historically the CPP area was famous for its cottage industries, especially hand loom weaving and pottery. There are a number of biri factories, brick fields, rice and flour mills in the project area that employ many men and women, although the involvement of women in the labor market is low.

Family labor is often used for crop production and crops are grown primarily for family consumption. Hired and outside laborers are mainly for work during peak agricultural seasons, particularly during sowing and harvesting of HYV boro crop. During the lean agricultural season, the local day laborers either migrate to other areas to seek employment or engage in earth-cutting, biri-making, petty trading and transpor

Table 5.16 Numbers of Boats Travelling to and from the Project Area

Markets	Number of Boats		Incoming (mt)			Outgoing (mt)
	Market Day	Non-Market Day	Rice	S/cane	Jute	Jute
Jugni	75	40	600	120	-	575
Karatia	30	12	-	-	120	-
Baillar Hat	50	20	60	-	-	-
Totals			660	120	120	575

Source: Field Survey 1992

Table 5.17 Total Seasonal Passenger Trips by Boat

Markets	Passenger trip	
	Non-market Day	Market Day
Jugni	41,000	32,000
Karatia	25,000	28,000
Boillar Hat	-	19,000
Totals	66,000	179,000

Source: Field Survey 1992

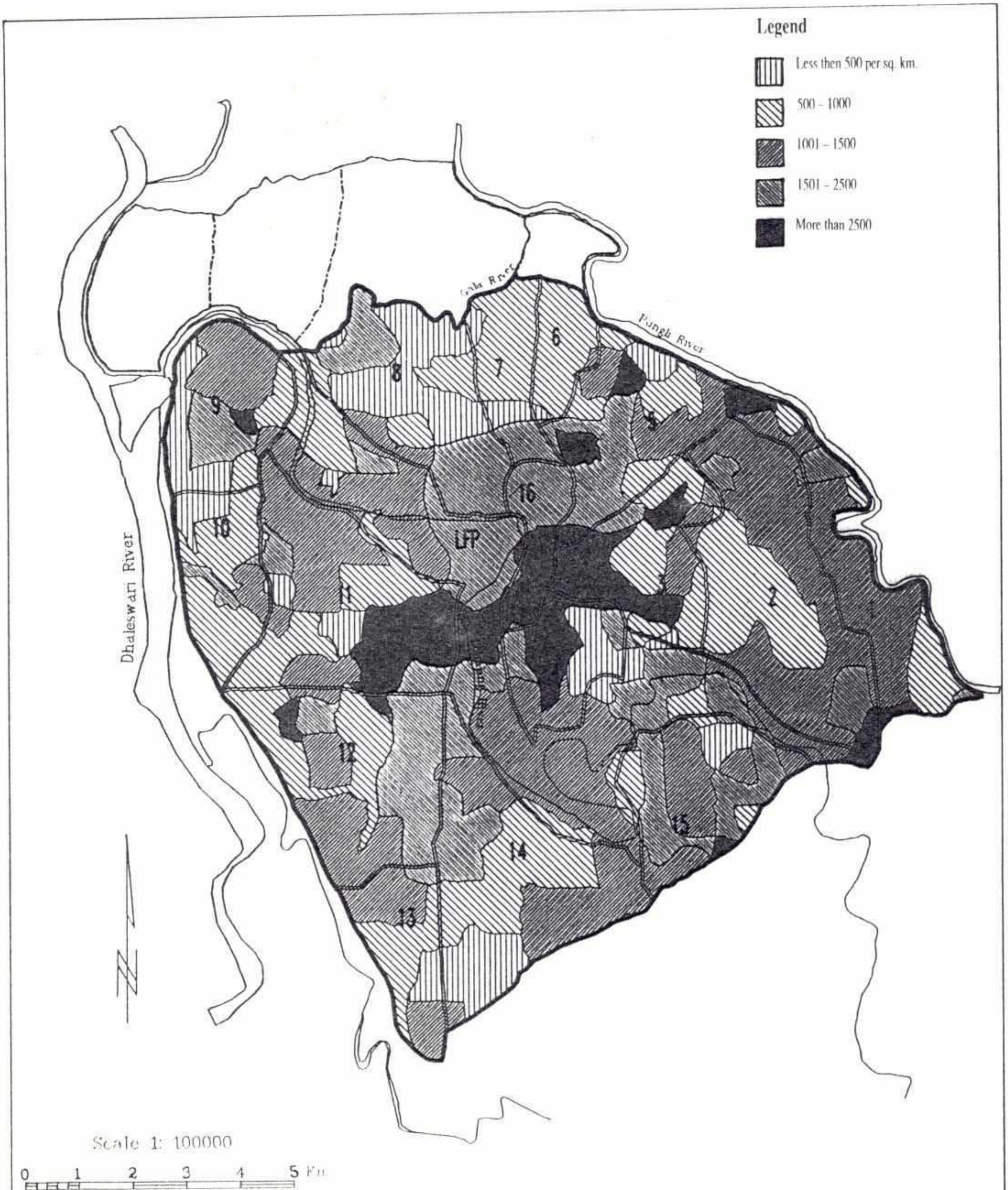
Table 5.18 Total Area, Households and Population of the Project Area by Subcompartments

Subcompartment No.	Area (km2)	No.of Mouzas/-Ward	No. of Households	Estimated Population[1]	No. Males	No. Females	Population Density ($/km^2$)
1	6.9	5	1,409	8,451	4,349	4102	1228
2	12.8	15	2,497	14,984	7,710	7274	1171
3	6.3	9	3,036	18,215	9,373	8842	2891
4	4.2	2	3,031	18,186	9,358	8828	4351
5	7.5	9	2,171	13,028	6,704	6324	1730
6	2.4	6	297	1,784	918	866	740
7	3.6	4	484	2,903	1,494	1409	809
8	9.0	7	1,523	9,138	4,702	4436	1011
9	6.1	7	1,132	6,792	3,495	3297	1121
10	4.9	6	597	3,580	1,842	1738	735
11	11.3	12	2,901	17,406	8,956	8450	1547
12	10.2	11	2,410	14,459	7,440	7019	1416
13	4.3	7	692	4,150	2,135	2015	976
14	11.4	12	1,858	11,150	5,737	5413	976
15	6.9	15	1,481	8,884	4,571	4313	1288
16	2.6	6(ward)	1,706	10,238	5,268	4970	3938
Lohajang Flood Plain (LFP)	19.7	8	4,514	27,082	13,935	13147	1375
Total CPP Area	130.0	135	31,739	190,430	97,988	92442	1465

[1] Population densities and total population have been calculated using the population figures from the Small Area Atlas of BBS (1981), Population Census and FAP 19 GIS-calculated mouza areas.

Source: ISPAN, GIS database for the CPP (1992)

Map 5.9



Population Density

ISPAN

tation work (rickshaw/van pulling) in their own locality. The daily wage rate for agricultural laborers varies between 15 and 20 taka (with one meal) during the lean season, and between 25 and 30 taka (with two meals) during the peak season. Advance sales of labor for cash is practically absent. Majority of the day laborers come from the landless and poor households. They are dependent on the large and medium land owners for employment throughout most of the year.

Although nearly 40 percent of the project area falls under the Tangail municipal area, lack of employment opportunities in Tangail town and population pressure prevent the urban sector from absorbing the growing labor force. This situation is further compounded by the lack of employment opportunities outside the peak season. There is no large factory or industry in the project area and, hence, few job opportunities exist outside agriculture. Very few women are in the agricultural labor force, and their non-agricultural income generating activities are extremely limited except for biri making and spinning.

Fishing-related activities employ a significant number of households in catching, selling and trading (Table 5.19), and 98 percent households in the fishermen villages depend entirely on fishing as their main source of livelihood. According to the FAP 20 household survey (1992c), there are 325 professional fishermen households within the CPP area who earn their livelihood mainly by fishing, while nearly 65 percent of the total rural households fish as subsistence fishermen. Subsistence fishermen catch fish primarily for family consumption, but sometimes they sell their catch to supplement household income. Professional fishermen generally fish in the floodplain, beels and rivers in the area. Sometimes they fish from waterbodies of the neighboring villages. They also catch fish in the pagars and ponds on contractual/hired basis with the owners. Their daily earnings range from 30 to 35 taka during the lean season and 50-60 taka during the peak season. The pagars are resourceful waterbodies and are usually excavated by the land owners to stock floodplain fish. During post-monsoon period, the floodplain fish migrate to the pagars. About 80-90 percent fishing in the pagars is done by draining out water through low lift pumps in the months of February and March and the rest by cast net and handpicking. The pagar owners earn, on an average, 10,000 taka from a pagar of 0.12 ha annually by selling fish after meeting their own fish consumption needs. Advance sale of pagar fishes for a fixed sum of money is also common. During early and full monsoon, professional fishermen fish freely on the edge of flooded beels and pagars. However, they are not allowed to fish inside the pagars or the beel by the owners during post-monsoon period. Many villagers, including professional fishermen, reported that the existing leasing arrangement of beels benefits few people in the area.

Leases of government (khas) beels are given every year to local fishermen's cooperatives (Matshajibi Samity) through auction against payment of a lease fee. Field observations suggest that most of the khas beels are leased to large land owner cum-trader-businessmen. The owners' power stems from their control of productive resources and marketing and the fact that many of the professional fishermen are heavily indebted to them. Communal fishing (locally called bais) is done in some of the beels on specific days by drum-beating in the markets. Fishermen believe in fishing as an ancestral vocation. There are uncertainties as to the future, partly due to a reduced number of free fishing areas and partly due to increasing cost of fishing nets, gears and boats in their trade. A large size fishing boat of 8m long and 2m wide costs nearly 20,000 taka and a seining net 300m long and 9m wide costs 40,000 taka. These sums are generally beyond the reach of professional fishermen. In addition, the professional fishermen face competition with the fishermen 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 non-agricultural occupations such as weaving and rickshaw-pulling.

Table 5.19 Main Occupation of Household Heads in the Project Area

Occupation	Percent of Household Head: Project Area: Rural (N=5918)	Fishing Villages (N=274)	Urban (N=1398)	Adjacent Area: 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-Ag. 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 Profession	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)

5.5.3 Land Ownership Distribution Patterns

The land ownership distribution pattern in the Project area is typical of other areas of Bangladesh in that at one end of the scale there are few households who control much of the land, while at the other end there are many who either own very little or no cultivable land at all. Table 5.20 presents data on the classification of sample households in both the project and adjacent area according to land ownership and farm size grouping by owned cultivated land.

While nearly 40 percent of the survey households own between 0.02 and 0.4 ha, they command only 13 percent of the total cultivated land in the project area. Thirty four percent of the same farm size category in the adjacent area own only 8 percent of the land, whereas the 4.6 percent of survey households who are large land owners (2.03 ha or above) in the project area command more than 19 percent of the total cultivable land. The overall distribution pattern in the project area also shows that the highest proportion of ownership of land is by the large and medium farmers. On the other hand, the small and marginal farmers who constitute nearly 67 and 59 percent of the total survey households in the project and adjacent area, respectively, the claim lowest proportion of land. Thus, the distribution of land ownership in both the project and adjacent area is skewed. The Gini ratio (GR), calculated from this ownership distribution, provides an inequality coefficient of 0.40 for the project area and 0.45 for the adjacent area (a Gini ratio of 1.0 indicates uniform distribution of land ownership). The Lorenz curve (Figure 5.3) shows the extent of inequality in the distribution of land ownership in both the project and adjacent areas.

5.5.4 Tenancy Market

An extensive tenancy market exists in the project area. Share cropping in or out is the predominant form of tenancy, accounting for nearly 85 percent of the total rented land. The other type of tenancy arrangement is mortgaged in or out. This is the payment of a fixed sum of

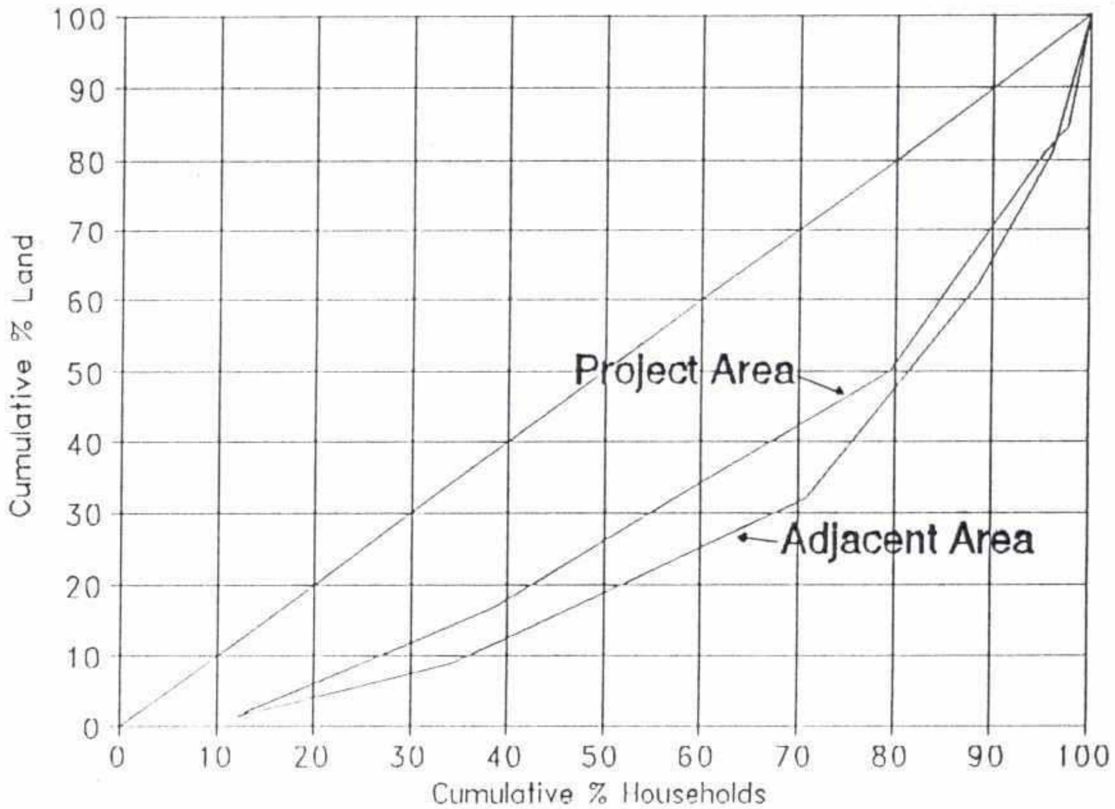


Figure 5.3. Lorenz curve indicating extent of inequality in the distribution of land ownership in the CPP and adjacent areas

money to the mortgagor by the mortgagee against a collateral of land that the latter has the right to cultivate as long as the mortgage money is not repaid. The mortgage rate varies depending on the land type and location. In the irrigated areas, the normal rate of mortgage is between 60,000 and 75,000 taka/ha, whereas in non-irrigated areas the mortgage rate varies between 35,000 and 45,000 taka/ha. The contractual arrangement under both mortgage and share tenancy is fully verbal and, therefore, highly insecure.

The system of share cropping, locally called barga, is generally for one cropping season, but may extend further, with an agreement that the gross produce will be shared equally if the land is cultivated conventionally. However, if modern inputs such as DTW and STW irrigation are used on rental basis, then one-fourth of the total produce is given to the pump owner towards the cost of irrigation. Thereafter, the remaining produce is divided between the land owner and the tenant into two equal shares. In most share-cropping contracts, except for HYV boro, the tenant provides all the inputs. In case of HYV boro, the cost of irrigation is borne equally by the land owner and the tenant, while the other inputs are provided almost entirely by the share-cropper.

5.5.5 Credit Relations

Most of the farmers in the project area need credit for increased production. However the average credit obtained in 1991 from non-institutional sources by farm households was consid erably higher than from institutional sources. More than 41 percent of the farm households and 25 percent of the non-farm households including professional fishermen borrow money from non-institutional sources with an interest rate that is above 100 percent (Annex 4). Two-thirds of the households borrow money from institutional sources at 16-20 percent interest rate. There is also a large number of households

Table 5.20 Classification of Sample Households According to Land Ownership (of Cultivated Land) in the Project and Adjacent Areas

	Project Area				Adjacent Area			
	Household		Area		Household		Area	
Category	No.	%	Ha	%	No.	%	Ha	%
Landless-1 (own no cultivable land)	05	3.8 (3.8)	-	-	08	6.1 (6.1)	-	-
Landless-2 (own up to 0.020 ha cultivable land)	01	0.8 (4.6)	0.012	-	-	-	-	-
Landless-3 (own 0.024-0.202 ha cultivable land)	11	8.3 (12.9)	1.43	1.5 (1.5)	08	6.1 (12.2)	0.88	0.7 (0.7)
Total landless	17	12.9 (12.9)	1.45	1.5 (1.5)	16	12.2 (12.2)	0.88	0.7 (0.7)
Marginal Farmers (own 0.206-0.405 ha cultivable land)	34	25.8 (38.7)	10.93	11.7 (13.2)	29	22.1 (34.3)	9.63	7.7 (8.4)
Small Farmers (own 0.409-1.012 ha cultivable land)	54	40.9 (79.6)	34.21	36.4 (49.6)	48	36.6 (70.9)	31.60	25.4 (33.8)
Medium Farmers (own 1.016-2.024 ha cultivable land)	21	15.8 (95.4)	29.31	31.2 (80.8)	23	17.6 (88.5)	33.99	27.3 (61.1)
Large Farmer-1 (own 2.028-3.036 ha cultivable land)	03	2.3 (97.7)	6.76	7.2 (88.0)	10	7.7 (96.2)	24.07	19.3 (80.4)
Large Farmer-2 (own above 3.036 ha cultivable land)	03	2.3 (100)	11.21	12.0 (100)	5	3.8 (100)	24.46	19.6 (100)
Total large farmer	06	4.6 (100)	17.97	19.2 (100)	15	11.5 (100)	48.53	38.9 (100)
Total	132	100.0	93.87	100.0	131	100.0	124.63	100.0

Figures in parentheses indicate cumulative percentages
Source : FAP 20 (1992c)

who borrow from non-institutional sources ateven higher rates. This is not surprising in view of the fact that there are a number of problems regarding credit acquisition from institutional sources.

There is no professional moneylender in the project area, but there are informal financial and lending sources who advance loans at a much higher interest rate. Friends, relatives and neighbors often help each other by providing loans on relatively softer terms with the understanding that the same will be reciprocated in the future. The major sources of credit for all types of households are friends/relatives, and Krishi and Grameen banks (Annex 4). A large part of credit is used by farm households for the purchase of agricultural inputs, whereas that of non-farm and fishermen households is expended in business capital and food collection.

Advance sale of crops before harvesting is absent in the project area. Field data, however, indicate that marginal and small farmers often sell their crops immediately after harvesting to meet the household expenditure and debts. Debt repayment is the major cause of decreased land among households (FAP 20 (1992c). Small land owners generally sell land in distress situations. The price of land per hectare varies between different land types and between irrigated and non-irrigated areas. In the irrigated area the price per hectare varies from 300,000 to 350,000 taka for land under HYV boro, whereas in non-irrigated area the price varies between 200,000 and 225,000 taka. Bandhak or mortgage of land occurs at different rates and most of the mortgage transactions occur due to debt repayment and family maintenance reasons.

5.5.6 Wealth and Equity

Land is the principal form of wealth in both the project and adjacent areas, but its distribution is not equal. Data collected from various social and economical categories indicate that in each and every village there are only a few (7 to 8) households who own much of the cultivable land, i.e. above 2 ha/family. In Rupshijatra and Beljan villages, for example, there are 8 to 10 households who own between 5 and 6 ha cultivable land per family, whereas there are many in those villages who claim only a tenuous hold on the land. The percentage of landless households is high (nearly 52 percent). Although no detailed household survey was conducted by FAP 16 for this study, data collected from 15 subcompartments indicate a high degree of inequality in the distribution of land among households. This finding is consistent with the data presented in Table 5.19. In every village interviewed by the EIA team, the small and marginal farmers indicated that their economic condition has deteriorated during the past 5 to 6 years due to flooding, drainage congestion and siltation problems.

The majority of the landless and land poor households have limited sources of income and hence meager or no savings at all. Furthermore, since there is no large factory or industry in the project area and since little or no employment opportunities exist outside the peak agricultural season, the landless and land poor households barely make a subsistence living. On the other hand, the dominant economic and political position of the large land owners offer them more opportunities to act as mediators or brokers between the village society and the urban centers.

5.5.7 Gender Relations

Women in the project area have limited access to land. Less than 6 percent of women receive property from their father (FAP 20 1992c), while a majority of them forfeit their rights to their brothers in exchange of *Naior* (visit to parental home at least once a year). The benefits from crop production or small-scale industry rarely go directly to the women. They have also little say in the affairs of the community. However, due to growing poverty, women's contributions to family income is becoming increasingly important for the survival of landless and marginal households. Women are increasingly joining the labor force in agriculture, traditional crafts and cottage industries. Table 5.21 presents data on the proportion of employed women in different income generating activities and the average annual wage. Major sources of income for women are from biri-making. Women also work as servants and receive their wages in kind.

Women's roles in family decision making is an important indicator of their status within the family. The status of working women is higher in this regard. Table 5.22 shows the degree to which women's opinions are sought in matters of family maintenance and/or investment by type of household in the project area. Field observations show that, though wives are consulted, they rarely play an equal role in decision making. Although women are more involved in home gardening activities than the men, it is their husbands who sell the produce and receive the money. However, they have better control in the raising, selling and receiving of money from poultry farming. Women are far less involved in planting and harvesting of trees, they are responsible only for nursing them (FAP 20

Table 5.21 Income Generating Activities of Employed Women in the Project Area

Activities	Percent of Employed Women								Average Annual Income/Women (Tk.)							
	Farm		Non-Farm		Fisherman		Urban		Farm		Non-Farm		Fisherman		Urban	
	FT	PT	FT	PT	FT 8	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
Numbers	4	17	4	9		6	1	0	4	17	4	9	8	6	1	0
Net Making	-	-	-	-	-	67	-	-	-	-	-	-	-	-	-	-
Packet Making	-	-	-	-	75	-	-	-	-	-	-	-	-	-	-	-
Quilt Making	-	-	-	11	-	-	-	-	-	-	-	600	-	-	-	-
Mat Making	-	12	-	11	-	-	-	-	-	1810	-	480	-	-	-	-
Crop Mulching	-	-	-	11	-	-	-	-	-	-	-	465	-	-	-	-
Paddy Boiling	-	3	-	-	-	-	-	-	-	550	-	-	-	-	-	-
Rice Husking	-	18	-	-	-	-	-	-	-	1133	-	-	-	-	-	-
Day Labor	-	-	25	-	-	-	-	-	-	-	2100	-	-	-	-	-
Maid Servant	50	-	25	-	-	-	100	-	2750	955	900	-	-	-	1080	-
Biri Worker	-	18	25	33	-	-	-	100	-	300	1200	807	-	-	-	1600
Weaving	-	24	25	33	25	17	-	-	-	1494	1980	1500	3050	3000	-	-
Small Business	-	-	-	-	-	17	-	-	-	-	-	-	-	-	-	-
Service	50	-	-	-	-	-	-	-	1310	-	-	-	-	-	-	-

N = number of employed women. FT = full-time, PT = part-time

Source: FAP 20 (1992c)

Table 5.22 Degree of Women's Involvement in Family Decision-Making

Willingness of Husband to Consult Wife	Percentage of Respondents Farm (N=132)	Non-Farm (N=132)	Fisherman (N=50)	Urban (N=50)
Always	44.7	53.0	36.0	58.0
Sometimes	51.5	43.2	62.0	36.0
Never	3.0	1.5	2.0	2.0
Not Applicable	0.8	2.3		4.0

Source: FAP 20 (1992c)

1992c). Some of the literate women are involved in family planning, teaching and NGO activities.

The involvement of NGOs and Grameen Bank in the development process is helping poor women through group savings and credit delivery, to become economically independent by earning an income. They are encouraged to start up small scale businesses like rice husking. Women in the area are mobile and are now traveling as far as Tangail town in search of employment.

Displacement of households by river erosion coupled with the absence of adequate, sanitary living conditions and reduced income during the floods puts women under additional stress. Women living in the flood affected areas, especially those outside the existing embankment, suffer most during floods. In a deteriorating economic situation, the cost of dowry is growing. The efforts made by the fathers and/or guardians of marriageable girls to pay it is a major cause of landlessness. Women with low socio-cultural status, are more vulnerable to changes in the resource base.

5.5.8 Health and Nutrition

The most common diseases in the case study area are diarrhoea, intestinal worm infestation, skin diseases and acute respiratory infection. Table 5.23 shows the incidence of disease in the project area. Water-borne diseases e.g. cholera/diarrhoea, typhoid fever, dysentery and jaundice, affect on average more than 27 percent of rural households.

Diarrhoeal disease increases during the monsoon and reaches a peak first in the post monsoon period (September to November) and again in the spring (March to May). Skin infection becomes acute during the post-monsoon period and remains so until the beginning of the next monsoon. Respiratory infections are most severe in winter (November to March). Malaria occurs in the post-monsoon period. Intestinal worm infestation poses a serious health problem throughout the year. Contaminated water is the primary cause of water-borne diseases. Table 5.24 presents data on the proportion of households using various water sources in the project area. Approximately 90 percent of rural households drink safe, tubewell water but in some villages there is a severe scarcity of safe water.

A minority of households, mainly located in remote areas, use unsafe ring well water. A majority of households in the fisherman's community do not have access either to tubewells or to ring wells and drink surface water from rivers and ponds. A few urban households have access to piped water supply of which some have been damaged and are polluted. Though tubewells are submerged during annual floods only in severely flood-prone areas, distance from safe water sources causes hardships for many households. In 37 out of 42 villages visited, people washed themselves and their animals in the same pond or beel. Lack of surface water poses a major health hazard during the dry season, when the remaining water becomes extremely contaminated. In addition, as Table 5.25 shows, nearly half of rural and a quarter of urban households use latrines discharging on to a water body. Runoff from pesticides, and waste chemicals and dyes used by weaving communities cause further pollution. In some villages the

Table 5.23 Incidence of Disease by Household Type (Household Members Affected Within Last Year)

Disease	Farm N=424	Non-Farm N=332	Fish N=128	Urban N=107
Cholera/Diarrhoea	8.0	11.1	3.9	2.8
Tetanus	0.2	0.3	-	-
Tuberculosis	0.7	0.6	-	-
Pox	4.5	1.2	1.6	4.7
Cough	5.2	6.6	3.1	6.5
Typhoid Fever	2.1	2.1	2.3	1.9
Dysentery	13.5	16.0	16.4	0.3
Jaundice	0.7	1.5	3.9	-
Influenza	8.7	10.2	11.7	3.1
Malaria	1.2	1.8	-	-
Kala-azar	0.5	0.3	-	-
Accident/Homicide	1.2	0.9	3.1	1.9
Running Nose/Fever	22.9	24.4	25.8	31.8
Gastric Ulcer	8.0	4.2	10.9	12.1
Scabies/Skin Infections	7.8	8.7	10.9	3.7
Abdominal Pain	4.3	3.6	3.1	1.9
Other	10.6	6.3	3.1	18.7

Source: FAP 20 (1992c)

Table 5.24 Households Using Various Sources of Drinking Water

Household Type		Sources of Drinking Water (%)		
		Piped Water	Tube Well	Ring Well
Farm	(N=132)	-	87.1	12.9
Non-Farm	(N=132)	-	91.7	8.3
Fisherman	(N=50)	-	36.4	1.5
Urban	(N=50)	14.0	86.0	-

Table 5.25 Sanitation Use by Type of Household

Type of Latrine		Percentage of Household Members Using Farm N=132	Non-Farm N-132	Fisherman N=50	Urban N=50
No Latrine		4.5	22.0	22.0	8.5
Latrine on Water Body		47.0	50.0	40.0	22.0
Service Latrine		1.5	-	-	-
Well Latrine	12.9	5.3	10.0	24.0	
Pit Latrine		31.1	18.2	18.0	16.0
Septic Latrine	3.0	4.5	-	30.0	

Source: FAP 20 (1992c)

water is so contaminated that it causes irritation to the eyes and skin.

Post monsoon drainage congestion causes stagnant water to collect in khals and ditches without the benefit of the flushing affect of normal water flows. Long-term contamination aggravates pollution problems in certain areas. For example, in Baruha Village, where the khal is blocked, people use it for soaking jute and dumping household wastes. There are pit latrines on both sides of the khals and during the rainy season dirty water overflows into the houses on the bank.

Intestinal worm infection has been identified as a serious health problem by Tangail Health Department, but nowhere was this mentioned by the villagers. Anaemia, which is reported to be widespread in the area, is aggravated by worm infestation. The Tangail Thana Health Office is running a mobilization campaign on sanitation and local government and NGOs are providing inputs for the construction and distribution of low cost latrines. However, these are still beyond the purchasing capacity of most poor households.Malaria is endemic in the project area. Sporadic cases were reported to the team in 8 villages during field work. Kala-azar cases were reported by villagers in Barobelta Village. In a recent investigation of a kala-azar outbreak in Kalihati thana it was found that 21 (58 percent) suspected cases were diagnosed as Kala-azar out of 36 (Abdullah-el Masum *et al.* 1990). ISPAN (1992d) has found a strong negative correlation between the incidence of kala-azar and the incidence of seasonal flooding in some areas in Bangladesh, and this likely explains the high incidence of kala-azar in Kalihati (manly highlands with little seasonal flooding) and relatively low incidence in the CPP (regular seasonal flooding).

Government health services consist of a general hospital in Tangail town with 100 beds and an out-patient's clinic staffed by 13 doctors, one TB out-patient's Clinic with 2 doctors, and 5 Union health centers, each with one doctor. There is also one private hospital and two clinics. There is only one maternity hospital with 8 beds, a well integrated structure of family planning and maternal and child health provision exists in the case study area. Family welfare centers provide clinic and field based FP and MCH services. The rate of adoption of family planning is reported at 60 percent of eligible couples. About 75-80 percent of pregnant women receive ante-natal care and a trained member of staff or traditional birth attendant attends deliveries. In addition, there is a school health service run by a doctor and primary health education is given in about a quarter of Primary Schools every year. All five health centers have immunization programs.

Nutritional deficiencies become prominent during pre-harvest "lean" seasons in September/October and February/March. Peak incidence of disease generally occurs during these periods. However, capture fisheries resources modify the normal trend of seasonal nutritional deficiency related to the crop cycle. Preliminary findings from a study on nutritional consequences of biodiversity in fishes (ISPAN 1992c) indicate that capture fisheries is the principal source of protein and vitamin A for households in the CPP area. Vegetable is also a major source of nutrition for households in the area. Aquatic vegetables such as arum and water lily are commonly consumed. Consumption of eggs and meat is negligible. Pulses are not commonly consumed.

5.5.9 Education and Awareness

The overall rate of literacy (defined as being able to sign name) is 41 percent (50 percent male and 32 percent female). However, Tangail Thana Education Department figures indicate a lower overall rate of 29 percent (36 percent male and 21 percent female). The rate in 1981 was 26.8 percent for Tangail Thana compared to 23.8 percent nationwide (BBS 1984). Annex 4 provides more detail statistics pertinent to the educational status in the project area. In general the literacy rate is higher in the project area compared to the adjacent area due to a relatively high level of urbanization. Female literacy in the project area is also higher due to influence of Tangail Town.

There are nearly 56,500 children between the ages of six to ten in Tangail Thana and 115 government Primary schools and 34 non-government primary schools, i.e. nearly 400 children for every primary school. Although 80 percent of children at primary age are enrolled, only 45 percent of those enrolled attend regularly and the drop-out rate is approximately 25 percent. Poor attendance and high drop-out are poverty related. According to the Thana Education Officer children are contributing to the survival of their families by working as hired labor in agriculture, weaving, brick fields, shops or as on-farm family labor. Attendance is particularly poor during planting and harvesting seasons. In addition, lack of clothes is a major constraint to children from poor households. Given the high level of unemployment, many parents from the very poor households do not regard education as important for their children's future.

Many families withdraw their daughters from school at puberty for religious reasons. Survey results show that in farm, non-farm and fishermen's households a high proportion of female respondents wanted only a minimum education for their daughters. However, provision of free education for girls in grades 1-8 has had a positive impact on enrollment of girls at junior high school, in both the rural and urban areas. Further, children's education is disrupted during the monsoon. During normal seasonal flooding many earthen roads become impassable. In Tangail Thana alone as many as 70 primary schools remain closed for a month because they are inundated every year. On the eastern side of the Jamuna, the char villages outside the embankment are severely flood affected and primary schools are closed for two to three months during the monsoons.

Difficulty in physical access and school closure due to flooding also affects secondary education. Communication problems affect girls particularly, as parents are concerned for their safety and security, if they have to travel far and under difficult circumstances.

5.6 Tangail Town

Tangail Town is the district headquarters. The total area of the town is 260 ha and its estimated zone of influence is 84 km^2 . According to the latest municipal assessment (January 1992), the population in Tangail town is around 152,203 (Tangail Pourashava 1992).

5.6.1 Flood and Drainage Condition

The Lohajang River flows through the central region of the town dividing it into two parts in a NW-SE direction. Tangail town is a relatively low-lying area. The town is not flood protected and the flood water from the Lohajang River enters the town through Muslim Akur Takurpara, Taltala, Dighulia and District Court's building area by overtopping the eastern bank during high river stages. Water enters through a culvert on the Tangail-Sontosh road from the Lohajang River via Dighulia and submerges Kachuadanga area and drains out through the same route during the receding period.

Tangail Canal flows through the middle of the town and is connected to the Lohajang River. The canal, that previously served as the major drainage and sewerage passage of the town, is now silted up and has been encroached by the growing settlement. Since this canal is not capable of draining the adjacent areas, the town faces drainage congestion. During peak monsoon water enters the town from Biswaser Betka and Tangail Canal. Water spreads over both sides of the canal and inundates the area to a depth of 30-60cm. Rainfall often causes flooding or drainage congestion for 15-20 days during the peak monsoon. In the 1988 flood, Tangail was fully inundated by water to a depth of 1-1.5m. It took 15-20 days for water to drain out.

In addition to drainage, river bank erosion is active in the town. Erosion of both banks of the Lohajang River has been occurring for the past four years. Its impact is most notable near the Stadium, Housing Society Area and District Court's Building where the river meanders.

Table 5.26 Bacteriological Report of Ground Water in Tangail Town (Sampled in January 1986)

Source	Number of Bacteria per ml.	Number of Coliform Bacilli/ 100 ml.	Number of Faecal Coliform Bacilli/ 100 ml	Free Cl limit 0.5 parts per 100,000	pH [1]	Remarks
Deep Tubewell Water Production Well #7 (Ansar Camp)	38	Nil	Nil	Nil	6.9	Satisfactory for human consumption.
Filtered Bed Water	32	Nil	Nil	Nil	6.9	Satisfactory
Underground Reservoir Water	5	Nil	Nil	0.2	7.0	Satisfactory
Tap Water from Street Hydrant	8	Nil	Nil	0.1	7.0	Satisfactory

[1] Acceptable range 7.0-8.3
Source: Tangail Municipality 1992.

Table 5.27 Bacteriological Report of Ground Water in Tangail Town (Sampled in March 1986)

Source	Number of Bacteria/ ml	Number of Coliform Bacilli/ 100 ml	Number of Faecal Coliform Bacilli/ 100 ml	Free Cl limit 0.5 parts per 100,000 parts	pH	Remarks
DTW # 7 (Ansar Camp)	2.6×10^7	7	Nil	Nil	6.7	Unsatisfactory for human consumption.
Low Lift Pump No. 7	3.0×10^7	9	Nil	Nil	6.6	Unsatisfactory
Water Street Hydrant (at Bazilpur Road)	2.9×10^7	7	Nil	Nil	6.7	Unsatisfactory
Water Street Hydrant (main road)	2.8×10^7	7	Nil	Nil	6.7	Unsatisfactory

Source: Tangail Municipality 1992

5.6.2 Groundwater

In the Tangail urban area, the Department of Public Health Engineering installed 8 DTW and handed them over to the Municipal Authority exclusively for drinking water supply purposes. Although the first two deep tube wells were sunk in 1964, water supply and services started only in 1969. At present four DTWs are in operation of which three supply treated water. There is a water treatment plant in the water works compound of the municipality which neutralizes iron and chlorinates the water. Water is supplied from an overhead tank through pipes to urban households. There are 12,700 residential holdings in the municipal area but only 1,585 (15 percent) have a piped supply. There are 17 street hydrants and 165 commercial pipe water connections in the Tangail town. The total length of the water supply pipe line is 27 km. There is no pipe water supply in Karatia urban area. 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 cooking purpose. Municipal water supply is not satisfactory from all the DTWs in all-seasons. Tables 5.26 and 5.27 show bacteriological and chemical tests of selected DTWs during the dry season.

The bacteriological examination report on the water of DTW No.7 (at Ansar Camp) shows wide variations between January and March. In the month of January coliform bacilli were absent, the number of bacteria/ml insignificant and the overall water quality satisfactory for human consumption. In March, a high content of bacteria and presence of coliform bacilli made the water unsatisfactory for drinking purposes. It is assumed that the existing treatment system does not guarantee the safety of the water. One of the possible sources of contamination in the water supply system is the uncovered water storage reservoir. Uncontrolled surface sewerage and waste disposal around the DTWs may be the cause for water contamination.Chemical tests of drinking water from groundwater source (Table 5.28) indicate that the concentration of iron and manganese is higher than the standard maximum contaminant level. Change in ground water level over three years (1989-1992) in Tangail indicates that the level of water table is gradually decreasing due to either inadequate recharge or excessive withdrawal of water (Table 5.29).

5.6.3 Land Use Pattern in Tangail Town

Tangail town is rural based, and agricultural activities occupy 51 percent of the municipal area. Housing and settlement occupy 34 percent of the Municipal area. Excluding the agricultural areas, the developed urban area covers around 640 ha. Homesteads cover 56 percent, administration 9 percent, commerce and industry 9 percent and educational institutions 5 percent of the urban area. Annex 5 shows existing and projected (to year 2001) land use for Tangail town (UDD 1989).

The main urban area lies on the east of the river which bifurcates the town from north to the south. Developments are rather sporadic except on the east and north of the District Headquarters. To identify the growth and development pattern of the Tangail town, aerial photographs of 1983 and 1991 were compared. The results showed that urban expansion took place in a northern direction along the Tangail- Jamalpur road and in a SE direction toward Tangail-Dhaka road in a linear pattern. It also revealed that the housing density within the old part of the town increased markedly.

5.7 Hazards and Risks

The physiography, river and drainage pattern and other natural conditions make the CPP area vulnerable to environmental hazards. The area experiences such natural and anthropogenic hazards as floods, cyclones, hailstorms, droughts, earthquakes, river bank erosion, embankment breaching, drainage congestion, water quality deterioration, sand deposition, exposure to pests and pesticide, and the failure of irrigation systems. Such hazards affect the human health. Natural disasters have led to increased morbidity and epidemic outbreaks, while nutritional degradation and physical disabilities have aggravated the problem further.

5.7.1 Hazard Profile for the CPP Area

Hazard related issues in the project area are presented in Table 5.30. Key problems relate to uncontrolled flood levels during the monsoon, and drainage congestion during pre- and post-monsoon periods. There are two sources of flooding, rain water (1550 mm average annual rainfall) and river flooding. In 'normal' flood years depressions are submerged to 1-2m deep. In years with high river floods, ridges are submerged and depressions are flooded up to 3m and more. Much of the lower land presently remains fallow in the rainy season because of the risk that rapidly rising flood water in June might drown aman seedlings (FAP 20 1992a). Potential damage of the flooding inside the project area has been given a rating between 0 and 1, related to the potentially damaged crop area for the years between 1952 and 1991. The return periods of the potential damage have been

Table 5.28 Chemical Tests of Groundwater in Tangail Town (Sampled from DTW #7, March 1986)

Indicator Indicator		Result Results		Maximum Contaminant Levels (MCL)
Temperature	:	28^{0} C	:	
pH	:	6.8	:	6.5 to 8.5
Electrical Conductivity	:	640u S/cm^{1}	:	
Dissolved Oxygen	:	3.5 mg/l	:	
Phenolphthalein Acidity	:	9 mg/l	:	
Total Hardness	:	63.49 mg/l	:	0-75 mg/l (soft)
Chloride	:	10 mg/l	:	250 mg/l
Iron	:	4.20 mg/l	:	0.3 mg/l
Magnesium	:	0.97 mg/l	:	
Manganese	:	0.30 mg/l	:	0.05 mg/l
Ca++	:	62.52 mg/l	:	
Sulphate	:	Negative	:	250 mg/l

Source: Tangail Municipality 1992

Table 5.29 Groundwater Depth at Different Intervals During Abstraction by DTWs in Dry Seasons 1989 and 1992

Ground Water Depth (m)	DTW#3		DTW#4		DTW#8	
	Mar'89	Apr'92	Mar'89	Apr'92	Mar'89	Apr'92
Static Water Depth	5.16	5.90	4.35	5.04	4.80	5.62
Depth after 15 minutes extraction	12.42	12.15	20.31	20.52	7.13	10.64
Depth after 30 minutes	12.40	12.14	20.26	20.52	7.13	10.70
Depth after 60 minutes	12.42	12.14	20.29	20.52	7.13	10.76

Source: Tangail Municipality 1992

assessed (FAP 20 1992a, Table 5.31).

5.7.2 Health Hazards

Figure 5.4 has been constructed from field observational data, and depicts the important or leading diseases and their extent in each sub-compartment in the project area. Relatively higher and drier land is more vulnerable to respiratory disease. Skin disease is found to be epidemic in the CPP area. Such water borne diseases as diarrhoea, dysentery, jaundice and typhoid fever affect more than 27 percent of the rural farm and non farm households in the project area. All these diseases show a seasonal pattern and indicate marked increase at the outset of the monsoon and a peak in post monsoon. The trend of acute respiratory disease and skin disease are found to be increasing over last 5 years in the project area. Prevalence of severe dust in dry season and stagnant but polluted water used for bathing and washing purpose by a large number of people in post monsoon period act as the catalytic agent for such diseases.

5.7.3 Trend of Flood Hazards in the CPP Area

The trend of the past five years in respect of flooding damage to homesteads, house inundation, crop damage, livestock and poultry losses are shown in Table 5.32. Annex 4 presents other hydrological and morphological hazards for each subcompartment in the project area.

Risks Associated with Drainage Congestion

Drainage congestion is an important environmental problem in the CPP area. People from 11 subcompartments recognized drainage congestion as a major constraint. The main reasons for drainage congestion are siltation of canals and beels and the development activities that lead to the blockage of normal drainage flow. Areas with drainage congestion are associated with the problems of waterborne diseases, skin disease, more vulnerability to fish and livestock diseases, reduction in cultivated land and its socioeconomic consequences. Areas under drainage congestion are subject to health hazard from polluted water due to jute retting.

Risks Associated with Bank Erosion

Bank erosion has been observed in subcompartments 1, 5, 6, 7, 10, 11, 12, 13 and 15, and is one of the severest hazards in the CPP area. More than 50 families in 1991 reportedly have been uprooted due to river bank erosion. Bank erosion is a recurrent event with a potential hazard to agricultural and homestead land, and properties. Economic value of land lost due to river bank erosion during 1991 and 1992 is estimated around 1.2 million taka.

Risks Associated with Siltation of Canals and Beels

Siltation of the Lohajang River bed at its offtake and other segments has reduced the capacity of the river particularly during the dry season. The consequence of this is scarcity of water, complete disruption of water communication and reduced area for fish refuge. Raising of canal beds (Ghoramara Khal, Kalibari Khal) due to excessive siltation is causing pre- and post-monsoon drainage congestion, subsequently affecting the harvest of boro crop and entry of floodwater into the beels and floodplain. Siltation of canals also creates problems in water transportation. Siltation of beel beds is a serious threat to the fish and other aquatic communities in the area. Reduced water level, particularly during drier periods, affects the water availability in all the perennial beels and leads to overfishing. This process if unchecked may lead to transformation of most affected perennial beels into seasonal beels (i.e. Enayetpur, Vatchanda and Hatila beels).

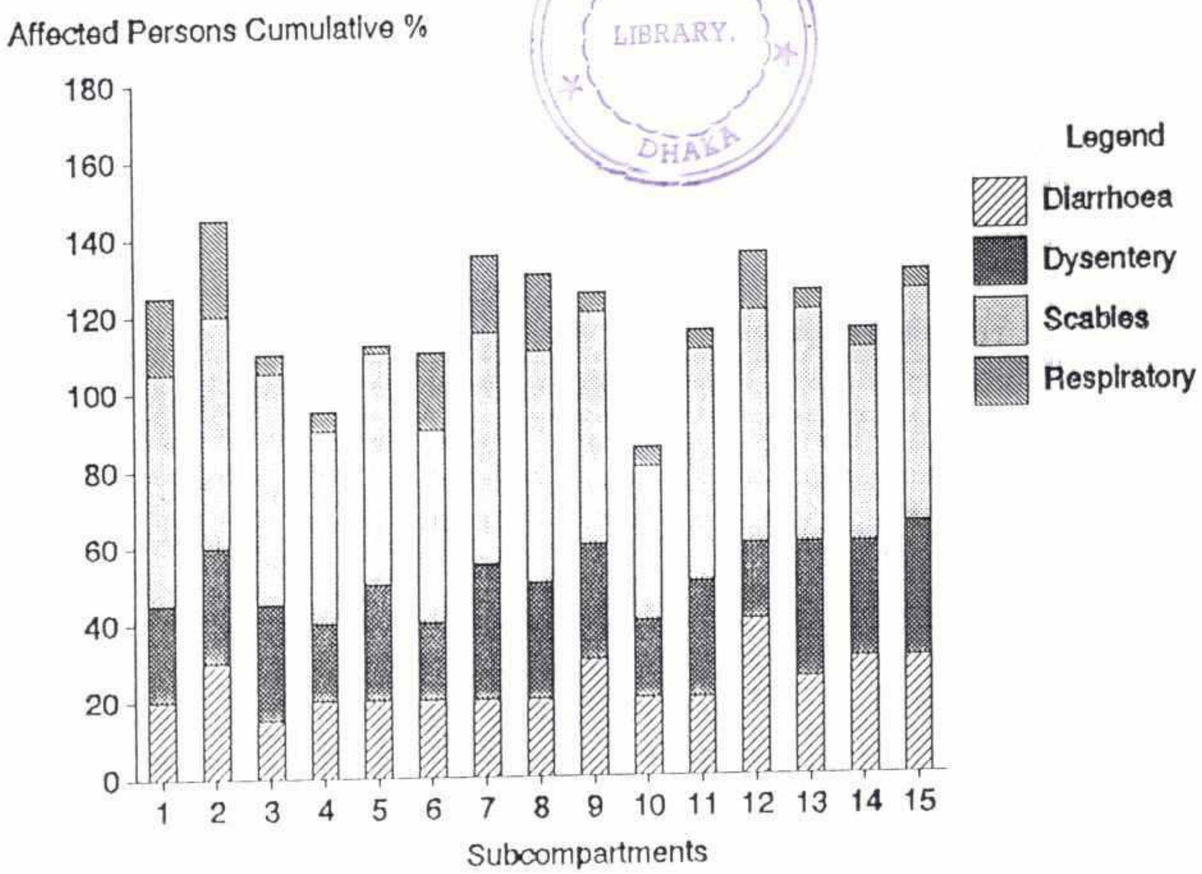


Figure 5.4. Incidence of Diseases by Subcompartment in the CPP

Table 5.30 Flood Hazard Profile for the CPP Area

Hazard Type	Event Parameters	Site Parameter	Period
Early Flood (Pre-monsoon)	Area flooded 1,488 ha	Land type: F3 Affected Ag. Area:16%	March to May
Monsoon Flood/ High River Stage	Area flooded 5,365 ha	Land type F1,F2,F3 Affected ag. area:58%	June to September
Post Monsoon Flood/ Drainage Congestion	Area Affected 3,346 ha	Land type: F1, F2 & F3 Ave.affected ag.land:36%	October to March
Failure of Irrigation System due to Groundwater Lowering during Drought	Ave. 20 % of STW affected	F_0 and F_1 land types	April to June

Source: Field observations 1992 and GIS database for the CPP Area.

Table 5.31 Return Periods for Flood Damage

Years	Rating	Damage Exceeded
1991	0.08	1 out of 2 years
1989	0.04	2 out of 3 years
1987	0.28	1 out of 10 years
1983	0.20	1 out of 3 years
1965	0.24	1 out of 5 years

Source: FAP 20 (1992a)

Table 5.32 Flood Hazard Trend in the CPP

	Percent Household Affected				
Year	Homestead Inundation	House Floor	Crop Damage Damage	Livestock Loss	Poultry Loss
1990	2.3	0.8	72.7	1.5	0.8
1989	5.3	-	66.7	1.5	0.8
1988	95.5	84.1	98.5	10.6	18.9
1987	9.8	0.8	31.1	-	-
1986	-	-	16.7	-	-

Source: FAP 20 (1992c)

Chapter 6

IMPORTANT ENVIRONMENTAL COMPONENTS

6.1 Criteria for Identification of IECs

Upon completion of field studies and literature reviews, the EIA team identified the environmental components likely to be impacted positively or negatively, and directly or indirectly by the proposed project actions. They were screened and the Important Environmental Components (IECs) were selected for detailed and, to the extent possible, quantified assessment. The IECs selected were environmental components, resources, resource uses and/or important environmental events or issues related to project development.

As indicated in Chapter 2, various CPP actions will be implemented in three construction and institutional development phases with a "go" or "no go" option on any specific or group of action(s). Since at this time the decision as to which actions may or may not proceed has not been made, the EIA team has assessed the project actions in their entirety, i.e. the assessment of the CPP was conducted with the assumption that all the phases of the project as planned will be implemented as scheduled. With this assumption, the important project actions were identified and categorized as follows:

1. *Controlled River Flood Water Entering the CPP Area*: the construction elements for this function include upgrading the existing horseshoe embankment into a peripheral embankment along the western, northern, and eastern boundaries of the CPP area, the emergency spillways, and main Lohajang inlet regulator, and a series of minor inlet regulators proposed for construction along the eastern and western peripheral embankment in addition to the existing four inlet regulators. The plan is to regulate the river flow only after July 15 during any normal flooding year. The main inlet is planned to operate after July 15 or earlier in case of abnormal flood.
2. *Controlled Inflow and Outflow from the Southern Boundary*: the construction elements for this function include upgrading and sectioning of the southern portion of the peripheral embankment/road, the drainage control outlets, and minor and medium inlet regulators planned for the southern embankment.
3. *Internal Water Control and Management Structures*: these elements include drainage improvement of selected khals, and medium and minor inlet structures to regulate flow within the subcompartments and the floodplain, and erosion control work along the Lohajang and peripheral rivers.
4. *Institutional Development*: FAP 20 (1992d) has planned a tailored, detailed and extensive institutional development and training plan to be implemented within a participatory framework. This plan will be implemented simultaneously with the phased-in structural work. The impact of the project's proposed institutional development measures has been assessed in this report in the context of the environmental management plan (Chapter 8).

The three categories of the structural measures described above have been assessed in terms of their influence on the following:

- Control of abnormal flood;
- Regulation of normal flood and water management;
- Improvement of internal drainage; and
- Control of bank erosion

The examination and study of the controlling, improving, regulating and managing influences of project actions on hydrological events formed the basis for assessing the project impact on environmental components. Pathway networks were constructed to understand and establish relationships between these hydrological influences and the environmental components. Among the environmental components likely to be impacted those meeting the following criteria were identified as IECs:

- sensitive to hydrological changes (with emphasis on change in land types and flood depth) ;
- essential resource base for economic and social activities (irrigated cropping and capture fisheries emphasized);
- important to health (drinking water quality and water borne diseases emphasized); and
- environmentally sensitive ecological and biological components (with emphasis on aquatic and terrestrial habitats and species diversity)

On the basis of above criteria, four groups of IECs were identified:

- IECs related to water resources;
- IECs pertaining to land resources;
- IECs of biological importance; and
- IECs related to other human concerns.

6.2 Matrix of IECs

6.2.1 Conceptual Models

Figure 6.1 schematically illustrates relationships between the project interventions and hydrological events/factors in the area and the subsequent network of the impact of hydrological changes on important water, land and biological resources and human activities.

Hydrology

Since the hydrological cycle is predominant in determining the nature and seasonal distribution of resources, the IECs have been considered in terms of the seasonal hydrological determinants and constraints, e.g. flooding, rainfall, drainage congestion, siltation and erosion. Figure 6.2 shows the major hydrological events in the project area. The IECs/activities/events within each of the major resource groups e.g. agriculture, fishery, wildlife, navigation, and other human concerns are displayed in seasonal calendars in Figures 6.3 through 6.7.

Agriculture

Cropping patterns and crop diversity for kharif 1, kharif 2 and rabi crops are scheduled according to land types (F_0 to F_3), flooding frequency and duration of floods. Rabi crops are grown primarily in the dry season and on highlands, while cultivation of sugarcane requires year-round production activity (**Figure 6.3**). For example controlled flooding pattern due to project interventions may change agricultural practices for some crops (increased HYV boro crop) and this, in turn, will change the demand for groundwater irrigation and application of more chemical fertilizers and pesticides. Increased use of chemical fertilizers and pesticides may cause further deterioration in the quality of surface water and increase the risk of water-borne and fish diseases. Homestead and plantation production would increase, resulting in more food, fodder, fuel, timber and building materials, but these are likely to be damaged during extreme floods when embankments are overtopped and/or breached.

Fisheries

Figure 6.3 shows that river fisheries in the CPP area follow a four stage cycle during a year, whereas beel fisheries cover only two cycles. There are many ways in which the project intervention can impact the annual and seasonal fish biological cycle. For example, by closing and/or restricting migration paths during spawning and return periods. Hydrological interventions could potentially reduce the productivity of river fish resources and fishing activity in the project area. They also could reduce grazing habitat for fish and wildlife by reducing the floodplain wetlands. Fishing in the floodplains, rivers and canals in the project area has a strong seasonal dimension (from July to October), whereas fishing in the beels is limited to the period from mid-November to mid-May. If the fisheries calendar (Figures 6.3 and 6.4) is compared with the agricultural employment/income calendar (Figure 6.5), it can be seen that fishing in the floodplain, rivers and canals coincides more or less with the lean period of agricultural employment. Hydrological interventions could

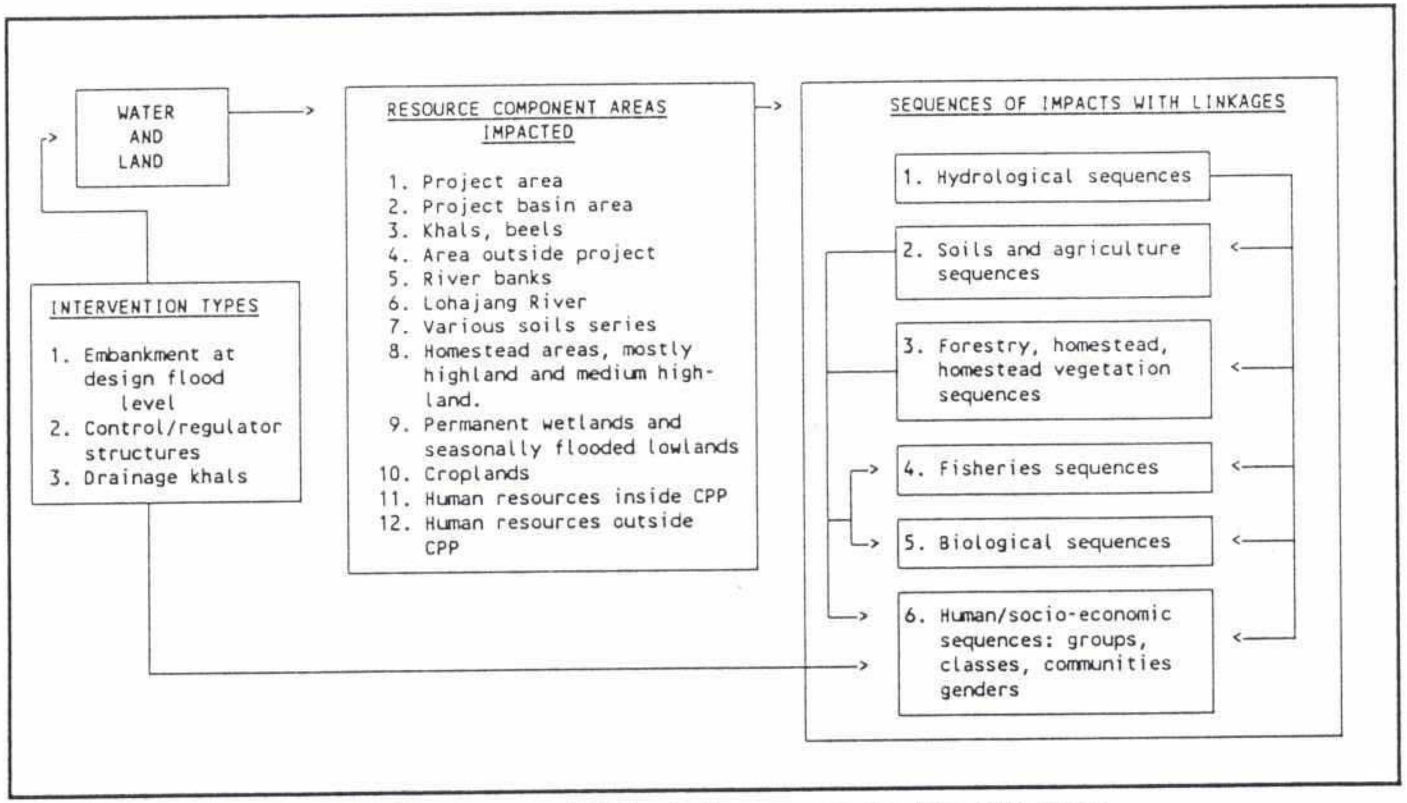


Figure 6.1 Environmental Cause and Effect Sequences in the CPP Area.

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potentially reduce fishing activity in the project area during the lean period of agricultural employment, thereby causing further imbalance in the general survival pattern of a large number of unemployed or underemployed agricultural day laborer.

Other Human Concerns

Figure 6.5 displays five different aspects of human concerns pertaining to employment, income, marketing and nutrition. Agriculture, capture fisheries, use of common property resources (especially beels) and nutrition from vegetables and fruits are more seasonal than weaving and culture fisheries. The latter through self employment, paid employment, income and marketing entails different activities during the whole calendar year with a gap in between. Conflicts over common property resources use (those between traditional versus vested interests) also show distinct seasonality in their main occurrence.

6.2.2 Impact Network

Table 6.1 presents the relationship between the resources and resource uses, the specific project actions or cumulative actions, and the likely impact on resource users. As expressed in the following table, the network begins with the project action (s) that normally causes a chain of primary and secondary impacts directly or indirectly on IECs. The effects of impacts are changes in IECs expressed in terms of unit or percentage increases or decreases in the quality and quantity of the resource components or resource use/consumption, and the social and economical issues associated with those changes.

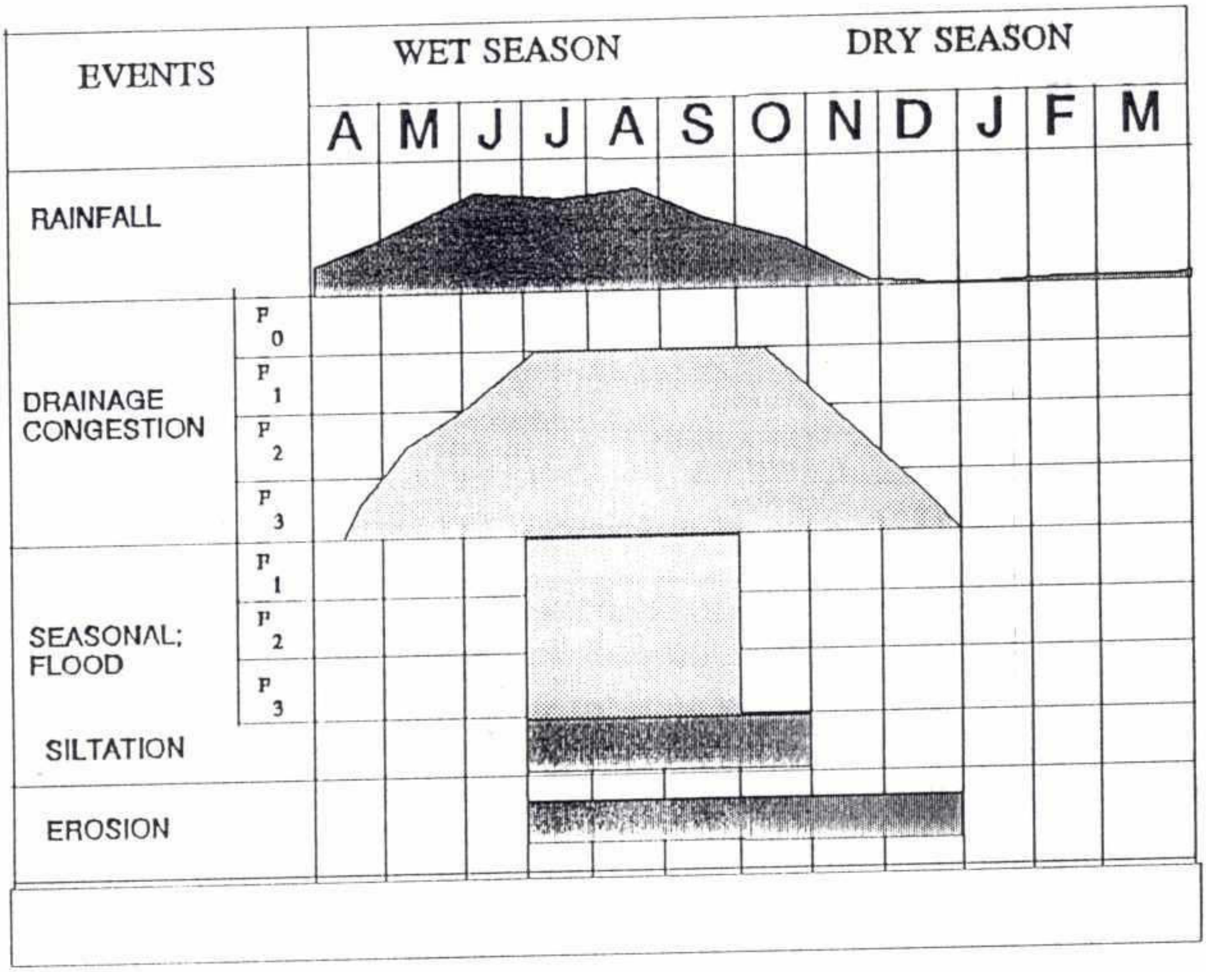


Figure 6.2 Hydrological Events in the CPP Area.

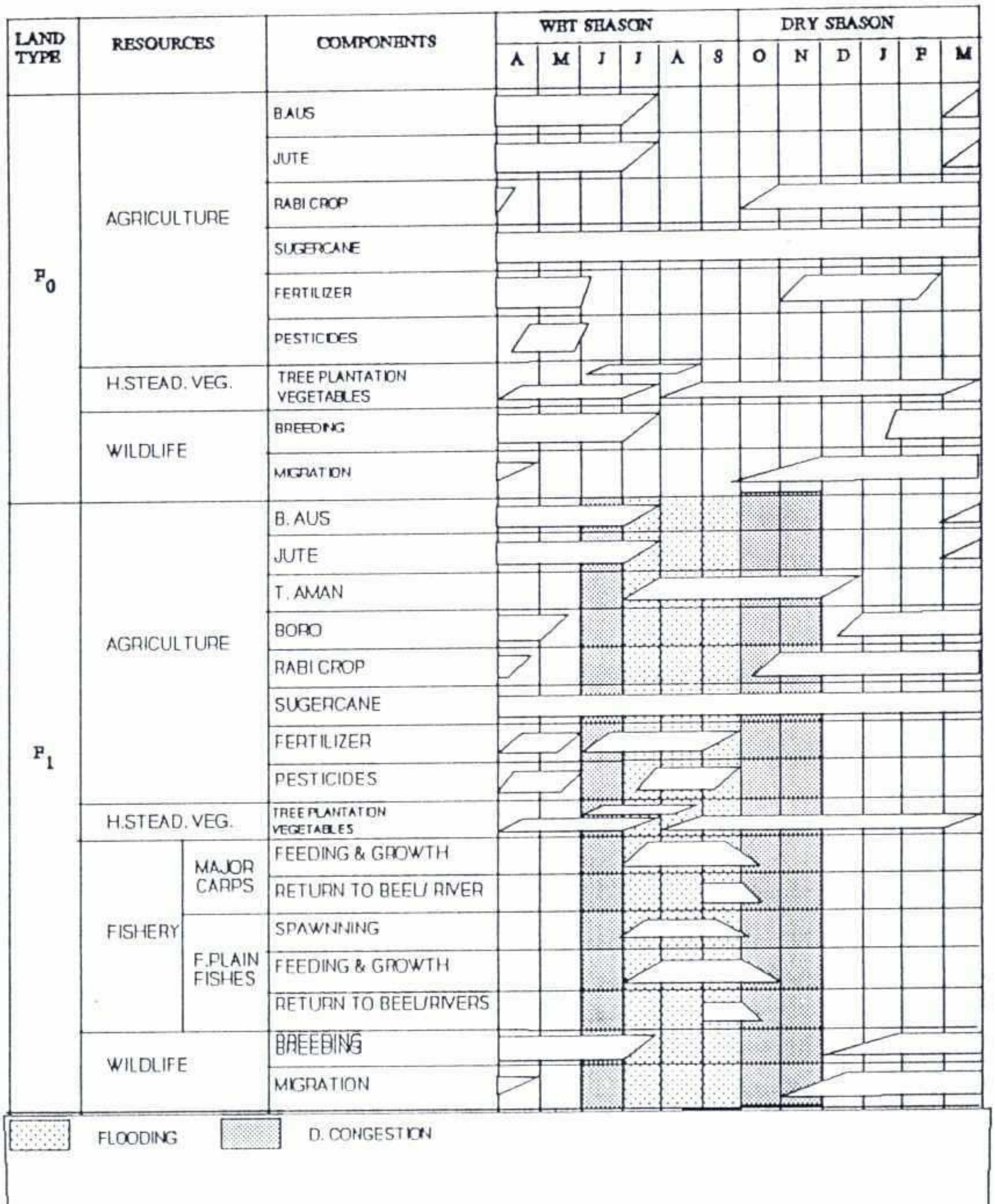


Figure 6.3 - Seasonal Relationship of Land and Water Resources in F_0 and F_1 Land Types to Flooding and Drainage Congestion

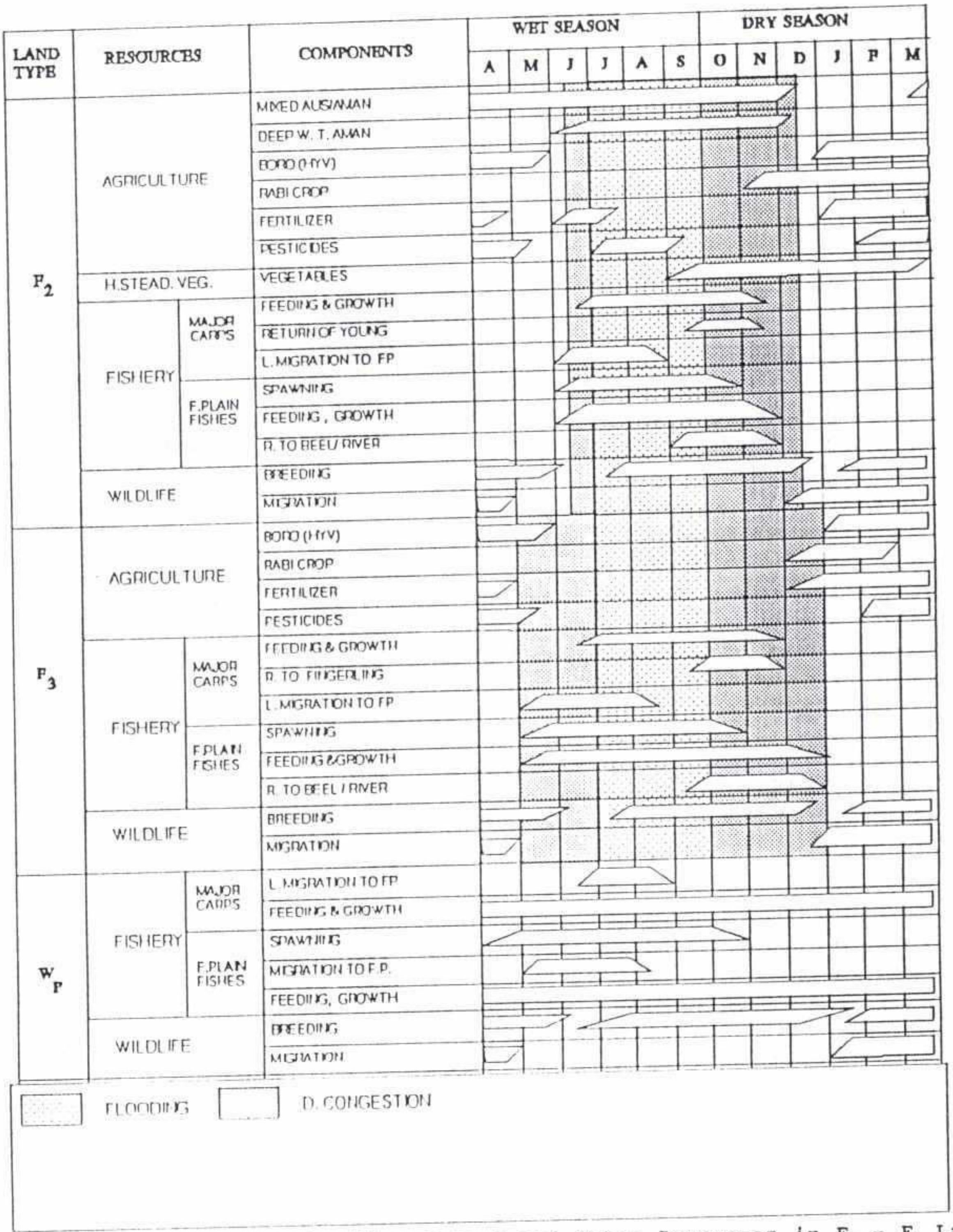


Figure 6.4 Seasonal Relationship of Land and Water Resources in F_2 - F_4 Land Types to Flooding and Drainage Congestion

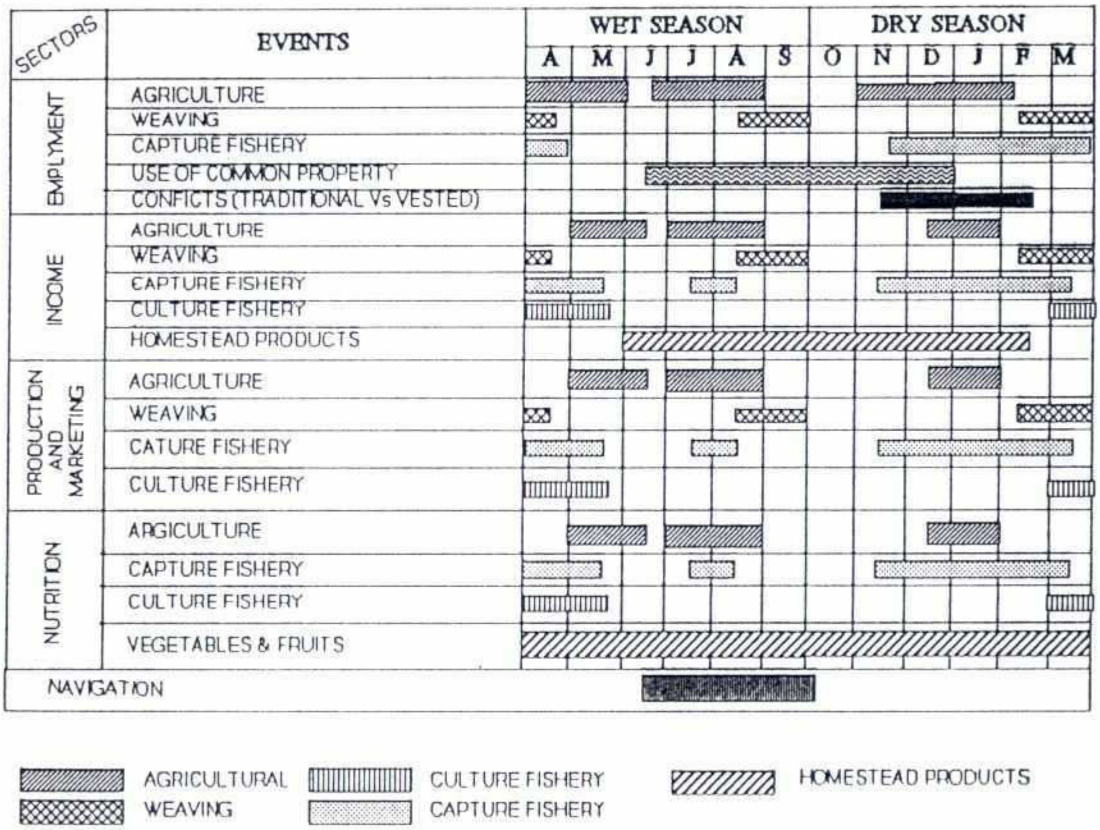


Figure 6.5 Seasonal Pattern of Socio-Economic Activities in CPP Area.

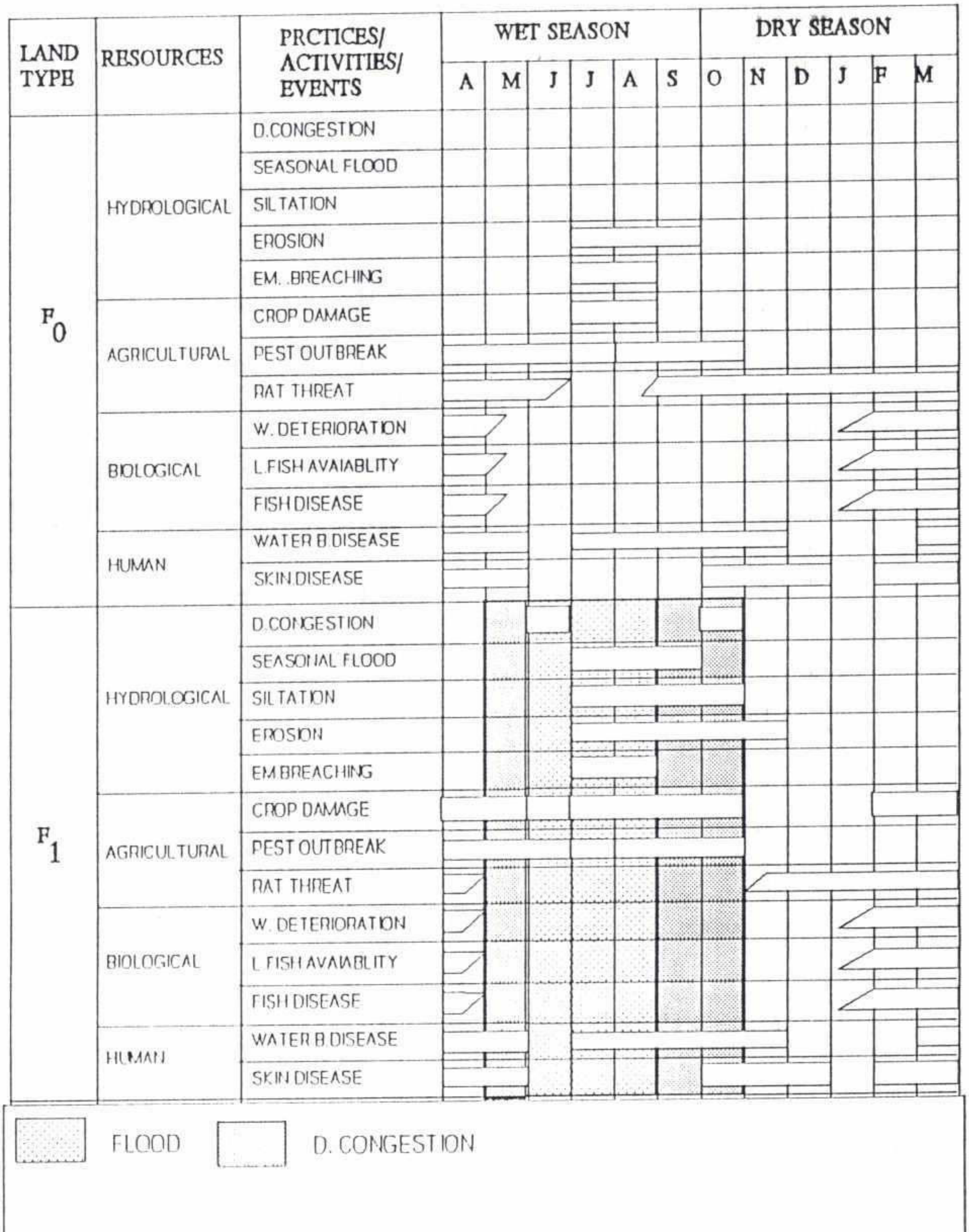


Figure 6.6 Seasonal Distribution of Hydrologically Related Negative Events in F_0 and F_1 Land Types

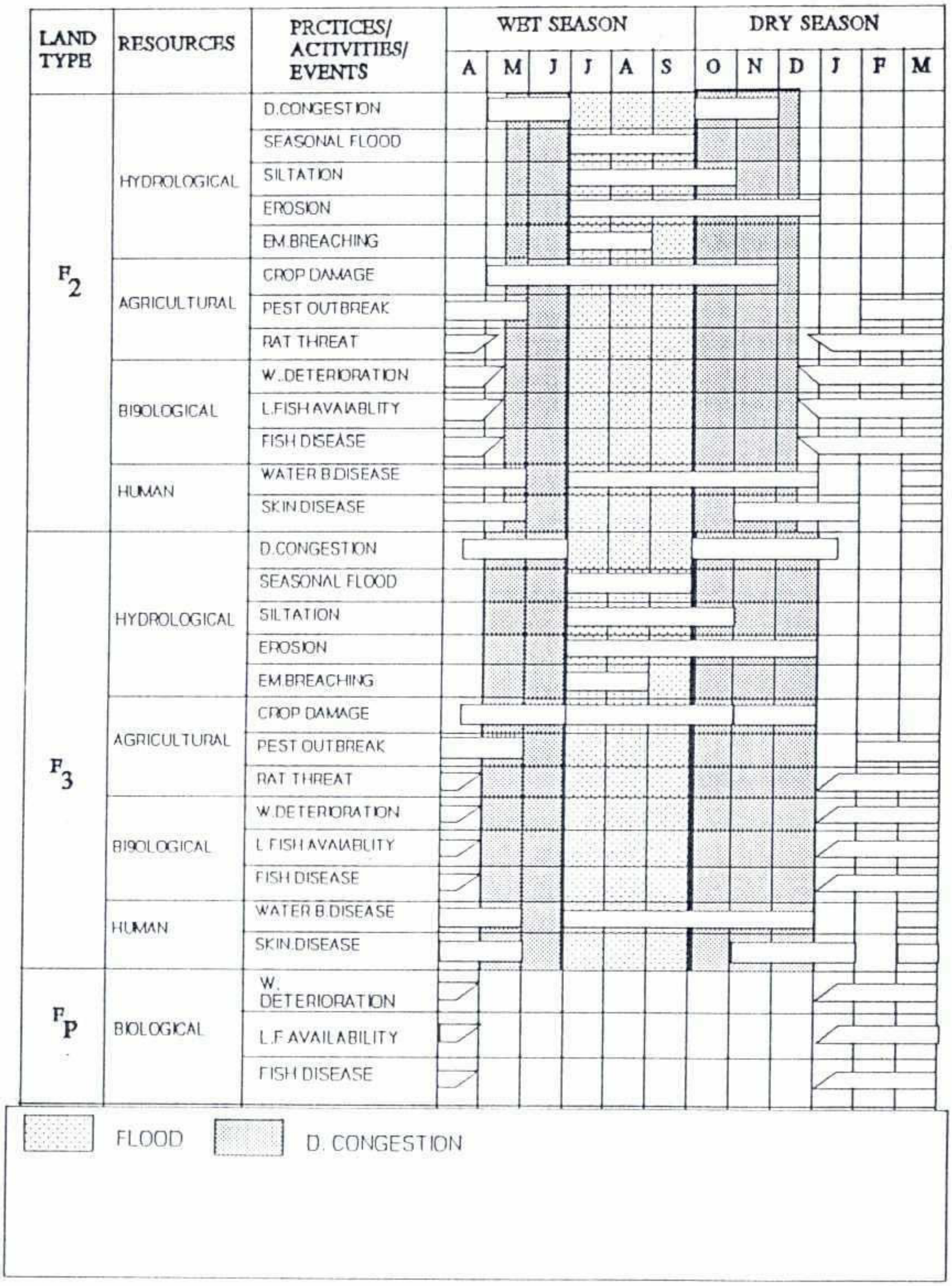


Figure 6.7 Seasonal Distribution of Hydrologically Related Negative Events in F_2 - F_4 Land Types.

Table 6.1 IECs/Project Action/Impact Sequences

Resources and Resource Use Users	Project Action	Potential Impact on Resource
Water Resources		
Surface Water:		
Water transport	Regulate normal flood	Controlled navigation/Impact on employment and income
Water transport	As above	Controlled navigation/Impact on marketing of goods/Input supply /Agricultural and fisheries production outputs
Extreme floods	Control of flood flow	Settlements/Life & land/Crop & homestead/Properties protection
Extreme floods	As above	Infrastructure (roads, railroad, installations, towns, etc) protection
Normal flash flood/ Sedimentation/ Siltation	Regulate normal flood inflow	Protection of crops, homesteads, land/Impact on soil fertility/Impact on beels and khals capacity
Normal river flood/ Bank erosion	As above	Protection of land, crops, and homesteads
Normal flood/Inundation	Regulate normal flood inflow and drainage improvement	Impact on seasonal and perenal wetland capacity
Surface water quality	Internal water management	Increased irrigated cropping/Increased use of chemicals/Impact on drinking water supply/Health & sanitation
Surface water quality	Internal water management	Increased irrigation & use of chemicals/Impact on fisheries production
Groundwater:		
GW recharge	Regulate the normal flood and improve drainage	Potential decrease in recharge groundwater
GW recharge	As above and internal water management	Increased abstraction by SDW/-DTW for drinking & domestic water supply & for irrigation

Continued -->

Table 6.1 Continued

Resources and Resource Use Users	Project Action	Potential Impact on Resource
GW quality	Internal water management	Impact on well water quality/ Drinking & domestic use due to increased use of chemicals as a result of increased irrigation
GW quality	As above	Increased use of chemicals as a result of increased irrigation impacting fish production & species diversity
Land Resources & Use		
Land Types	Regulate flood inflow/ inflow	Change in land type/Increase in HYV area/Increase in crop yield production
Land Types	Internal water management/Improved drainage	Change in land type/Reduced crop damage
Land Types	Regulate inflow/outflow /Internal water management	Change in land use/Impact land ownership, income, farm labor, landlessness & tenancy relationships
Land Types	Above	Impact on settlement & homestead production/Development of new or/and abandonment of settlements and homesteads
Land Types	Above	Impact on health (potential decrease in water-borne diseases and increase in respiratory diseases and kala-azar)
Energy Use	Above	Alleviation of fuel shortages
Biological Resources		
Fisheries/Open capture	Regulate flood inflow/ management/Drainage improvement	Fish production/Impact on income & employment, health and nutrition
Fisheries/Open capture	As above	Impact on fish species/Fish diversity/Impact on nutrition & health of disadvantaged (professional and subsistence fishermen)
Fisheries/Culture	As above	Impact on fish production/- Income & employment

Continued-->

Table 6.1 Continued

Resources and Resource Use	Project Action	Potential Impact on Resource Users
Aquatic Habitats	As above	Impact on area & species & overall biodiversity of aquatic fish and aquatic wildlife
Terrestrial Habitats	As above	Impact on area & species & overall biodiversity of wildlife
Other IECs of Concern to Communities		
Project construction activities	All structures	Short term employment/Increase income
Operation and maintenance	All structures	Short term & long term employment/Increase in income
Road repair and construction	Peripheral embankments	Impact on marketing & input supplies/Increased transport of goods/Increased access to support services (health, education etc.)
Community development	Institutional development	Impact on community organization development/Potential impact on formation of cooperative and associations/Potential impact on access to NGO services & credit facilities
Technical Skills/ Awareness & education	Training program	Potential impact on increasing technical skills in production /Impact on various community development activities
Tangail Town		
Groundwater supply and use	Drainage improvement	Potential impact on rechargeability/Impact on drinking and domestic & control flood inflow in the water supply & sanitation/Decreased drainage problem impacting on project area sanitation & health
Groundwater Quality	As above	Increased use of farm chemical/Impacting water supply quality/Health
Extreme floods	As above & control of floods	Increased protection of settlements/Life & properties/Infrastructure
Normal floods	Above & bank erosion control in Tangail town	Settlement & infrastructure protection

Chapter 7

IMPACT ASSESSMENT AND ANALYSIS

7.1 Future Without Project

7.1.1 Hydrology

Records for the past 200 years show that the CPP area was severely affected by floods in 1787, 1824, 1834, 1871, 1915, 1960, 1968 and 1974 (Tangail District Gazetteer 1986), and again in 1987 and 1988. Severe floods have not been described in hydrological terms, rather the incidence were categorized as severe in terms of damage to properties and loss of life. The trend indicates that the average interval of severe flood recurrence was about 35 years until 1960 and only 7 years since then implying that flood frequency trend has sharply increased over time. FAP 20 (1992d) shows a 1:8 year frequency for flood damage to crops at the level that occurred in 1988. It is likely that reductions in channel capacity (rivers and khals) and storage capacity (floodplain and beels), as well as closure of khal offtakes due to sedimentation and siltation, rising river beds, and various inappropriate and non-maintained human interventions are the factors responsible for the accelerated flooding.

The consequences of increasing vulnerability to flood during the next decades, under a non-intervention scenario, are significant. During high flood years, significant areas of cultivable land may be buried by sand deposition causing loss of fertile topsoil and loss of crops. The damages caused by seasonal flooding may be further aggravated by blocked outlets of important drainage channels. Progressive siltation of such channels will promote water stagnation over larger land areas. Existing embankments probably offer little protection against overspill. Natural breaching will continue and possibly be aggravated in future. There will be more public cuts of village roads and embankments to drain out stagnant water from the lowlands and homestead arenas. Erosion will continue to displace households along the river banks and exacerbate the process of landlessness and out-migration.

Groundwater abstraction in the CPP is mainly for irrigation and drinking purposes. At present (1992), there are 616 STW and 76 DTW in the project area. The area under irrigation is currently 5,500 ha. This compares to 3200 ha of total irrigated land for the entire Tangail thana in 1981-82. The area under irrigation has increased significantly in a decade mainly through extensive use of tubewells. The groundwater table fluctuated from 11.90 meters (PWD) in 1987 to 12.14 meters (PWD) in 1991. It appears that annual recharge has been adequate to accommodate the increased water abstraction. It is not certain that the trend for increased irrigation will continue into the future under conditions of no hydrological and water management intervention. Increased threats of flood damage and the risk of crop failure due to drainage constraints may work against expansion of irrigated area in the future.

7.1.2 Fisheries

Capture Fisheries

National data and recent statistics indicate that capture fisheries production has been declining over the past few years. The reasons for such decline is reduction in aquatic habitats, obstruction of fish migration, overfishing, water pollution and the like. It appears that the CPP area is no exception from the national trend. The population growth, increase in agricultural activities, and sedimentation, decreasing capacity of khals in maintaining and regulating the flow in and out of the water bodies such as beels are likely factors responsible for gradual reduction in aquatic habitats. Figure 7.1 shows a significant reduction in the capacity of Jugnidho Beel in the project area from 1977 to 1992 and the projected trend of capacity reduction in the future. Similar trends are expected to occur in case of other major beels in the project area.

Projecting the annual decline in fish production (around 2 percent) into the future, the capture fisheries production in the CPP area will likely decrease during the next 20 years from the present production level of 380 tons/year (1992) to 215 tons/year in the year 2012 under the no-

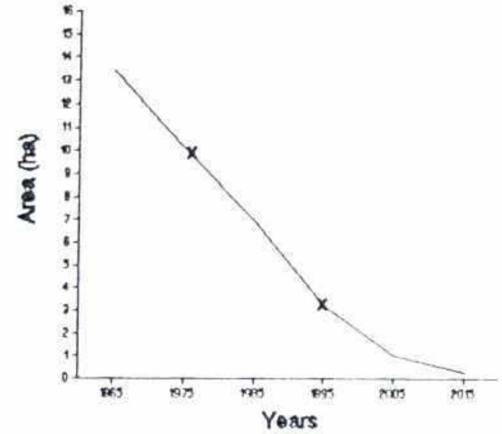


Figure 7.1 Long-term trend in the size of Jugnidho Beel. Crosses indicate measurements taken from aerial photographs.

intervention scenario.

Considering the past trend of species extinction, it can be projected that this trend will continue as a result of hydrological changes, reduced habitats, pollution and overfishing. Although the District Gazetteer of 1983 recognized Tangail as being rich in fish diversity, recent trends reveal the opposite to be true. Mohaseer (*Tor tor*), an endangered species, has not been seen in Tangail area in recent years. The FAP 20 household survey (FAP 20 1992c) revealed that six species of fish - goinnya, sharputi, meni, calibaush, tara bain and ellong - are rarely observed in the CPP area. Considering the past trend of species extinction it is anticipated that the three mentioned species will become extinct from the CPP area in future with the possibility that additional species join the list of rare or endangered species by the year 2012.

According to the preliminary findings of a case study on fisheries conducted by FAP 20 (in preparation), about 6.5 tons of pesticides are being applied per year in the CPP area. This figure probably will increase with the inclusion of more areas for HYV paddy cultivation in future. It is estimated that by the year 2012 pesticide requirements will be about 7.5 tons per year. According to FAP 20 (1992d) the fertilizer recommendations for irrigated boro (HYV) and T.aman alone are close to 700 kg/ha (urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc) or approximately 3,500 tons. Increased irrigation will increase the rate per unit area and the total fertilizer application at much higher rates. Increased application of agrochemicals will have adverse impacts on fish and fisheries resources. Residual concentrations of DDT and Dieldrin, both non-degradable pesticides, were detected in the tissues of punti fish at levels of 0.021 and 0.088 ppm, respectively. Both levels are within the carcinogenic risk range for humans consuming the fish. Since the rate of application of pesticides and fertilizers will increase in future, the rate of accumulation of hazardous substances in fish tissue will increase proportionately. This condition will make more people vulnerable to diseases associated with chemicals and would adversely impact fish health, production and species diversity.

Culture Fisheries

Unlike capture fisheries, culture fishery production has followed an increasing trend over the past few years. Data for Tangail district shows that the rate of fish production in cultured ponds has increased from 1161 kg/ha in 1983/84 to 1239 kg/ha in 1988/89, an increase of 6.7 percent in 5 years and equivalent to an average annual increase of or an annual increase of 1 percent. If this trend continues, the rate of production of fish in cultured ponds in the CPP area would increase to approximately 1625 kg/ha by 2012.

The production of fish from culturable ponds in Tangail area has increased from 338 kg/ha in 1983/84 to 851 kg/ha in 1988/89. As the culturable ponds are yet to be managed properly, this figure may increase to its maximum static level of 1000 kg/ha probably during the next 5 years.

With no intervention, it is estimated that the production of fish from cultured ponds in the CPP area would likely increase from the present level (1992) of 33 tons/year to 40 tons/year by 2012. The production of fish from culturable ponds by year 2012 would probably increase slightly to 19 tons/year from its present level of 16 tons/year. Therefore, the total production of fish from culture fishery is estimated to increase from the present level of 49 to 59 tons/year by 2012.

7.1.3 Wildlife

The degradation of wildlife resources in the project area follows the national trend. Human population growth in the area leads to qualitative degradation of the terrestrial habitats and decline of wetlands. A comparison between the national lists of extinct wildlife and historical information (The Bengal District Gazetteers of 1917 and Bangladesh District Gazetteers of 1983), indicates that 10 wildlife species disappeared from the project area within the past 60 years. The pink headed duck which existed in the project area until 1976 (as reported in the Gazetteers of 1983) is now extinct globally. Fresh water crocodile, wild boar and king vulture have been listed as recently extinct wildlife. The population of Pallas' fishing eagle is now in a critical condition. The populations of monitor lizard, jungle cat and large indian civet would be likely affected due to conversion of habitats from the Inland Densely Vegetated TEZ to lower quality habitats. The trend obviously has been towards extinction of wildlife and will probably continue in the future (Table 7.1).

Changes in Madhupur tract vegetation and inflowing industrial wastes originating from the Jamuna Fertilizer Company, upstream of the project area, are other likely factors contributing to degradation of terrestrial and aquatic wildlife in the project area. Under a no intervention scenario, it is expected that the trends of events and actions described in Table 7.1 would continue. Most of the endangered/threatened wildlife species in the project area are wetland dependent. As such the trend of wetland reduction and degradation in terms of quantity and quality would lead to elimination of a good number of wildlife species in future.

7.1.4 Land Resources

Agriculture

Without a project, the current land types and current cropping practices are expected to remain the same (Table 7.2). Pre-monsoon drainage congestion will continue to damage boro HYV crops in the low-lying areas (F_3) during the months of May through June. TD aman will continue to be damaged at the early stages of growth. Seasonal floods caused by heavy rainfall and river flooding will continue to damage T. aman and B. aman crops. Post monsoon drainage will deteriorate, causing further decreases in the area available to rabi crops. It is estimated that the area affected by crop damage will increase from the present 2374 ha to 3418 ha in the future. The loss of crops due to drainage congestion and floods could increase as high as 5,000 tons annually (Table 7.3). At present, about 3,000 tons of foodgrain are lost annually.

In order to compensate for the crop loss/damage, farmers are likely to increase the areas under boro by installing more tubewells. The present irrigated area of 60 percent of the cultivated land is expected to increase to about 70 percent. Increased irrigated areas would probably occur in F_2 and F_3 land types. This would introduce a cropping pattern of TD aman - boro (HYV) by replacing existing jute/mixed aus & aman/rabi cropping patterns.

An increase of irrigated areas by tubewells would increase foodgrain (paddy) production by an estimated 3578 tons. Future cropping intensity would remain more or less the same. On the basis of Table 7.2 data, future manpower requirements for agricultural activities in the CPP area under the "without project" scenario are estimated at 3,051,000 person/days for one year of cropping activities (Table 7.4). This figure is slightly higher than the baseline estimates of 3,011,000 person/days.

Forests and Homestead Vegetation

Inundation from periodic flooding and soil saturation from drainage congestion would continue to damage seedlings, saplings, suckers and shoots. Inundation and water saturation currently weakens the root system of about 20 percent of mature trees and make the plants vulnerable to pests and diseases. This condition would affect the 20 percent yield of fruits,

Table 7.1 Possible Actions and the Resultant Effects on Wildlife Populations

Trends of Actions	Possible Impacts
Cutting large trees for brick piles, land acquisition for road (e.g. Tangail-Delduar) and timber	Loss of species: kites, vultures, eagles, other raptors and biological imbalance
Planting trees (e.g. Eucalyptus) not attractive to wildlife	Increase in common resident birds, change in species composition, low biodiversity
Clearing edge undergrowth by flood or dry season burning	Edge dependent wildlife exposed and killed (e.g. monitor lizards), increase of agricultural pests
Draining wetlands for boro cultivation and blocking inlets from the river to wetlands	Decline in waterfowl and waders, loss of wetland productivity
Overuse of pesticides and fertilizers	Impacts to insectivorous wildlife (e.g. frogs, birds), environmental imbalance
Fishing activities during breeding season (April-September)	Disturbance of resident waterfowl, degradation of water quality, decline in wetland productivity
Human activities (agricultural/hunting) in lowlands during migration period (November-February).	Impacts to resident and migratory birds, ecological degradation
Conversion of multi-species natural ecosystems (mixed forest/grassland) to monocropping	All wildlife species impacted

Table 7.2 Expected Cropping Patterns Without Project

Cropping Pattern	Area (ha)				
	F_0	F_1	F_2	F_3	Totals
Sugarcane	506				506
B-Aus-Rabi	35		181		216
Jute-Rabi	35		434		469
B Aus-T.Aman(L)-Rabi		268			268
Jute-T.Aman(L)-Rabi		592			592
Jute-T.Aman(H)-Rabi		76			76
Mixed Aus and Aman-Rabi				523	523
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)		537	272		809
TD Aman-Boro(H)			2169	439	2608
TD Aman-Mustard-Boro(H)			735		735
T.Aman(L)-Mustard-Boro(H)		134			134
T.Aman(H)-Mustard-Boro(H)		113			113
TD Aman-Boro(L)				104	104
Mustard-Boro(H)			268		268
Total	576	1821	4248	2552	9197

Table 7.3 Expected Crop Damage Estimates (Without Project)

Crop	Damage Free Area (ha)	Damage Free Yield (t/ha)	Damaged Area (ha)	Damaged Yield (t/ha)	Production (tons)	Production Lost (tons)
B. Aus	406	1.5	78	0.5	648	78
Mix Aus and aman	460	1.9	63	0.9	931	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
TD.Aman	1216	1.7	2231	0.4	2959	2901
Boro (HYV)	6094	4.5	382	2.0	28187	955
Boro(L)	104	2.5			260	
Paddy					37954	4801
Wheat (H)	873	2.0			1746	
Potato	300	9.5			2850	
Jute	703	1.8			1265	
Sugarcane	506	40.0			20240	
Mustard	1439	0.8			1151	
Pulses	350	1.0			350	
Vegetables	100	3.5			350	

Table 7.4 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 Person-Day/ha
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(000 P/D)		395	378	182	305	374	250	238	166	55	47	298	363	3051

vegetables and timber and would reduce the vegetative cover. A 50 percent damage rate to vegetables is expected.Flash floods would probably damage about 10 percent of field crops (see Table 5.7 in Chapter 5). Crop failure will inevitably cause overconsumption of trees and other non-crop vegetation for food, fuel, fodder and cash. People will become dependant mostly on trees for biomass energy that could be met by husks, crop residues and straw (see Chapter 5). Distress-sales to buy rice and to meet other expenses could occur to compensate for field crop failure.

It can be expected that the direct impact of flood and water congestion on reduced homestead production will increase deforestation and consequently impact fuel supply, nutrition efficiency and the overall household economy. The economic stress caused by reduction in homestead vegetation has been and will be more pronounced on rural women.

7.1.5 Navigation

Under the existing situation, use of watercourse for transport and various economic activities is confined to the flooding season from late June to October. The CPP area has a reasonably good network of rural roads. In the future the importance of watercourses for delivery of goods, inputs and passengers will probably decrease. Furthermore, heavy siltation may permanently close the inlet of Gala Khal and confine navigation to the interior of the project area. Navigation and access to watercourses will remain important for fishing purposes.

7.1.6 Socioeconomic

Population and Settlements

Without intervention, the population of the project area will continue to increase, and if the national projected growth rate of 1.8 percent between 2001 and 2011 is taken into account, the population of the project area would increase by nearly 20 percent by the year 2011 (Table 7.5). The increasing population will put tremendous pressure on the available land and water resources in the project area, causing further reductions in the land-human ratio and per capita agricultural land availability. The increase in farm households and farm population would lead to progressive decline in average farm size (Table 7.5), thereby further subdividing the farm holdings into many small parcels. This will reduce the production efficiency of the farmers. Under conditions of increasing damage risk to crops, loss of land, and reduced soil productivity due to flood and drainage congestion, farmers probably would not cultivate the land as intensively as before. Those trends, if not checked, will exacerbate the process of landlessness and out-migration.

Settlements along the main rivers will continue to be affected by overspill and those on the outside of embankments would be more affected during high flood years. High floods may lead to the break up of linear type of settlements along the riverbanks and may increase the number and density of clustered settlements on the highlands and beel areas, making them more densely populated. The possible increase in clustered settlements would require construction of new homesteads in the highlands and beel areas, thereby reducing the availability of potentially good agricultural land in those areas. Moreover, the direct impact of flood would require that the homestead mounds in the low-lying areas be raised every year, causing financially extra burden to many poor households. These households may have the tendency to shift their homesteads from low-lying areas to medium high and high land that currently are being used for agricultural purposes.

Livelihood and Subsistence

Without intervention, the expected reduced crop and homestead production would result not only in loss of income and employment for many households, but also cause a reduction in per capita major foodgrain availability (Table 7.5). Total food availability per capita may reduce from the existing 364 grams to 263 grams per day by the year 2011. This figure is far below the national average requirement of 450 grams per capita/day.

Table 7.5 Trends in Some Selected Socioeconomic Aspects in Tangail CPP Without Project

Socioeconomic Factors	1981	1991	2001	2011
Total Population	190,430	236,580	288,960	345,948
Growth Rate(%)	2.31	2.17	2.0	1.8
Density km²	1,435	1,820	2,223	2,661
Farm Population	84,366	104,810	108,018	153,265
Farm Households	14,061	20,551	29,095	40,980
Average Size of Farm Households	6	5.1	4.4	3.74
Average Farm Size(ha)	0.71	0.49	0.34	0.24
Total Land Availability per capita for Farm Population(ha)	0.15	0.12	0.10	0.08
Agricultural Land Availability per capita Farm Population(ha)	0.11	0.09	0.07	0.06
Agricultural Labor Requirements (man-days Annually 000)	N.A.	3,011	3,051	3,343
Landlessness (Farm and Non-farm Holdings%)	41	51	62.3	74.6
Major Foodgrain Availability per capita (rice and wheat)				
Per day(gram)	N.A.	337	282	241
Per year (kg)	N.A.	123	103	88
Total Food Availability (rice, wheat, potato, pulses and vegetables)				
Per day (gm)	N.A.	364	307	263
Per year (kg)	N.A.	133	112	96

The growing imbalance between land availability and population increase, and the lack of employment opportunities outside peak agricultural seasons will lead to progressive deterioration in the quality of people's life. This deterioration will adversely affect the landless and land poor households, thereby pushing many of them to migrate to Tangail town and other urban centers (particularly Dhaka city) in search of employment. The existing trend of exodus of people from the rural area to urban centers simply indicates that by 2011 the population of Tangail town, if it increases at the 1981-1991 growth rate of nearly 51 percent, will be more than double, thus putting tremendous pressure on the already over-crowded urban center and further causing overconsumption of the resources and pollution of its environment. This "push factor" will have a negative impact on the presently over-crowded Dhaka city and its environment.

Without intervention, the net effect of the continued current trends on the livelihood and subsistence pattern of people will increase poverty, inequality and unemployment. The professional fishermen community are the most sensitive group to deterioration of water resources in the project area. Their livelihood will be adversely affected by the reduction in aquatic habitats and a gradual decline in capture fisheries production due to continuous siltation of wetlands. Considering the past trend of species extinction and the loss of fish diversity, overfishing due to increased population pressure and fish diseases due to water pollution will have a negative impact on the animal protein requirements of the households.

Land Ownership Distribution Patterns

A decreasing trend of resource productivity will severely reduce the primary source of income for many landless and land-poor households. This, in turn, would force many small and marginal farmers to sell their land in distress situations, probably at a lesser value, in order to feed their families. Leasing and mortgaging will increase and in many cases will lead to permanent transfer of land from the mortgagor to the mortgagee in order to cover the debt liabilities. This trend will further concentrate land and income into the hands of small minority of rural elites.

The implication of the trends described above for the overall distribution of wealth and equity is apparent, and if the proportionate increase in total population between 1991 and 2011 is taken into account it is possible that almost three-fourths of the rural households would become landless by the year 2011 (Table 7.5). Such a trend, if realized, will have a significant negative impact on socioeconomic development in the project area.

Tenancy Market

As more land would be likely acquired by large land owners, the tenancy market would expand and work exclusively in their favor. As the pressure of population on limited available land increases, little land will be available for share-cropping contracts. The lack of employment opportunities outside agricultural sector will, inevitably, increase competition among the landless and land-poor households for share-cropped land. The likely consequence will be the imposition of stiffer terms and conditions of tenancy by land owner.

Credit Relations

The "patron-client" relationships will persist and possibly turn into impersonal relationships of "domination" and "dependence", giving way to increasing marginalization and a polarization process. Non-institutional sources of credit with usurious rates of interest will continue and often dominate the credit market. If the existing difficulties in obtaining credit from institutional sources are not removed, more households will seek loans from informal credit sources at even higher interest rates. This will enhance the transfer of resources from poorer to richer households and exacerbate the process of landlessness.

Education

The Tangail District population census shows that the rate of literacy (ROL) for the total population was 20.3 in 1981, rising to 23.6 percent in 1991. The ROL for females only was 13.5 and 15.7, respectively, in the same years. However FAP 20 (1992c) estimated the overall ROL in the CPP area at 40.3 percent and for females 30.5 percent. Over the 10 year period (1981-1991) the increase was 3.3 in the total rate and 2.2 percent in the female ROL. The ratio between the total and the female rate is 0.66. Assuming that there will be no external intervention and all other factors remain the same in the project area, the ROL for the total population could rise to 30.8 and 18.0 respectively, using BBS basic statistics. If the projection is based on FAP 20 household data, the ROL could rise to 47.5 and 36.0 respectively.

Gender Issues

The status of rural women will follow the overall trend in the area. With limited opportunities, continued flooding and inundation, drainage congestion, and damage to homestead production will have continual and direct negative impacts on women. Women in the more remote areas will have limited access to development organizations (NGOs) who are active in the project area on activities focussing on women. They are not likely to benefit from those developments. With the continuing increase in population, and decline of traditional rural based activities such as paddy husking by "dhenki", the opportunities for work for women will reduce. Most women have no skill or training, hence the scope for women's work will become narrower. With little or no income to supplement the household income, women's already weak position will become even weaker.

Without intervention and with declines in overall production, it is expected that the per capita food intake will further reduce. Since the disparity in the eating/feeding patterns of females and males is poverty related, the nutritional status of the females is expected to reach lower proportions. This situation will be exacerbated as a result of expected decline in homestead vegetable production. Added to this situation is the predicted decline in capture fisheries that further reduces the animal protein intake. With a decrease in their nutritional intake the instances of illness among females will increase. In addition to health issues arising from low nutrition intake, worsening of drainage condition and water stagnation will continue to impact the health of the household members in the future.

The existing health delivery system is not adequate to cope with increasing health concerns. The poor sanitary condition is one of the main health hazards in the project area, especially for the women. On the basis of existing data and the past trend, it is projected that water borne diseases in the project area will increase 5 percent for scabies, 3.5 percent increase in dysentery, and approximately 5 percent for acute respiratory diseases. In developing those estimates it was assumed that health services in the area remains relatively the same. However, increasing efforts by active NGOs, if maintained or strengthened, could probably check the increasing trend of diarrhoea and malaria incidence.

7.1.7 Tangail Town

The trend in land use patterns in Tangail town was established by comparing the aerial photographs and SPOT images of 1964 and 1992, and from interviews with local authorities (Table 7.6).

7.2 Future With Project

7.2.1 Hydrology and Land Types

River Flooding and Drainage

Flood control and water management measures planned by the CPP would affect directly the hydrological resources in the project area and induce significant changes in land inundation, water storage and delivery capacity and drainage.

The underlying tenet of the CPP is to control river flooding and manage the water inside the project area. The purpose of peripheral structures is to control or partially control the normal flood. They are also prerequisite for controlled drainage from the project area to the Lohajang River. The peripheral control, through gated structures, would protect the project area from abnormal flood, or reduce the flooding through partly ungated structures. The spillways planned for the peripheral embankments, would help in controlling the water level within the river during high floods, and would provide a higher downstream water level in case of overtopping of the embankment. The main inlet regulator, planned for the upstream of the Lohajang River would control the inflow to the project area after July 15 during the normal floods. The southern closure embankment is primarily for drainage control in the project area and guiding the water towards a SE direction. It also protects the area in case of abnormal floods.

The measures described above, if implemented and operated as planned, would fully control the river flooding in the compartment, would ease the drainage condition, and would allow for internal water management for various purposes.

Groundwater

Groundwater modelling has been undertaken by MPO (1987), although no specific modelling has been applied to the Tangail area. The MPO modelling (Figure 7.2), based on the Debidwar area in Comilla, indicates an average 35 percent reduction in potential recharge when medium and low lands are fully protected from flooding and rainwater is the main source of recharge. Model results were variable, as demonstrated by fairly wide confidence limits. The overall effect of flood protection is a steepening of the rainfall-recharge response, and a marked reduction in potential recharge in dry years. Rainfall data from the central region of Bangladesh (WARPO 1992) suggest that dry years of frequency about 1 in 10 have an annual rainfall of about 70 percent of that of average years. Figure 7.2 suggests that a 70 percent of average rainfall would be in the zone where groundwater recharge would be significantly reduced. It is concluded that groundwater recharge in the CPP would be affected by a reduction in seasonal flooding and imposition of a controlled flooding regime, but that the effects would probably be noticeable or measurable only in dry years. Under such conditions, STWs would probably not be able to access their normal water table for the driest part of the year (March-June) and in very severe cases DTWs might be affected for a few months in the dry season.

Control of river floods and inundation would directly cause significant changes in land type distribution. With project intervention, through controlled river discharge in the Lohajang River Basin, the inundation would occur primarily due to rainfall and runoff and controlled river flood. Therefore, the inundation would be less severe and drainage problem would be significantly reduced. Maps 7.1 - 7.3 present predictions and changes in flood depths under project condition.

Chapter 9 briefly describes the assumptions used in computing the flood depth for the project condition and land types for the baseline condition.

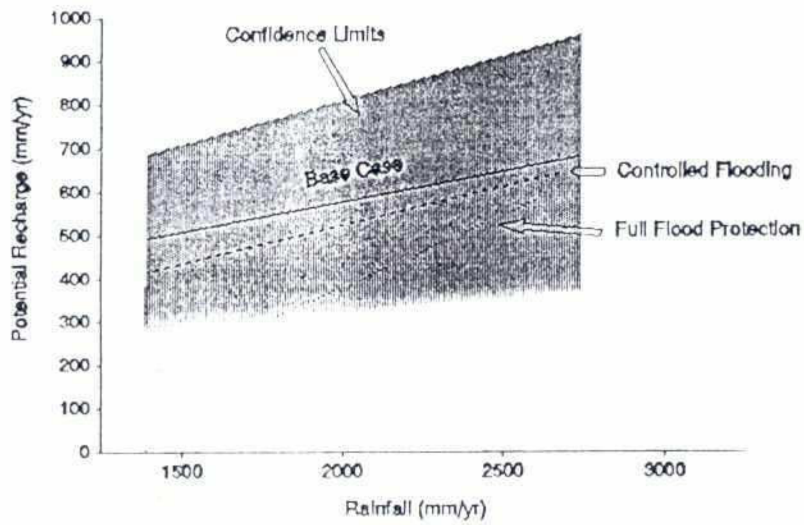
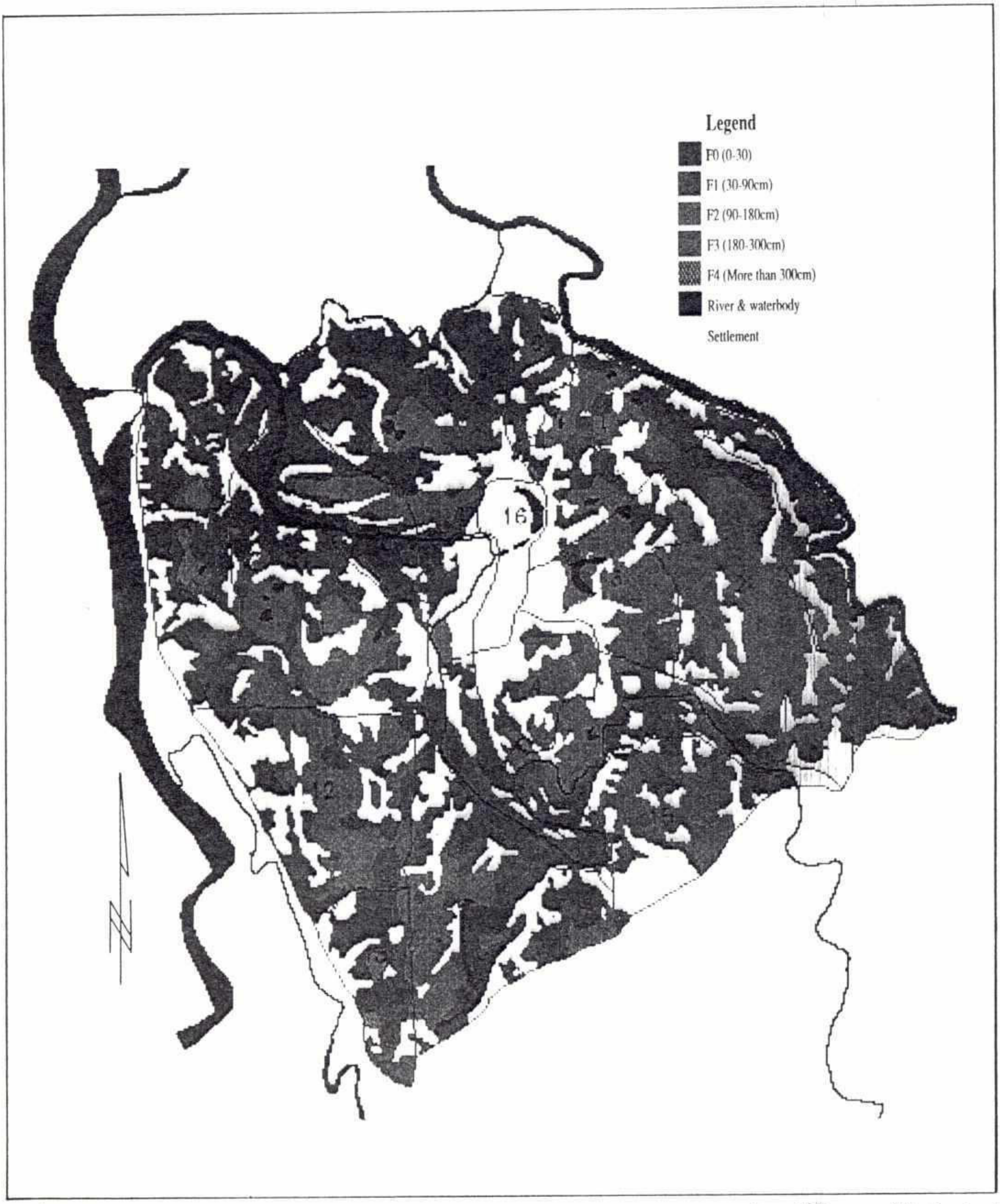


Figure 7.2 Effects of Reduced Flooding on Potential Groundwater Recharge (Adapted from MPO 1987)

225

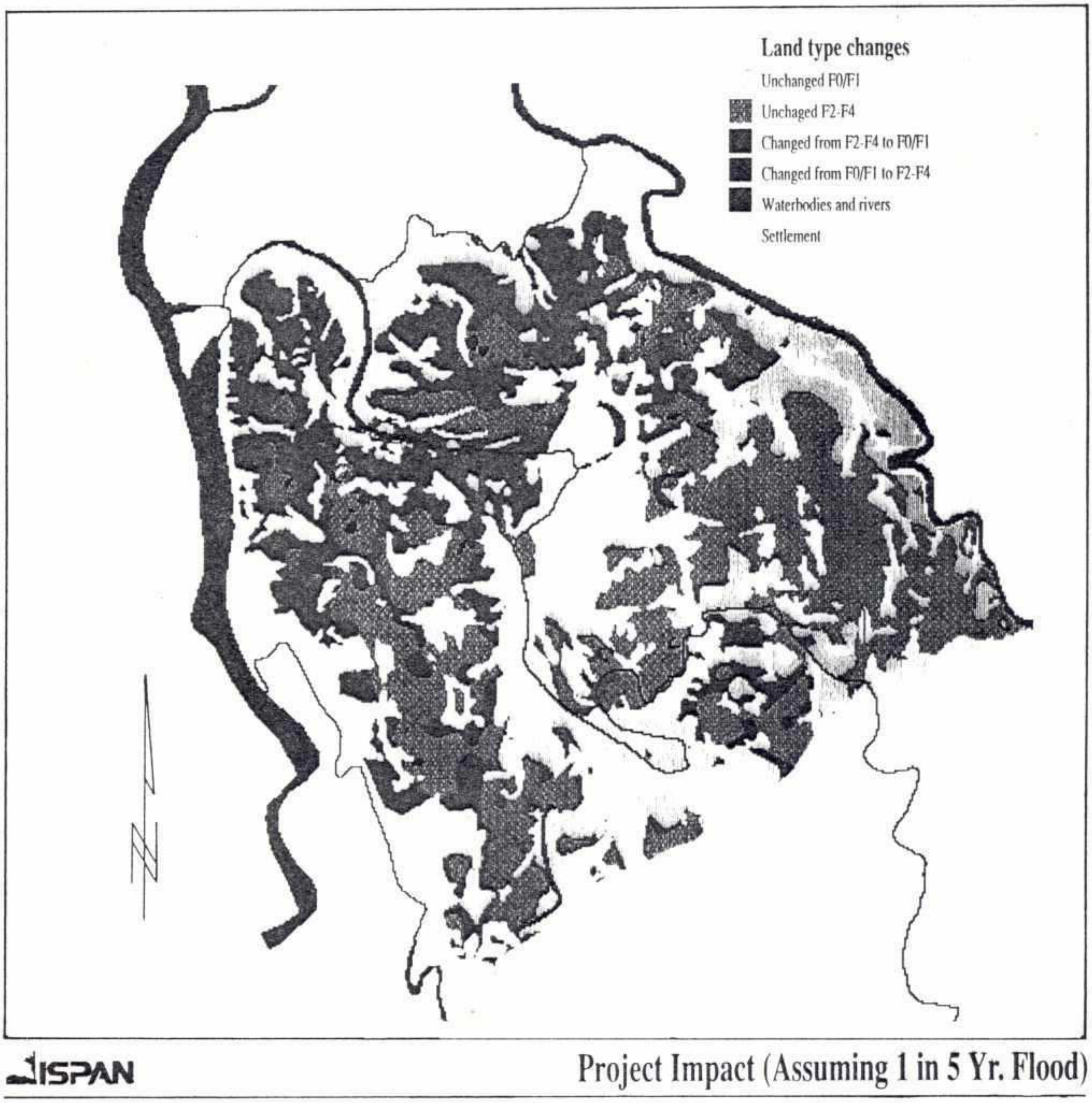
Map 7.1



Land Types with Project

029

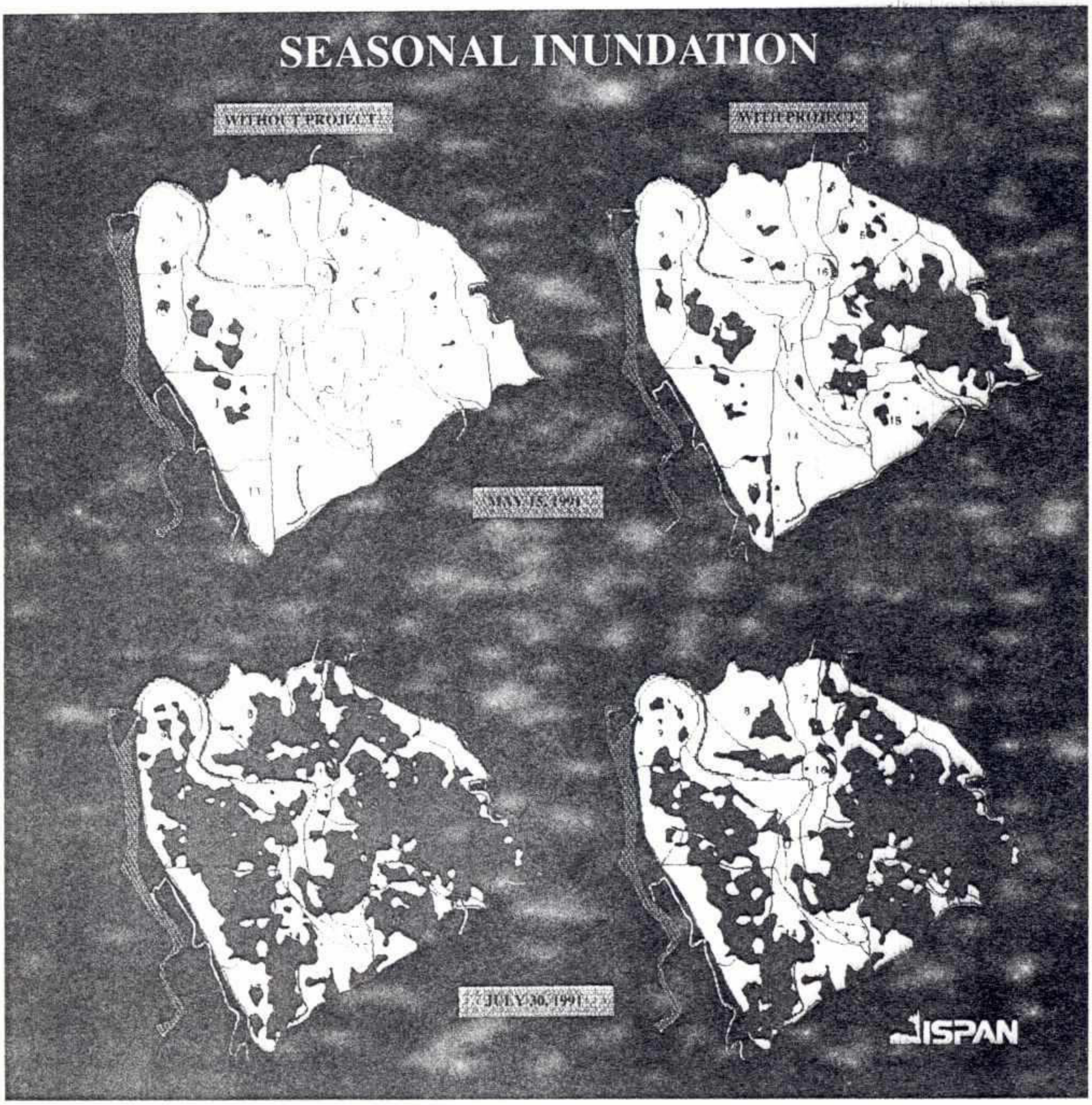
Map 7.2



ISPAN

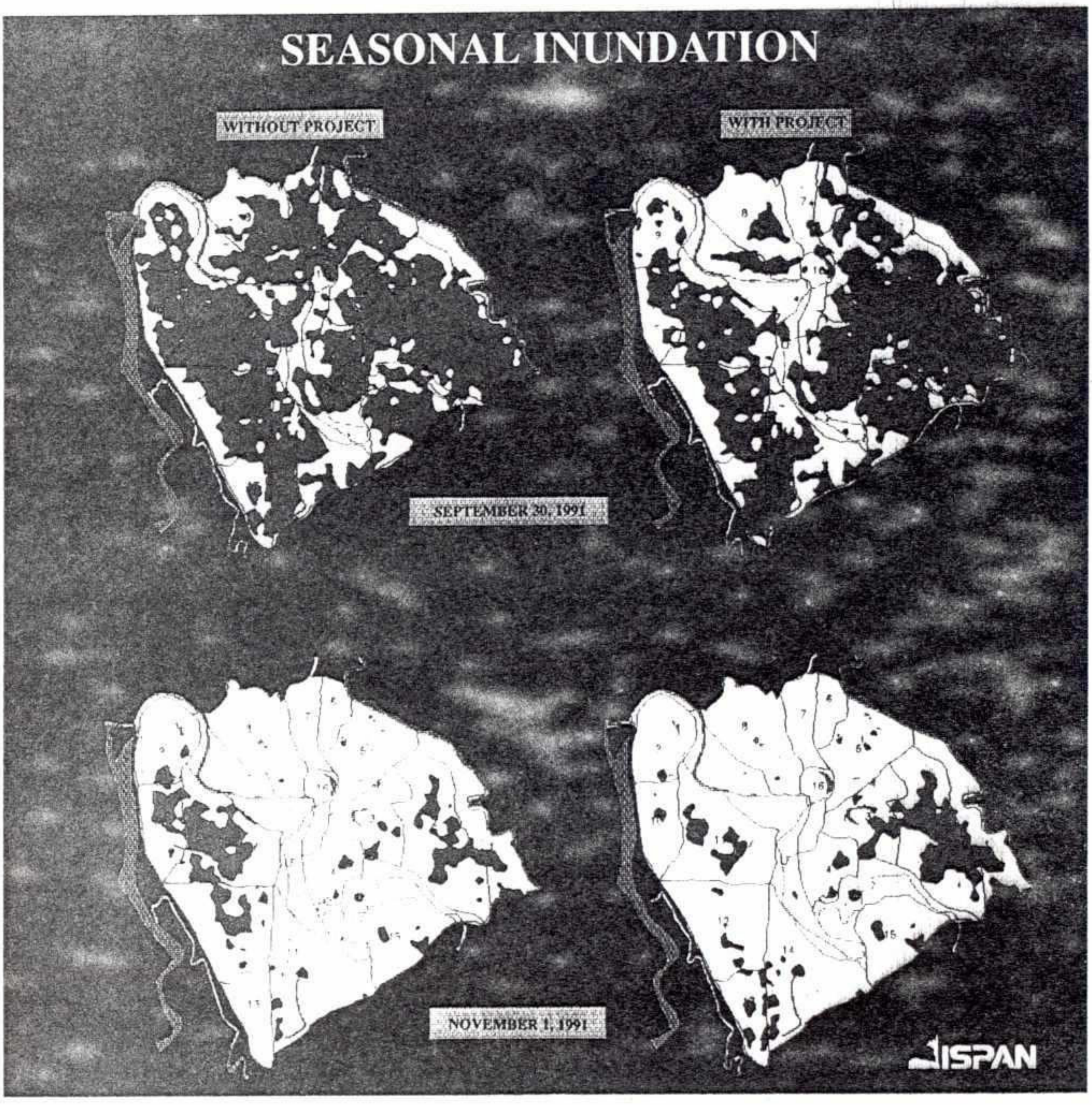
Project Impact (Assuming 1 in 5 Yr. Flood)

Map 7.3



Areas inundated to a depth of 180 cm or more are shaded in blue

Map 7.4



Areas inundated to a depth of 180 cm or more are shaded in blue

Table 7.6 Trend of Selected Physical and Social Changes in Tangail Town

Indicators	Trend Over Next 20 Years
Urban area	123% Increase
Flood and Poor Drainage Incidence	5% increase over existing levels
River Bank Erosion	Continued severe threat to infrastructure
Groundwater Quality	Will deteriorate
Land Use Pattern	30% reduction in agricultural land 25% increase in residential area
Demand of piped water	75% increase

Impacts on Land Types

Using the hydrological modelling and simulation and GIS processing, changes in flood depth under a full river flood control condition have been computed. Map 7.1 depicts projected land types for a 1:5 seasonal flooding occurrence. The map has been generated from data for a selected water level occurring under project conditions in July, as an approximation to a 1:5 3-day maximum water level, which is not available given present data and hydrological modelling limitations. The depicted land types are thus approximations (refer to Chapter 9 for a more detailed discussion pertaining to flood depths and land types).

Table 7.7 compares land types under baseline and the projected flood control conditions. As can be expected, the F_0 and F_1 land types are significantly increased under flood control conditions. Conversely, seasonally inundated F_2 and F_3 land types are drastically reduced. Map 7.2 illustrates the impact of a projected full flood control scenario on each land type compared to the existing condition. If these projections are considered as an approximation to a controlled river flood scenario, then the CPP area would be affected in terms of increased availability of drainage free land for irrigation, reduced drainage condition, reduced land inundation with implications for fisheries and promotion of cropping, and the associated socioeconomic and ecological effects. Those implications and impacts have been assessed and analyzed in this section.

Impacts on Soil Phases

With the project, the soils of the project area would largely be free from drainage congestion and protected from seasonal flood and therefore more intensively used for agricultural production. The depth of surface inundation of soils would be reduced in the monsoon season. As a result, the areas covered by highland and medium highland phases would increase and the medium lowland and lowland phases would reduce. Part of the Sonatola, Silmondi medium highland phase may become highland phase, while medium lowland phase of Sonatola, Silmondi, Dhamrai soils may be included partly under the medium highland phase of the same soil series. The change significantly increases the proportion of very good and good agricultural land.

Reductions in soil nutrients such as sulfur, zinc and potassium have been measured in existing flood control projects (ISPAN 1992e, Rashid 1992) where embankments prevent or reduce the deposition of river-borne sediments. Controlled flooding will be permitted in the CPP and some sediment deposition on lands would likely continue although probably at reduced levels due to control of higher flood levels and sediment trapping by regulators and culverts. The CPP area is already under intensive agriculture with relatively high levels of fertilizer inputs, and any reductions in silt-derived nutrients would probably be very small in comparison to soil fertilization from artificial means.

Table 7.7 Distribution of Land Types under Baseline and Project Conditions

Land Type	Baseline Condition (ha)	Project Condition (ha)
F_0	576	2472
F_1	1821	2906
F_2	4248	3461
F_3	2552	358
Total Cultivable Land	9197	9197

7.2.2 Habitats and Species

Terrestrial

The magnitude of project impacts on terrestrial habitats and wildlife population has been assessed on the basis of habitat change due to the project actions and expected changes in agricultural production practices. With the project, the terrestrial habitats associated with agricultural land (TEZ-6) would be impacted significantly. Projected increases in boro cropping and increase in settlement areas and homestead production would impact the habitats. Table 7.8 shows the project impact on changes in land areas in a given set of dates using 1991 data.

An increase in agricultural land would lead to increases in population of granivorous birds and rats. Intensification of cropping would be associated with increased application of chemical fertilizers and use of pesticides. The two practices impact on surface and groundwater quality. Table 7.9 summarizes the causes (project actions) and the effects (project impacts) on terrestrial habitats and the wildlife in the project area.

Aquatic

To estimate project impact on seasonal inundations, hydrological modelling estimates of water levels were utilized by the GIS mapping to compute and show the spatial change on inundation at four different seasons under the baseline and the controlled river flood conditions. Table 7.8 shows the computation results and Map 7.3 depicts the impact on inundation.

The project would lead to an estimated decrease of between 1000 - 1500 ha of aquatic habitat during the months of July (monsoon) to September (immediately post-monsoon) (Table 7.8), i.e. 8.7 percent in July and 11.7 percent in September. The changes are more marked in the western and eastern parts of the CPP area (Map 7.3). This change would reduce the shelter for resident wading birds of the Dhaleswari River charlands that fly to the CPP area. Resident waterfowl would be affected primarily as a result of the project impact on fishery resources. Expectedly, the change from November to April between the baseline and "with project" conditions is very small, and as such would not affect populations of migratory birds. Table 7.9 describes the project actions and the likely impacts on aquatic habitats and species.

In the absence of periodic flash flooding under the project condition, increases in pesticide and fertilizer use combined with increasing urban waste discharge through Tangail Khal and continuing jute retting can be expected to decrease water quality and lead to accelerated eutrophication. Other effects may include reductions in populations and species of plankton and benthos. Macrophyte production would be reduced under project conditions. Submerged and emergent gent macrophytes would be affected first through an accelerated rate of eutrophication. With likely increased use of insecticides the population of beneficial species such as frogs, spiders, earthworms and even mollusks could be affected.

Table 7.8 Projected Impact of the Project on Flood-Free (Terrestrial) Areas

Date	Present[1]		With Project[1]		Change (Total Area)	
	Area (ha)	Percent[2]	Area (ha)	Percent[2]	Area (ha)	Percent
15 May '91	12678	97.5	10803	83.1	-1875	-14.4
30 July '91	5862	45.1	6992	53.8	+1130	+ 8.7
30 September '91	4855	37.3	6376	49.0	+1521	+11.7
30 November '91	12303	94.6	12185	93.7	- 118	- 0.9

[1] Estimated from GIS and hydrological modelling
[2] Percentages against total area of the CPP (= 13,000 ha)

7.2.3 Fisheries

Capture Fisheries

The life cycle of the freshwater fish communities has become adjusted to the hydrodynamics of the floodplain river system. The open water capture fisheries resources are therefore directly related and dependent on regular annual seasonal flooding. It is evident that the capture fisheries resources within the CPP area would be seriously affected under full flood control. The production of fish in open waterbodies would be affected mainly due to two factors:

- blocking of migratory routes
- reduction in area, depth and inundation period of waterbodies

The reduction in the size and depth of waterbodies would result in poor growth rate of fish as well as overfishing in beels and floodplains.

Fish Diversity

Fifty-six species of fish have been found in the waterbodies within the CPP area (ISPAN 1992c). Among those, 28 are believed to be dependent on both river and floodplain to complete their life cycle (Table 7.10). These species mainly live in rivers during dry season. They migrate laterally onto the floodplain through khals for spawning feeding and growth during early monsoon. Their larvae, young and adults migrate back to the river during late monsoon when water recedes. Migration of fish eggs, larvae and adults is one of the vital issues for sustenance of fish diversity in an open water system. Installing gated regulators on watercourses would block fish migration. As a consequence, most of the mentioned species would likely disappear from the waterbodies of the CPP area.

Water Quality

Surface water quality in the project area would deteriorate due to lack of flushing impact by river flood and increased application of fertilizers and pesticides. With increased practice of HYV cropping, the annual application of agrochemicals may exceed 7.5 tons. This increased application of pesticides would further degrade the water quality in the project area with adverse consequences on fish health, production and species diversity.

Macrophyte Coverage

Under present baseline conditions, an average around 60 percent of the surface area of each of the beels within the project area is covered by floating vegetation, mainly water hyacinth. Excess macrophyte coverage reduces the natural productivity of beels by clouding the sunlight.

Under project conditions, the lack of flushing in the main monsoon period is expected to lead to an increase in the area of macrophyte coverage to 90 percent. This would have consequential

Table 7.9 Project Impacts on Wildlife Populations

Project Actions and Causes	Impacts on Wildlife Populations	Remarks
Construction of embankment would reduce seasonally flooded water bodies	Population of waterfowl and wading birds would significantly decline	Decrease in natural nutrient loading (flood-borne)
	Threat to population of Pallas' Fishing Eagle and Fishing Cats	These endangered species may disappear from the project area
	Decline in Frog population (April-July, breeding period)	Decrease in natural nutrient loading (flood-borne)
Controlled flow in khals and the Lohajang River would reduce mudflat areas	Reduction of shoreline birds (e.g. pond herons)	Decrease in natural nutrient loading (flood-borne)
Increase of F_0 and F_1 land types and increase in boro cropping (HYV)	Increase in granivorous birds population (e.g. Munia)	Increased crop damage Increased pests (insects)
	Increase of rat population	Increased crop damage
Decrease of F_2 and F_4 land types	Decline of wading bird populations which feed on invertebrates within low cultivable lands (e.g. woodcock)	Decrease in natural nutrient loading (flood-borne)
	Effect on frog populations	Rearing period (paddy crop) from August-March
Increase of fertilizer and pesticides due to increase in HYV crop production	Insectivorous bird population would be affected	Decline of insectivorous birds and insect eating insects would lead to increased use of pesticides
Plantation of Songrass along the road side	Increase in granivorous birds populations (e.g. Munia)	Increased crop damage
Plantation of timber plants e.g. Mahogany, Koroi, etc (or less desirable plant species e.g. Eucalyptus) with undergrowth	Increase population of bats, predatory birds, fox, mongoose	Ensure sustainable population of specific species
Low growth of aquatic macrophytes in reduced waterbodies	Decline in populations of waterfowl and wading birds (migratory & resident)	Eutrophication
Reduction of water quality due to reduced areas of waterbodies/ concentration of water related ingredients/controlled flushing	Decline in populations of waterfowl and wading birds (migratory & resident)	Eutrophication

impacts on the productivity of the beels.

Fish Production

The production of fish in waterbodies within the CPP area would decrease substantially due to the project intervention. It is estimated that the production of major and minor carps would decrease by 95 percent, catfish by 80 percent, hilsha by 100 percent, small shrimp by 20 percent, and small fish (miscellaneous fish) by 30 percent. The annual production of fish would thus decrease from the present production of 380 to 219 tons per year.

Fishing Households

There are approximately 17,000 subsistence fishing households in the CPP area. The average fishing days per household is 43 days/year (ISPAN 1992c). It is estimated that each household catches 8.6 kg fish per year (200 g/day). Therefore, the total catch of this group in the CPP area is estimated 146 tons per year, i.e. 38

Table 7.10 List of Fish Species Likely to be Affected under Project Conditions.

Scientific Name	Local Name
1. *Catla*	Catla
2. *Labeo rohita*	Rui
3. *Labeo calbasu*	Kalibaus
4. *Labeo gonius*	Gonia
5. *Labeo bata*	Bhangra/Bata
6. *Cirrhinus mrigala*	Mrigal
7. *Cirrhinus reba*	Tatkini
8. *Puntius sharana*	Sharputi
9. *Salmonasta phulo*	Fulchela
10. *Rasbora elanga*	Ellong
11. *Aspiropadia jaya*	Piali
12. *Wallago attu*	Boal
13. *Ompok bimaculatus*	Kanipabda
14. *Ompok pabda*	Pabda
15. *Ailiichthys punctatus*	Baspata
16. *Pseudeutropius atherinoides*	Batasi
17. *Eutropiichthys vacha*	Bacha
18. *Mystus aor*	Aair
19. *Mystus vittatus*	Tengra
20. *Mystus cavasius*	Gulsha
21. *Gagata spp.*	Gang Tengra
22. *Nemacilus 2 spp.*	Balichata
23. *Notopterus chitala*	Chital
24. *Notopterus*	Foli
25. *Mastacembelus armatus*	Baim
26. *Macrognathus aculeatus*	Tara Baim
27. *Rhinomugil corsula*	Khorsula

percent of the total catch in the CPP area. In addition to subsistence fishing households, there are 325 professional fishing households living in the CPP area. The average catch per household in baseline condition is 720 kg/year and the total catch by this group is 234 tons/year or 62 percent of the total catch in the area.

Under post-project conditions, the total annual catch in the area is estimated to be 219 tons per year. It is anticipated that the number of subsistence and professional fishing households and their catch distribution would remain the same in post-project condition. The catch per subsistence fishing household would be reduced to 4.9 kg/year (114 g/day) and the total catch by this group would be 83 tons per year or a reduction of 43 percent over the baseline condition. Similarly, the annual catch of each professional fishing household would be reduced to 418 kg/year and the total catch by this group would be 136 tons per year or a reduction of 42 percent over baseline conditions.

Income from Fish

Under the baseline condition the annual value of fish caught per subsistence fishing household is Tk. 430 and the total value of fish caught by this group is Tk. 7,450,000/year (ISPAN 1992c). The annual worth of fish caught by professional fishing household is Tk. 36,000 and the total income by this group is Tk. 11,700,000 per year. Under the project condition is projected that those values would reduce to Tk.245 per household and Tk.4,150,000 for the total value of fish caught in case of subsistence fishing, Tk.20,900 for professional fishing households and Tk.6,800,000 for the total community respectively.

Culture Fishery

Culture fishery e.g. pond aquaculture in the project area would benefit by the project. At present, there are 27 ha of culture and 19 ha of culturable ponds in the area. The present rate of production is estimated at 1239 and 851 kg/ha/year for cultured ponds and culturable ponds respectively. The total production of fish from respectively. The total production of fish from ponds is thus 49 tons per year. In the project condition there would be less risk of damage to pond fishery by flooding, thus it is expected that the rate of production in cultured ponds would increase up to 2000 kg/ha/year. It is also expected that about 50 percent of the culturable ponds would upgrade to cultured ponds. Therefore the area of cultured and culturable ponds would increase to 37 and 9 ha, respectively. The total production of fish from ponds would thus increase to around 82 tons/year.

7.2.4 Land Resources

Agriculture

With the project the cultivation of high yielding varieties would increase significantly as a result of increase in highland and medium highland areas. Farmers would become interested to increase HYV boro cultivation by installing more tubewells. They also may practice supplementary irrigation for transplanted aman crops when it is preceded by boro crops on F_0 and F_1 land (Table 7.11). At present 40-50 percent of the cultivated land is under irrigation. This would likely increase to more than 70 percent. Based on changes in land type and past cropping history in the project area, a cropping pattern close to what may be implemented by farmers has been constructed (Table 7.12).

Paddy production is projected to increase from 34,000 tons to 46,000 tons annually. Present cropping intensity of 196 percent would likely increase to 214 percent. Double and triple cropping would likely be increased in the future in the project areas. As a result, the agricultural labor requirements and inputs would increase leading to a more active economic environment in the project area.

Approximately 3,100 tons of crop damage could be prevented annually. Damage to transplanted deep water aman at the early stage of growth caused by pre-monsoon drainage congestion could be managed. With the project, boro crops currently grown in low-lying areas (F_3 land) could be protected until harvest time. Seasonal flood damage to transplanted aman and broadcast aman could be greatly reduced. The likely negative impact of the project on cropping patterns would be in reducing the crop diversity since the general tendency would be more towards irrigated rice production.

Homestead Vegetation

The project would have direct and indirect positive impacts on vegetation in general and homestead or farm forestry in particular.

During the 1988 flood, about 95 percent homestead and 88 percent house floors were inundated and 70 percent vegetable gardens were damaged (FAP 20 1992b). The EIA field data revealed that inundation caused by high flood and water saturation of the soil due to drainage congestion directly damages about 80 percent of seedlings, saplings, suckers and shoots and about 20 percent of mature homestead trees. Therefore, with the implementation of the project as planned, those damages would be prevented or reduced and a safer environment for increased production of food, fuel, fodder, and shelter would be created. Changes in land types would increase the field crop production and as such would reduce the stress demand on trees and non-crop vegetation. Approximately 50 percent of traditional resources of household energy is related to field crops in the form of husks, straw and crop residues.

In addition, the drainage condition of low-laying homestead areas would be improved even during the early rabi season. Therefore, various cash vegetables e.g. chili, sweetgourd .brinjal, cauliflower, cabbage could be grown safely, harvested and marketed in time for a desirable return. One decimal (0.004 ha) of flood free and well managed vegetable garden is estimated to bring in a cash income of around Tk.1,000.00 per year. One sapling of a tree e.g. jackfruit can earn Tk.100 per year, as timber, and a cumulative income of Tk.5,000.00 after ten years including a price raise during the period. Those figures exclude the value of annual fruit, fuel and fodder of this multipurpose tree. Based on the analysis of past trend, with project, the land

Table 7.11 Crop Areas and Production with Project

Crop	Area (ha)	Yield (tons/ha)	Production (Tons)
B.Aus	612	1.5	918
B.Aman	148	1.6	237
T.Aman (L)	3256	2.2	7163
T.Aman (H)	1506	3.0	4518
T.D.Aman	2125	1.7	3612
Boro (H)	6574	4.5	29583
Paddy			*46031*
Jute	1505	1.8	2709
Wheat	1117	2.0	2234
Potato	400	9.5	3800
Sugarcane	506	40.0	20240
Oilseeds	1303	0.8	1042
Pulses	600	1.0	500
Vegetables	100	3.5	350

area occupied by homesteads would increase 10 percent. This would be a loss of cultivated land.

7.2.5 Navigation

The main project actions affecting the navigation in the area would be construction of the main inlet regulator and drainage outlet of the peripheral structures. FAP 20, Interim Report 1992, proposes mitigation measures to reduce the impact of those actions on navigation. Without an appropriate mitigation measure (s) the navigational route of Chilabari to charlands would be severely impacted at Jugni. The blockage cuts the access to Chilabari in the project area by two kilometers. That is, the charlands settlers have to unload at Jugni and make other transport arrangements to reach the market and medical facilities at Chilabari during the flooding season. Also, it is estimated that annually around 173,600 passenger trips would be reduced if structural arrangements for allowing navigation are not taken. Other considerations include the impact of this structure on cost of goods and deliveries using alternative transport, and employment and income of boat owners and workers.

Construction of an inlet regulator at Sadullapur khal would reduce the passengers trips by approximately 19,000. In addition, this would increase the cost of deliveries to Boillar hat days.

7.2.6 Socioeconomic

Population and Communities

With the implementation of the project, particularly with increased income from agricultural and homestead production, there may be a positive impact on the rate of literacy that, in turn, may have an indirect impact on the growth rate of population in the CPP area. This would, by implication, reduce the anticipated increase in total population and therefore bring down the pressure of population on the existing land and water resources of the area. The reduction in population growth rate may have a positive impact on the existing land-man ratio and per capita agricultural land availability, leading to decreased land fragmentation. This would improve the productivity of the farm holdings and as a result, farmers may cultivate the land more intensively. With the project, homesteads are

Table 7.12 Cropping Patterns under Project Conditions

Cropping Pattern	Area (ha) under patterns				
	F_0	F_1	F_2	F_3	Total
Sugarcane	506	-	-	-	506
B.Aus-Rabi crop	182	-	-	-	182
Jute-Rabi crop	278	-	477	-	755
B.Aus-T.Aman(L)-Rabi crop	-	430	-	-	430
Jute-T.Aman(L)-Rabi crop	-	635	-	-	635
Jute-T.Aman(H)-Rabi crop	115	-	-	-	115
B.Aman-Mustard-Boro(H)	-	-	148	-	148
Boro(H)	-	-	183	358	541
T.Aman(H)-Boro(H)	1219	-	-	-	1219
T.Aman(L)-Boro(H)	-	1641	350	-	1991
TD Aman-Boro(H)	-	-	1520	-	1520
TD Aman-Mustard-Boro(H)	-	-	605	-	605
T.Aman(L) Mustard-Boro (H)	-	200	-	-	200
T.Aman(H)-Mustard-Boro(H)	172	-	-	-	172
Mustard-Boro(H)	-	-	178	-	178
Totals	2472	2906	3461	358	9197

Table 7.13 Agricultural Labor Requirements Under With Project Condition

Crop	Area (ha)	Person - Days Per Hectare												
		J	F	M	A	M	J	J	A	S	O	N	D	To-tal
1. B. Aus	612			15	35	40	20	30	10					150
2. Aus-Aman	-			15	30	30	5	5				30	20	135
3. B. Aman	148			15	30	30						30	20	125
4. T. Aman (L)	3256						10	40	30	20	10	25	25	160
5. T. Aman (H)	1506							50	50	20	10	25	20	175
6. T. D. Aman	2125					10	30	30	20			30	30	150
7. Boro (H)	6574	50	50	15	30	40	15						20	220
8. Boro (L)	-	30	15	20	30	15						20	40	170
9. Jute	1505			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	1117	10	10	10	20							30	25	105
12. Mustard	1303	20	10								5	30	15	80
13. Pulses	600	5		10	10						5	10	10	50
14. Potato	400	20	20	60	10							30	50	190
15. Vegetables	100	30	30	40							20	50	40	210
Total ('000s person/days)		400	384	194	320	294	242	350	269	108	74	302	406	3343

likely to spread from the existing medium high to medium low and the lowlands. During extreme flooding events, sudden breaching and overtopping of embankments may seriously damage newly constructed homesteads and threaten human life as well. Moreover, families living outside the project area, but inside the impact area, (especially those on the charlands and Dhaleswari floodplain), would be more vulnerable to changes induced by controlled flow (embankments) to and from the Dhaleswari River and the Pungli River. These families may have to migrate to Tangail town in large numbers, causing tremendous pressure on the already tight employment situation.

Furthermore, families displaced by embankment construction and its set back requirement would permanently lose ancestral homes, homesteads and agricultural land. This may cause considerable stress, particularly to the poor who would become refugees. Given the limited or no availability of khas land in the CPP area, those displaced families would face severe difficulties in finding a suitable place to build new homesteads and begin a new settlement with their meager sources of income. The issue of compensation has to be addressed thoroughly in case of those people.

Livelihood and Subsistence

With the project, the crop production and cropping intensity would increase. This increase would require increased agricultural labor requirements, from the existing 3,051,000 person/day to 3,343,000 person/days for a one year cropping activity under the project (Table 7.5). Those figures translate into additional requirement of around 920 person per day. As the areas under F_3 land would be significantly reduced and F_0 land increased, more land would become flood free, resulting in expansion of agricultural land area. This would facilitate a year-round agricultural production activities and may widen the opportunities for agriculture-based and non-agricultural employment and small scale marketing, and small scale industries.

Intensification of agricultural activities would generate employment and may increase the wage rates. Such impacts would increase the income of the landless and land-poor households and help absorb the expanding labor force in agriculture. With an increased income, households may have the capacity to improve their present nutritional deficiency and enhance their standards of living.

On a more negative side, the project would significantly impact fish availability as well as income generation and employment in the fish subsector. Fish consumption by fish-dependent communities (capture fisheries) would likely decrease due to reduced fish resources. Although a number of alternatives are being considered to reduce and mitigate project's impact on capture fisheries production in general and on fish stock in particular, it would have residual impacts on fish consumption and nutrition, particularly among capture fisheries-dependent communities.

Professional fishermen may abandon fishing and seek other occupations, pressing the already tight employment market. It is likely that some of the flooded beels and jalmahals that are currently being used as common property resources would be converted to agricultural land. Furthermore, this trend would have residual impact on ecological and biological aspects of fisheries e.g. habitats and fish migration pattern from the rivers to the beel areas and vice versa.

Application of chemical fertilizers and pesticides would be increased in the course of intensification of agricultural production. Increased use of agrochemicals would have residual impact on surface and groundwater quality, thus increasing risks on human health and fish diseases.

Land Ownership Distribution Pattern

With the project, more land would be brought under HYV crops. This would increase the crop production, but the benefits of increased production may not be shared equally by all household categories. Availability of capital resources varies among household categories. Those with capital resources would be more likely to take advantage of and benefit from the opportunities created by the project, hence consolidating their holdings. Flood protection measures may improve the existing inequality in the distribution of land ownership in the sense that it potentially can increase the income of landless and land-poor households from various project generated sources and project spinoff activities. It is true that large and medium farmers who have the capital resource would most benefit from increased production, the small and marginal farmers may also gain as their land would be protected from flooding, more opportunities would be available for gainful employment, and landless laborers may have more cash in hand to improve their living standards. The direction of the positive and negative trends discussed above would largely depend on how effectively the institutional development component of the project would be implemented.

With the project, land prices for F_1 to F_3 land types would increase. This may allow some economic benefits to small and marginal farmers who must sell or mortgage land under strenuous conditions. However, the small and marginal farmers would probably sell less as the risk of crop damage due to flooding would be greatly reduced. Distress sale and mortgage of land would also reduce due to the same reason.

Tenancy Market

With the project, the existing tenancy market would further expand and as more land became flood free, sharecropping would increase. However, given the growing imbalance between land availability and population growth, not enough land would be available for all possible tenants. Land shortage would enable large land owners to dictate the terms and conditions of tenancy in their favor. In other words, competition for land would cause severe downward pressure on tenure terms to the advantage of large land owners. In a situation where all tenancy contracts are mainly verbal and highly insecure, it is most likely that tenant farmers would work the land under more iniquitous terms and conditions. Again, with increased cost of irrigation and other HYV inputs, land owners may not share the cost of production in the same proportion as is currently being shared. The traditional sharecropping system may give way to various forms of annual cash rentals such as lagit, chukti and pattani etc. which are presently absent in the project area.

Credit Relations

As stated earlier, the average credit obtained by farm households from informal sources is considerably higher than institutional sources. With implementation of the institutional support components of the project, it can be expected that more marginal and small farmers may gain access to formal credit sources to meet their financial needs. However, as long as the existing bottlenecks pertaining to collateral and terms are not removed the informal financial sources would continue to operate with high interest rate terms. Prevalence of high interest rates would facilitate the transfer of resources from poorer to richer households and exacerbate the inequality in the distribution of land in the long run. The institutional development aspect of the project, when implemented as planned, can ease the credit constraint to small producers.

Wealth and Equity Situation

The exact impact of the project on income distribution is difficult to assess, particularly the increase or decrease in household income and assets. However, given the existing land ownership distribution it is unlikely that increased production of HYVs would significantly change the existing pattern of ownership and wealth in the project area. Undoubtedly, opportunities for gain would be created. Effectively implementing the planned institutional support activities and the mitigation measures proposed can potentially work towards a better distribution of the project benefits among all household categories.

Gender Relations

Increase in the family income arising from improved agricultural and other sources probably would not have a significant and immediate positive impact on the actual, social status of the women in the project area. However, such increases would have an indirect impact on the women through an overall improvement in the quality of life of the people in the project area.

Most of the income generating activities involving women are in traditional and manual such as weaving, bidi and net making, and paddy boiling/husking. Most of the NGOs operating in the area are involved in loan/credit and MCHFP activities in accessible areas. Road improvement work planned under the project would improve road communications and may extended the GOB and NGOs services including basic technical and skill development training to the more remote areas (refer to Annex Four for the list of NGOs). This may provide more diversified work opportunities. Furthermore, with the project, increased labor requirements in the agricultural sector would increase the opportunities for women to engage in paid work to supplement the family income. Employment in the weaving and bidi sectors would probably remain static. An increase in family income and purchasing capacity, and availability of food grain may increase the grain consumption by women. Since more land would become flood free it is expected that homestead vegetation would increase, thus contributing to improvement in their calorie intake. However, the potential negative impact on capture fisheries would have a significant residual impact on nutrition of women in poor fishermen's households.

Health

Baseline data indicates that 90 percent of the people in the project area have access to safe drinking water. In spite of the statistics, incidence of such water borne diseases as diarrhoea, cholera and typhoid are high. The use of khal, river and pond water for bathing (people and animals) and washing appears to be the prime contributing factor. Women are frequently in contact with contaminated water during their household chores and with patients suffering from those diseases. This factor coupled with women's weaker physical condition, make them more prone to diseases. Though MCHFP services are being provided through the GOB and NGOs, women normally have less access to those services. Improved road communication as a result of the project would ease women's access to those facilities. Improved drainage in the project area may also have impact on health since stagnant and contaminated water that is used for all domestic and personal purposes facilitates the incidence of scabies, skin and parasitic infections.

The CPP area is currently a low risk zone for kala-azar (visceral leishmaniasis) which is transmitted by sandflies. The incidence of kala-azar is high in the highland areas immediately north of the CPP. Kala-azar in Bangladesh is strongly correlated with the occurrence of FCD/I projects which increase the amounts of seldom flooded highland (mainly F_0 and F_1 land types). The risk of kala-azar transmission is about 17 times higher inside FCD/I projects than outside (ISPAN 1992d) and the incidence in the CPP with project is expected to rise as land types are converted from F_2 and F_3 into F_0 and F_1.

7.2.7 Tangail Town

The flood control and water management interventions of the CPP will affect directly hydrological conditions in Tangail Town and cause significant changes in land inundation, bank erosion, drainage and ground water quality. Peripheral structures will be designed to protect the town from abnormal floods. Protection against bank erosion by means of river training works and measures such as mattressing with boulders, geotextiles, brickwork and concrete blocks are expected to be utilized. Localized inundation due to high rainfall and runoff will continue to occur.

Under present conditions ground water quantity is known to be drawing down at the rate of 0.25m/year. The project will increase the rate of groundwater depletion due to reduction in flood related aquifer recharge and the lowering of water tables by increased tubewell pumping to meet the 75 percent higher demand of piped water over the next 20 years. Ground water quality is presently not satisfactory due to high concentrations of iron and manganese, and occasional high concentrations of coliform bacilli. Groundwater quality in the urban area will probably deteriorate further under project conditions due to a lack of flushing by river floods. There may however be increased flood free land and improved drainage, as well as a positive impact on health and sanitation since stagnant and contaminated water that is used by the poor urban dwellers facilitates the incidence of waterborne diseases.

The CPP is not expected to measurably affect the growth rate of the urban area (123 percent expansion over 20 years) nor the rate of reduction in available agricultural land (30 percent decrease over 20 years).

7.3 Summary of Impact Assessment

Table 7.14 presents a summary of assessment and scoring concerning the CPP proposed actions. Although this EIA rendered a unique effort towards quantification of assessments, the reviewer is reminded that all the quantified projections and predictions inevitably carry a certain level of assumption and subjectivity. In certain areas such as groundwater, health, and nutrition quantified information specific to the project area was not available. For the data presented in case of "without project" scenario, to the extent possible, future trend analysis was used to derive a subjective or quantified assessment.

7.4 Residual Impacts

Given the nature and known efficiency of the mitigation measures available to deal with the major expected negative impacts, there will be some residual impacts which will remain after project implementation. These are briefly described in Table 7.15. The most significant of these deal with the fisheries resource and its use by, and availability to, the communities within the CPP area.

7.5 Impacts Beyond CPP Boundaries

The effects of the CPP would extend beyond the immediate project boundaries as defined. Two main interactions would be responsible for this:

- hydrological effects up- and downstream of the CPP, produced by flow regulation into and through the CPP area; and
- socioeconomic effects produced by the movement of people, goods and services across the CPP boundaries as a result of project-related activities, e.g. construction.

Four distinct components comprise the areas CPP in which impacts may occur:

- upstream of the CPP area, north of Gala Khal and the Lohajang River between the Pungli and Dhaleswari rivers up to the Bara Basalia - Mirpur road;
- the area between the western embankment of the CPP and the Dhaleswari;
- the area n Delduar Thana south of the southern boundary of the CPP area upto the Elanjani River and Karatia-Dhaka road; and
- east of the CPP area and the Pungli River.

and its left flood plain.(FAP 20, Household Survey, Annex 1.1, Sept. 1992).

The modelling points used by SWMC (1992) in the application of the North West Regional Model are indicated in Figure 7.3 and the summarized results of the model runs are indicated in Table 7.16. Examples of the model output for selected points are given in Figure 7.4.

The model results suggest that backwater effects of the CPP would be measurable upstream as far as the Dhaleswari-Pungli bifurcation. The largest upstream effect would be in the Old Dhaleswari immediately below the Lohajang offtake, where peak water levels would rise by about 40cm in an average year and up to 65cm

Table 7.14. CPP: Quantified Impact Assessment

1. IECs	2. Baseline (Present) Condition	3. Future w/o Project	4. Future with Project	5. Change from baseline to Future w/o Project Unit	5. %	6. Change from baseline to Future w/Project Unit	6. %	7. Impact Assessment (Col 6 - Col 5) Units	7. Impact Type[*2]	8. Score
Land Type (ha)										
F_0	576	576	2472	0	0	+1896	+329	+1896	SM/HM	+2.5
F_1	1821	1821	2906	0	0	+1085	+60	+1085	SM/HM	+2.5
F_2	4248	4248	3461	0	0	-787	-19	-787	SM/LM	+1.0
F_3	2552	2552	358	0	0	-2194	-86	-2194	SM/HM	+2.5
Drainage Congestion (ha)	1549	Increase	Decrease	Increase	NQ	Decrease	NQ	Decrease	SM/LM	+1.5
Ground Water	Adequate	Slow decrease	Decrease in dry years	Slow decrease	NQ	Decrease in dry years	NQ	NQ	RM/LM	-0.5
Annual Crop Production										
Total area irrigated (ha)	5398	6198	6574	+800	+15	+1176	+22	+376	SM/LM	+1.5
Total potential paddy production (tons)	37551	42755	46031	+5204	+14	+8480	+23	+3276	SM/LM	+0.5
Total paddy production (tons)	34376	37954	46031	+3578	+10	+11655	+34	+8077	SM/HM	+3.0
Total paddy production lost (tons)	-3175	-4801	0.00	-1626	+51	+3175	+100	+4801	SM/HM	+3.0
Total rabi production (tons)	7751	6447	8026	-1304	-17	+275	+4	+1579	SM/HM	+1.5
Total jute production (tons)	2947	1265	2709	-1682	+-57	-238	--8	+1920	SM/HM	+1.5
Crop diversity (Non-paddy/paddy)	1:2.1	1:3.2	1:2.6	Decrease		Decrease		Decrease	RM/LM	-1.5
Cropping intensity (%)	196	196	214	0	0	+18	+9	+18	SM/LM	+0.5
Total farm labor requirements (x 1000 person days)	3011	3051	3343	+40	+1	+332	+11	+292	SM/HM	+1.5
Homesteads										
Housing (ha)	1751	1926	2101	+175	+10	+350	+20	+175	SM/LM	+0.5
Garden crops (ha)	875	963	1050	+88	+10	+175	+20	+87	SM/LM	+0.5
Tree crops (ha)	875	963	1050	+88	+10	+175	+20	+87	SM/LM	+0.5
Homestead vegetation damage (%)	-20	-20	0	0	0	+20	+100	+20	SM/HM	+3.0
Biomass Energy Shortage (%)	-52	-60	-10	-8	+15	+42	+81	+50	SM/HM	+3.0

Continued

Note: NQ = not quantified
S= sustainable, SM = sustainable with mitigation, RM = reversible with mitigation, IR = irreversible, LM = low magnitude, HM = high magnitude

Table 7.14. Continued

1. IECs	2. Baseline (Present) Condition	3. Future w/o Project	4. Future with Project	5. Change from baseline to Future w/o Project Unit	5. %	6. Change from baseline to Future w/Project Unit	6. %	7. Impact Assessment (Col 6 - Col 5) Units	7. Impact Type	8. Score
Capture Fisheries										
Annual production (tons)	380	251	219	-129	-34	-161	-42	-32	IR/LM	-3.5
Professional fisherman household production (kg/year)	720	NQ	420	Decrease		-300	-42	Further decrease	IR/LM	-3.5
Subsistence fisherman household production (kg/year)	8	NQ	5	Decrease		-3	-38	Further decrease	IR/LM	-3.5
Fish diversity (no. of species)	56	51	28	-5	-9	-28	-50	-23	IR/HM	-5.0
Culture Fisheries								0		
Annual Production (tons)	49	66	82	+17	+35	+33	+67	+16	SM/HM	+1.5
To al employment (persons)	NQ	Increase	Increase	NQ		Increase		Larger increase	SM/LM	+1.5
Aquatic Habitat (ha)										
e-monsoon	322	No change	2197	No change		+1875	+582	+1875	SM/HM	+1.5
oon	7138	No change	6008	No change		-1130	-16	-1130	RM/HM	-1.5
ost-monsoon with ainage congestion	8145	No change	6624	No change		-1521	-19	-1521	RM/HM	-1.5
Post-monsoon without drainage congestion	697	No change	815	No change		+118	+17	+118	SM/LM	+1.0
errestrial Habitat (ha)				0						
Pre-monsoon	12678	No change	10803	No change		-1875	-15	-1875	RM/HM	-1.5
Monsoon	5862	No change	6992	No change		+1130	+19	+1130	SM/HM	+1.5
Post-monsoon with drainage congestion	4855	No change	6376	No change		+1521	+31	+1521	SM/HM	+1.5
Post-monsoon without drainage congestion	12303	No change	12185	No change		-118	-1	-118	RM/LM	-0.5
Wildlife								0		
Presently endangered species	7 species	5 species	3 species	2 become extinct	-29	4 become extinct	-57	2 lost species	IR/HM	-5.0
Presently threatened species	10 species	10 species	6 species	No change	0	4 species decline	-40	4 declining spp.	RM/HM	-3.0
Presently common species	29 species	No change	13 will decline	No change	0	13 spp. decline	-45	13 declining spp.	RM/HM	-3.0
Pesticide contamination	Prevalent	Prevalent	Prevalent	Increase	NQ	Increase	NQ	Increase	RM/HM	-3.0

Continued

Table 7.14. Continued

1. IECs	2. Baseline (Present) Condition	3. Future w/o Project	4. Future with Project	5. Change from baseline to Future w/o Project Unit	 %	6. Change from baseline to Future w/Project Unit	 %	7. Impact Assessment (Col 6 - Col 5) Units	 Impact Type	8. Score
Road communication (km)	262	NQ	NQ	Improved	NQ	Improved	NQ	Improved	S/LM	+0.5
Navigation										
Annual passenger trips ('000s)	245	NQ	113	NQ		-132	-54	Likely decrease	RM/HM	-2.5
Annual volume of goods marketed (tons)	900	NQ	875	NQ		-25	-3	Small decrease	RM/LM	-0.5
Socio-economic										
Subsistence fishing (kg fish/household/-year)	2.6 - 3.5	NQ	NQ	Decrease	NQ	Decrease	NQ	Decrease	IR/LM	-3.5
Crop production wages (annual, w/o food, million Tk.)										
Peak season	135.5	457.7	501.5	+322	+238	+366	+270	+44	SM/HM	+3.0
Lean season	90.3	305.1	334.3	+215	+238	+244	+270	+29	SM/HM	+3.0
Construction employment (person/years)	0	0	9533	No change	0	+9533	-	+9533	NS/HM	+2.0
O&M employment (no. jobs)	0	0	580	No change	0	+580	-	+580	SM/LM	+1.5
Quality of Life										
Gender issues	NQ	NQ	NQ	Slight improvement		Slight improvement		More improvement	SM/LM	+1.0
General Health	NQ	NQ	NQ	Improvement		Improvement		More improvement	SM/HM	+3.0
Nutrition - crop based	NQ	NQ	NQ	No change		Improvement		Improvement	SM/HM	+1.5
Nutrition - fish based	NQ	NQ	NQ	Decrease		Marked decrease		Further decrease	IR/HM	-3.5
Vector-borne disease incidence	NQ	NQ	NQ	Gradual increase		Increase		Increase	RM/HM	-1.5

Continued

Table 7.14. Continued

1. IECs	2. Baseline (Present) Condition	3. Future w/o Project	4. Future with Project	5. Change from baseline to Future w/o Project Unit	5. %	6. Change from baseline to Future w/Project Unit	6. %	7. Impact Assessment (Col 6 - Col 5) Units	7. Impact Type	8. Score
Tangail Town								0		
Drinking water	High Fe & Mn	Deteriorates	Deteriorates	Deteriorates	NQ	Deteriorates		Deteriorates	RM/LM	-0.5
Groundwater depletion	0.25 m/yr	NQ	NQ	Decrease	NQ	Decrease		Decrease	IR/LM	-1.5
Flooding hazard	High risk	High risk	Low risk	No change	NQ	Decrease		Decrease	SM/HM	+3.0
Drainage problems	Prevalent	Prevalent	Decrease	No change	NQ	Decrease		Decrease	SM/LM	+1.0
CPP Rural Settlements										
Flooding hazards	Prevalent	Prevalent	Decrease	No change	NQ	Decrease	NQ	Decrease	SM/LM	+2.5

Table 7.15. Residual Impacts Expected after Project Implementation and Application of Practical Mitigation Measures

IECs	Baseline (Present) Condition	Assessed Impacts	Impact Score [Worst=-5.0]	Magnitude	Reversibility[1]
Fisheries and Aquatic Habitats					
Aquatic habitat: monsoon	7138 ha	-1130 ha	-1.5	High	Reversible
Aquatic habitat: post-monsoon	8145 ha	-1521 ha	-1.5	High	Reversible
Fish diversity	56 species	-23 species	-5.0	High	Irreversible
Capture fishery production	380 tons/year	-32 tons/-year	-3.5	Low	Irreversible
Professional fishing production	720 kg/hh/year	Further decrease	-3.5	Low	Irreversible
Subsistence fishermen	8 kg/hh/year	Further decrease	-3.5	Low	Irreversible
Agriculture					
Crop diversity ratio	1:2.1	Decrease	-1.5	Low	Reversible
Terrestrial Habitats					
Terrestrial habitat: pre-monsoon	12678 ha	-1875 ha	-1.5	High	Reversible
Terrestrial habitat: post-monsoon	12303 ha	-118 ha	-0.5	Low	Reversible
Ecosystems					
Pesticide contamination	Prevalent	Increase	-3.0	High	Reversible
Navigation					
Boat use of waterways	245000 pass./year	Likely decrease	-2.5	High	Reversible
Cargo use of waterways	900 tons/year	Small decrease	-0.5	Low	Reversible
Public Health Concerns					
Household subsistence fishing	2.6 - 3.5	Decrease	-3.5	Low	Irreversible
Nutritional use of fish	NQ	Further decrease	-3.5	High	Irreversible
Vector-borne disease incidence	NQ	Increase	-1.5	High	Reversible
Tangail town drinking water	High Fe & Mn	Deteriorates	-0.5	Low	Reversible
Tangail town groundwater depletion	0.25 m/yr	Decrease	-1.5	Low	Irreversible

[1] Assuming practical application of mitigation measures (see text)

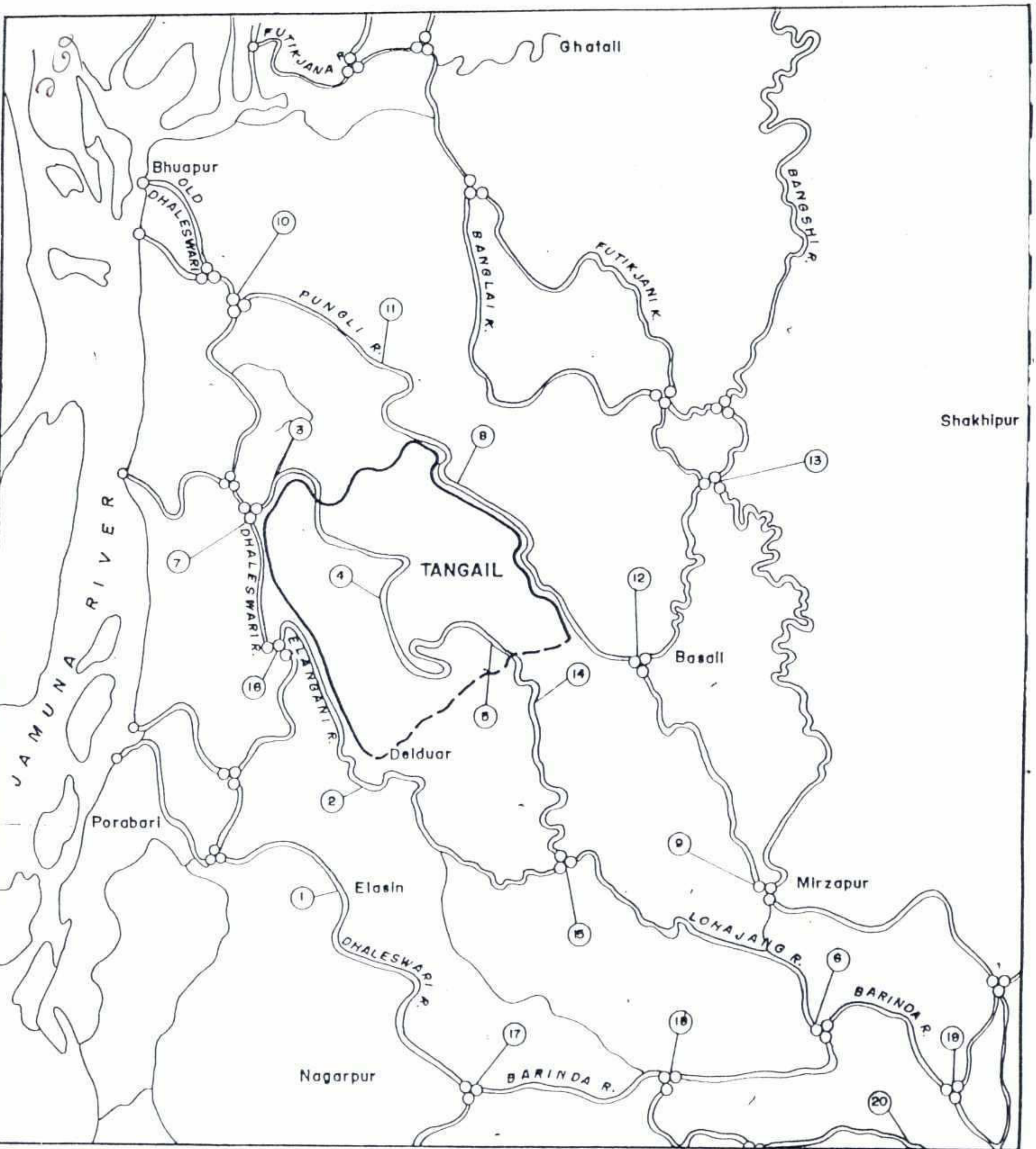
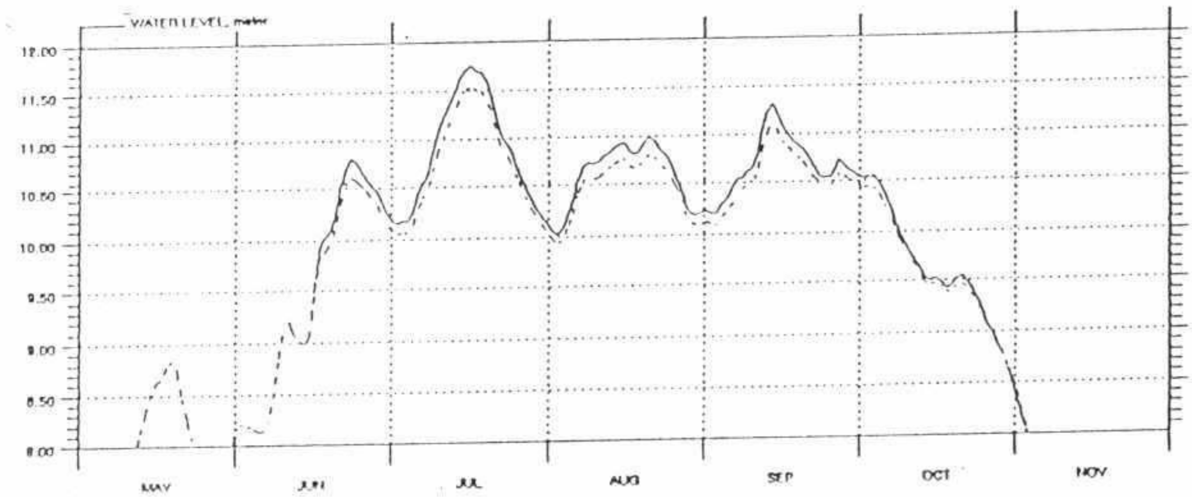


Figure 7·3 The CPP Impact Area Boundary and Water Level Modelling Points.

Source : Surface Water Modelling Centre, 1992.

Dhaleswari River above Lohajang confluence



Pungli River, on eastern boundary of CPP area

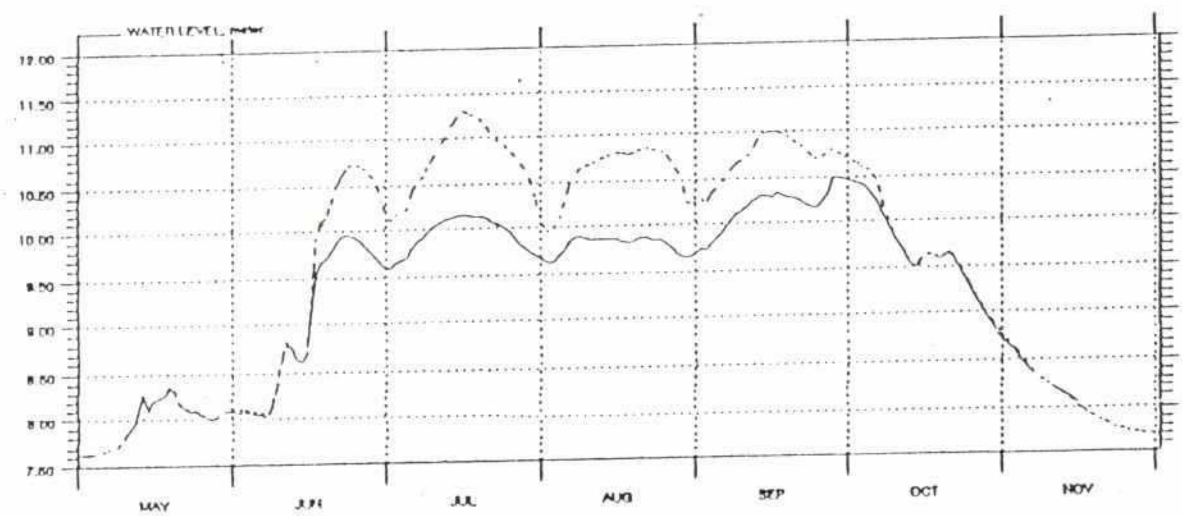


Figure 7.4 Examples of modelling output from SWMC runs of NCRM for CPP area. Dotted line = conditions without project, solid line = conditions with project.

Table 7.16. Changes in Peak Water Levels at Selected Locations Outside the CPP as a Result of Flow Regulation Within and Around the CPP.

Location*1	High Flow Year (1988/89)	Low Flow Year (1989/90)	Average Year (1991/92)
1	+0.05	0.0	0.0
2	+0.20	+0.05	+0.05
3	+0.65	+0.35	+0.40
4	0.30	+0.10	+0.10
5	0.0	0.0	0.0
6	+0.80	+0.25	+0.20
7	-0.10	0.0	0.0
8*2	-1.00	-0.75	-0.90
9*2	-0.80	-0.47	-0.80
10	-0.75	-0.30	-0.70
11	-0.30	0.0	0.0
12	-0.05	0.0	0.0
13	-0.70	-0.10	-0.15
14	-0.05	0.0	0.0
15	0.0	0.0	0.0
16	-0.05	0.0	0.0
17	-0.70	0.0	0.0
18	-0.35	0.0	0.0
19	-0.70	0.0	0.0
20	-0.60	0.0	0.0

*1 Shown on Figure 7.3

*2 Inside the CPP project area

in a high flow year. Peak water levels in the Pungli River would increase by about 25cm in average years and upto 80cm in high flow years. The biggest drop in water levels outside of the CPP area would be in the Lohajang River immediately south of the CPP boundary. Model results suggest these changes would not be measurable beyond the Lohajang-Elanjani confluence in average or low flow years, but in high flow years the measurable changes could extend all the way to the Bangshi River.

The increased peak water levels in the Dhaleswari and Pungli would extend only through the main part of the peak flow season, a period of about 3-4 weeks. Before and after this peak period, the differences in water levels between the present and future conditions would be much smaller, typically of the order of 10-40cm (SWMC 1992). Downstream water level declines due to the project would extend through major portions of the hydrological cycle. These changes in peak water levels would undoubtedly cause changes in the extent and depth of flooding in lands adjacent to the rivers, and would alter the distribution of land types and the associated cropping patterns. The extent is likely to be small in relation to the flooding created by project-independent rainfall flooding. The sequential effects on cropping patterns and agricultural production are likely to be smaller yet and overshadowed by project-independent effects such as farmer preferences and marketing effects.

Landless people in the adjacent areas may find employment opportunities within the project area. Moreover they may find temporary shelter along the inner side of the embankment. Women may find job opportunities in road maintenance and plantation programs, and there may be some benefits in availability of biomass energy along the embankments. Fishermen of the downstream reaches may encounter increased fish production due to reduced fish migration towards the project area.

7.6 Cumulative Impacts

The North Central Regional Model (SWMC 1992) was uses as basis for evaluating any cumulative hydrological effects of the CPP and

Table 7.17. Changes in Peak Water Levels at Selected Locations Outside the CPP as a Result of Flow Regulation Within and Around the CPP Combined with Closure of the Northern Dhaleswari River.

Location*1	High Flow Year (1988/89)		Average Year (1991/92)	
	CPP only	CPP+ Dhales. Closure	CPP only	CPP+ Dhales. Closure
1	+0.05	-0.70	0.0	-1.10
2	+0.20	-0.80	+0.05	-0.85
3	+0.65	+0.30	+0.40	0.00
4	+0.30	+0.20	+0.10	-0.45
5	0.00	0.00	0.00	0.00
6	+0.80	-0.60	+0.20	-0.75
7	-0.10	-0.25	0.00	-0.40
8*2	-1.00	-1.20	-0.90	-1.30
9*2	-0.80	-0.95	-0.80	-1.05
10	-0.75	-0.85	-0.70	-0.70
11	-0.30	-0.20	0.00	-0.30
12	-0.05	-0.15	0.00	-0.60
13	-0.70	-0.80	-0.15	-0.50
14	-0.05	-0.10	0.00	0.00
15	0.00	0.0	0.00	0.00
16	-0.05	-0.60	0.00	-0.35
17	-0.70	-0.85	0.00	-0.25
18	-0.35	-0.50	0.00	-0.20
19	-0.70	-1.10	0.00	-0.40
20	-0.60	-0.60	0.00	-0.40

the closure of the northern intake of the Dhaleswari River due to construction of the Jamuna Bridge. Comparison of peak water levels due to the CPP alone and to the CPP plus the Dhaleswari closure (Table 7.17) shows that the two projects would produce combined effects in the reaches below the CPP but that these would be relatively small (peak water level differences of 10-20cm for most locations. The differences that these changes would make in terms of flooding would be very small and difficult to measure. Upstream of the CPP, there would be some offsetting of effects between the projects - the backwater effects of the CPP would counteract some of the drops in water level caused by the closure of the Dhaleswari. These differences would also be relatively small and the net effect on flooding would be equally small and difficult to quantify. The cumulative effects of the Dhaleswari would only persist through the monsoon period of about 3-4 months duration since the northern Dhaleswari ceases to flow by about September-October and remains stagnant through the dry season. The overall conclusion is that cumulative impacts of the CPP and the Dhaleswari closure would occur but would be very small.

Chapter 8

RECOMMENDATIONS FOR THE ENVIRONMENTAL MANAGEMENT PLAN (EMP)

This section of the EIA report provides a series of recommendations for consideration in inclusion in the Environmental Management Plan (EMP). This EIA report does not provide a detailed EMP, rather it makes recommendations towards development of such a document which should form the link from the EIA stage through to the implementation stage of the project, should be the environmental equivalent of the engineering design documents and drawings (ISPAN 1992a), and should contain sections pertinent to mitigation and enhancement, monitoring, people's participation, institutional arrangements, compensation arrangements (if applicable), cost estimates for implementation of the EMP and the proposed schedule for implementation.

8.1 Impact Management

8.1.1 Mitigation, Enhancement and Compensation for Structural Objectives

Flood Protection and Regulation

The CPP intends to upgrade the existing embankment to the level of 1988 flood, and provide peripheral structures including main and medium inlets and spillways. These actions would provide protection against flood and would reduce the risk to infrastructure, lives and properties. Several measures are proposed for consideration by the CPP concerning the proposed flood regulation structures.

- Any major structural work such as southern peripheral structures, and the main inlet regulator should be discussed with the appropriate community interest groups prior to the construction. In order to succeed, the CPP must have the support of the wide group of various communities it intends to assist.
- Careful consideration should be given to future developments in the North Central region that may affect the overall operations of the CPP. Those developments may include closure of Dhaleswari because of the proposed Jamuna Bridge (see Chapter 8), and construction of the left embankment of the Brahmaputra.
- The applicability of the mathematical model for water management at subcompartment level involving small water channels should be tested. The test and trial and "phase in" approach of the CPP allows for flexibility in selection, design, and construction of alternative measures that may find to be more appropriate during the course of the project. Continued efforts in data collection particularly water levels are needed to add to the efficiency and adequacy of the mathematical model that is currently used for design and projection purposes.
- The CPP area is heterogeneous in hydrological, agricultural and socioeconomic conditions except for a few subcompartments. More detailed and site-specific information should be collected during the design and planning of structural and non-structural measures.
- Cuts and breaches to the embankments, and the inlet structures and roads should be examined systematically and periodically. Such systematic approach should be included in a detailed repair, operation and maintenance plan for all the major structures.
- Development of a flood preparedness plan for more populated areas should be considered. The plan should include measures for early warning, evacuation, sheltering, disaster relief management of the population at risk in case of abnormal flooding. The proposed Compartment Water Management Board, when in place, should develop the flood preparedness plan and organize periodic awareness training/campaign programs in collaboration with the relevant NGOs and the local authorities. As part of

flood preparedness plan, the said board also should develop a mobilization committee that could act swiftly in case of emergencies. Another mitigation measure is to allocate areas as shelter during the high flood for the people outside the project area. These shelters could be provided by extending the embankments.

- A detailed compensation plan has to be developed in compliance with the existing regulations and traditional norms in Bangladesh for the households who would be losing their land and properties as a result of realignment, construction and upgrading of embankments, roads and other structures (refer to Section 8.2.3 for details)

Capture Fisheries

The CPP would impact significantly capture fisheries production, fish species diversity, and economic activities of full time and subsistence fishermen. Expected reductions in miscellaneous fish would have major impacts on diet of fish-dependent communities and on species diversity. Although the project, under normal circumstances, intends not to block or regulate the Lohajang River flow until July 15, the loss of capture fisheries is estimated approximately between 80 to 100 tons per year if no mitigation measure is taken. In terms of production, this loss could be only partly compensated with expected increase in culture fisheries, up to around 40 tons per year, and this compensatory amount will not accrue to all the landless and poor groups who suffer the losses. Increasing the opportunities for culture fisheries cannot be considered a viable option for fishermen who would be affected, nor a mitigation for biodiversity reduction. Culture fisheries production operations require a different set of inputs, capital infusion and managerial skills to which affected fishermen have no access and no skill to manage.

- A critical component of any mitigation plan would be the development of a structure on the Lohajang River which permits up and downstream passage of adult and juvenile fish. FAP 17 (pers. comm.) have initiated investigations of such a structure and consider that the use of a retracted gate may be feasible. The use of effective fish passes for all regulators in the CPP should be further studied, tested and implemented.
- Consideration should be given to maintaining a high enough water level after July 15 and during the monsoon season by controlled drainage. This measure, if found feasible, would partly maintain the feeding ground for beel fish.
- During the dry season, the water level in perennial beels decreases. Excavation of selected beels available and accessible to the fishermen could be considered. This should increase the survival rate of mature beel fish for the next fishing season. This measure should be studied in the context of effectiveness of the excavation on fish catch and diversity, and water delivery to the excavated beels.
- Although no specific sustainable compensation measure for fishermen impacted can be conceived at this time, the possibility of developing the "beel concept" and fishermen association approach should be considered. The possibility of integrating the beel concept with khas land/jalmahals (that are currently leased out) should be studied. One option would be to take these areas out of the lease system and reserve them as common property resource. Another option would be to form an association of the fishermen with the right to fish those areas.
- Promotion of integrated rice/fish production should be considered as an enhancement measure to increase the economic return from the project. The intensive extension undertaking required to promote this concept is more applicable to progressive farmers in the area. For reasons indicated above, it cannot be considered as a viable substitution, compensation, or mitigation measure for the fishermen affected by the project.

Most of those affected by reduction in capture fisheries do not own land or if they have limited land they do not have the skills required for managing a mixed production scheme. In case of more progressive farmers, the impact of pesticides and chemical fertilizers used rather extensively for HYV crops may not be suitable for fish production.

Navigation

- The main inlet structure and peripheral protection structures would hinder navigation during monsoon. The possibilities for adjusting the major gate structures to allow for navigation should be studied and considered. The structure of the main inlet and operation of gate should be adjusted to accommodate certain level of navigation that is necessary for the economy and communication needs of the community. FAP 20 (1992d) proposes adjusting the structure of the main inlet for allowing 60 percent of the existing level of navigation. It is important to realize at least this level of navigation.
- Provisions should be made to construct passages at the main inlet regulator, at Sadullapur inlet regulator, and other medium regulators for the boat passengers to transfer their goods across those structures.
- Improving the road between the Jugni market and Tangail town is a reasonable partial trade off for reduced navigation.

Groundwater

- There should be a systematic study on the impact of the project on groundwater recharge after implementation of the project. Use of groundwater for irrigation and drinking water would be significantly increased in the project area as a result of increase in irrigable land and population. Controlled river flooding, improving khals and drainage canals and increased abstraction of water for various purposes would impact the recharge of the groundwater.
- Abstraction of groundwater should be monitored continuously and when necessary should be limited to safe (recharge) yield.
- Location and placement of the STWs and DTWs should be controlled and when necessary regulated.
- With expected increasing demand on groundwater, consideration should be given to cooperative development of STWs and DTWs for combined domestic and irrigation uses.

Improved Drainage

In order to enhance the drainage improvement efforts and also facilitate the maintenance of navigation routes, it is recommended that simple and low cost methods to be used to dredge periodically the improved khals and drainage canals. The bandalling method using bamboo mat panels may be applicable to smaller khals. Manual cleaning of smaller canals, and offtake areas, if done regularly, would alley the use of more costly dredging.

Tangail Town

The limited structural intervention proposed for the town does not seem to be adequate in mitigating the potentially serious drainage problem. Although this task is not the mandate of the CPP, efforts should be made to make project expertise available to assist with more comprehensive planning for removing the serious drainage problem in town.

Impacts in Bordering Areas

Most of the areas north and south of the project area would not be affected significantly. The surface water modelling runs indicated that there might be impacts in lowering the water level in the main rivers. Upstream areas would be affected during peak discharges due to ponding effects of the main inlet that would be closed during high flood. This may have impact on homesteads and properties located in subcompartments immediately north of the CPP area. Mitigation measures among others may include raising the houses and roads and providing shelter. The possibility of ponding effect of the main inlet when it is closed should be discussed with the communities affected before any mitigation measure is taken.

8.1.2 Mitigation and Enhancement Measures for Institutional Development and Strengthening

Institutional Issues

The need to emphasize people's participation and its institutionalization has been stressed in several studies (FAP 12 1991, FAP 13 1992, FAP 20 1992d). These studies have shown that success and sustainability of FCD/I projects require people's participation in all phases of the project and close collaboration between and within various government and non-government organizations. FAP 20 (1992d) describes a comprehensive program involving all concerned in the process of designing and testing compartmentalization. The stated primary aim of institutionalization program of the CPP is to develop mechanisms for operating and maintaining the compartmental water management system. Institutionalization should allow decisions to be made at the lowest possible level inside the compartment and those living outside the project area, and all those who would be adversely affected. FAP 20 (1992d) proposes an active step-by-step approach aiming at testing, fine-tuning and adapting the institutional arrangements for the CPP area through the following committees:

- Water users groups (WUG) at field level
- Subcompartment water committees (SCWC)
- CPP Executive Committee (CPP/EC)
- Compartment Water Management Board (CWMB)

The concept of compartmentalization is new and in a developmental stage. The concept deviates to a great degree from the established practices of water management in Bangladesh. On the technical side, it is not yet clear how optimal water management objectives would be achieved at the regional, compartmental, subcompartmental, field and/or farm level. With regard to non-technical issues, the project has not yet systematically looked into all the institutional aspects. The ideas developed so far still have to be discussed with and approved by the responsible authorities. While it is not the mandate of the CPP to deal with the broader institutional aspects of water management, it certainly has a great responsibility to address or test several key issues in institutional development that in long term may have national level implications if the compartmentalization concept is to be implemented in other areas. In this context the following recommendations are made.

- A comparative assessment has to be made on the relative interests of different socioeconomic groups (e.g. large vs. small farmers, high vs. low land farmers, paddy vs. jute growers, fishermen vs. boatmen) water management. This assessment would assist in determining the real beneficiaries of the project and ascertain that views of those adversely affected are considered in planning for water management interventions at subcompartment and farm level.
- A strategy has to be developed as to how the beneficiaries would be organized below subcompartmental level.
- It is necessary to determine the spatial expansion of subcompartments over time and the organization(s) responsible.
- It is important to define clearly the role of the NGO (selected or to be selected) and its field staff to carry out community development tasks. Role definition has to be made within the framework of coordination with other local authorities and government agencies.

The followings are more specific recommendations for consideration by the CPP management. They may be considered as mitigation and enhancement measures concerning institutional development and strengthening activities.

- The institutions identified by the CPP (e.g. BWDB, BRDB, DAE, LGED, DOF and Union Parishad) should be given specific responsibilities to implement the mitigation provisions of the EMP, e.g. BWDB in design and construction, maintenance and inspection, relocation and settlement; BRDB in credit delivery and supply of inputs; DAE in integrated pest management and increased use of organic matters; and Union Parishad in income generation programs, tree plantation, improvements in tenancy contracts, property rights and distribution of available khas lands etc. The collaboration and coordination between the various government agencies is particularly important in such activities. Specific areas of collaboration with detailed financial implications need to be spelled out.
- More coordination between local and national NGOs should be realized and what specific task a selected NGO (be it Grameen Bank, Proshika or CARE) would perform is to be clearly spelled out. The existing network of formal and informal institutions should be utilized.
- An Environmental Review Committee comprising representatives from concerned NGO, DOE, LGED, BWDB, DPHE, DOF and District/ Thana level medical practitioners should be formed to assume direct responsibilities regarding environmental monitoring. An alternative is to mandate this task to the proposed Compartment Water Management Board.
- Inter-subcompartmental conflicts and conflicts that may arise between people living inside and outside the compartment should be resolved through effective use of the institutional arrangements.
- In the formation of WUGs and SCWCs, the experience of the G.K. Project, Systems Rehabilitation Project and farmers or community managed projects in Taiwan, Tanzania, Indonesia and the Philippines could be gained and lessons learned from these projects could be fruitfully applied in the water management of the Tangail CPP.

Training

Training in both structural and non-structural aspects is vitally important for sustainability of the CPP initiated improved systems for water management. The project has developed a broad training program targeting different groups and subjects. A tentative outline of the training program has been presented in FAP 20 (1992d). The purpose of the training program is to create or strengthen the required skills at various levels in integrated water management, and to develop and test a training package that can be used at other institutions or locations. Specific locations for training, both at home and abroad, including provisions for study tours and excursions, is suggested.

- It is recommended that the training Program should aim at the representatives of beneficiaries, field and technical staff of various line departments and effectively involve people at the grass-roots level.
- Training should be imparted on improved agricultural practices, and other development activities (e.g. IPM, culture fishery, social and community forestry, etc) impacted by the project or developed as project spinoffs. These efforts would enhance the project initiated activities and would help the CPP in achieving its objectives.

8.1.3 Mitigation and Enhancement Measures for Support Activities

As expressed earlier, the CPP would have significant impact on agricultural activities. If all the project objectives are met, it would have spinoff impacts on enhancing the other economic activities in the project area and beyond. The following recommendations target the project and the government and non-government institutions in the area to enhance the outputs and maximize the return from the project. These recommendations could also be considered as mitigation measures to reduce project's negative impact on subsistence fishermen communities who might benefit from the project spinoff developments.

Agriculture Sector

Post project conditions may accelerate polarization process between rich and poor. The process may be checked if credit and training opportunities were made available for optimum utilization of resources. Intensification and diversification of agricultural uses could be realized if landless and marginal farmers (owning <0.40 ha of land) who constitute almost 40 percent of the farmers could access the credit and modern input packages delivery facilities through BRDB, K. ishi Bank, NGOs, Grameen Bank and other institutions.

- Grameen Bank should be approached to facilitate credit delivery systems to the landless and women. Improved farm practices such as supply of DTWs, STWs, power tillers and tractors could also be made available through the expansion of Grameen Bank services. Landless cooperatives of the KSS type should be formed in relevant subcompartments so that members of the Landless Contracting Societies could tap various services on appropriate terms and conditions.
- Department of Agricultural Extension (DAE), the relevant NGOs, the Krishi and Grameen Banks and the like should play a key role in introducing technical package for increased production; safe and controlled use of water for irrigation and domestic uses; safe and proper use of pesticides (through integrated pest management practices) and fertilizers; and improved seeds, seedlings and saplings.

Other Sectors

Tangail is known for its handloom and powerloom based textile industries. This industry is important for supplemental household income, particularly for those households that would be adversely affected by the project.

- It is recommended that efforts be made to maintain and enhance the production of this sector in the project area. Other small industries that may be enhanced to reduce the project impact include brass work, bamboo work and pottery. Those efforts should be more in the realms of extension and credit and marketing supports.

Marketing

There are eight major and 27 minor markets in the CPP area. Several of these markets would be adversely affected by the project. Although the plan is to leave the main inlet at Lohajang open until mid-July under normal conditions, the period from mid-July to October would be critical for marketing deliveries.

- Efforts should be made to improve the unmetalled road network connecting the major markets to the main metal roads in order to partially compensate for the residual impact of the project on navigation.

Health and Nutrition

The most common diseases in the Tangail CPP are diarrhoeal, skin disease, dysentery, acute respiratory infection and intestinal worm infestation. Prevalence of water borne diseases are comparatively higher than those of other diseases. Many of these diseases are related to the standing and stagnant water. The project through flood control and drainage improvement would improve the condition. However, expansion of irrigated rice farming may well lead to an increase of all year habitats of disease vectors. Since, malaria exists in the project area, the post project condition may promote malaria.

- Educational and clinical precautions have to be made in order to mitigate negative impacts of malaria.

An important concern is the disease kala azar (visceral leishmaniasis). It has been reported that this disease occurs mainly in flood controlled areas (ISPAN 1992d). Kala azar is endemic in areas above the northern boundary of the CPP area. Currently, the project area is in low risk for this disease.

- The incidence of kala azar must be monitored closely when the project is implemented.

At present, standing water and HTW are used for drinking and domestic purposes. The project, through controlled flooding would indirectly promote the use of groundwater sources. From a health point of view this is highly desirable. Provision of safe all year drinking water, sanitation and community health education programs are the major ways to combat the problem.

- A major health education program should be organized to make people aware about the water borne diseases. Health and environmental NGOs in association with the Public Health Department and Thana Health Complex could mobilize resources to tackle the issues.
- A solution should be sought to minimize the effects of retting on polluting the waterbodies.

The CPP would impact significantly capture fisheries production, fish species diversity, and economic activities of full time and subsistence fishermen. Expected reductions in miscellaneous fish would have major impacts on diet of fish-dependent communities and on species diversity.

- The decrease of fish protein sources from capture fisheries needs to be replaced by sources derived from culture fisheries.

Tree Plantation Program

Existing road network in the CPP is approximately 260km. Currently 18km of the road sides have been planted by the local government authority (Thana Afforestation Program). The deforestation rate is relatively high in the project area for domestic fuel and brick field purpose.

- An active tree plantation program along the road and embankments should be reactivated.

8.2 Impact Monitoring and Reporting

8.2.1 Recommended Ecological, Hydrological, Land use, and Socioeconomic Indicators

A monitoring program is needed in order to systematically monitor and evaluate the project's impact on IECs as the project progresses and after the project has been completed. Environmental monitoring requires projects to identify a set of indicators that could be measured, assessed, evaluated periodically to establish a trend of impact. In the context of the CPP, the following criteria is proposed for selection of monitoring indicators in the project area:

- indicators representing the spatial and temporal extent of the project impact;
- indicators representing the most critical IECs identified during EIA; depending on the degree of impact, the IECs should represent the hydrological and biological resources and issues and the socioeconomic issues associated with the impact on those resources;
- indicators that could be measured, monitored and evaluated in certain time intervals and those that could be quantified conveniently;
- indicators that could reflect the impact of mitigation measures; and
- indicators that could show the extent of residual impacts.

Hydrological and Biological Indicators

- Storage capacity of selected beels
- Abundance of selected fish and wildlife species
- Selected homestead and natural plants

- Changes in the areas of F_0, F_1 land types in selected subcompartments
- Groundwater fluctuation
- Groundwater quality at selected sites
- Surface water quality at selected sites

Socioeconomic Indicators

- Amounts of irrigated land at selected subcompartments
- Area and unit area production of boro crop at selected subcompartments
- Area and unit area production of T.D.-Aman at selected subcompartments
- Changes in land ownership and land consolidation and concentration trend in selected subcompartments
- Fish production in selected beels
- Culture fishery production at selected subcompartments
- Homestead food production at selected subcompartments
- Number of boats and level of navigation activities at selected sites
- Number of households living primarily on capture fishery
- Number of breaches on embankments and roads
- Number of STWs at selected subcompartments

8.2.2 Recommendations for Implementation of the Monitoring Plan

Institutional Arrangement and Responsibilities

The CPP is distinct from other FAP projects in concept and objectives. The concept of controlled and semi-controlled flooding is to be tested in Tangail in order to produce criteria, guidelines, manuals and a training and demonstration program for replication elsewhere in Bangladesh. Implementation of the CPP involves a number of governmental institutions. The support of those institutions is vital for successful implementation of the project. Table 8.1 presents a summary list of various governmental and non-governmental organization that should get involved in implementation of the project, and a list of the activities recommended for implementation. Annex 4 includes a list of the NGOs active in the project area.

Indicators Monitoring

The CPP is a pilot project. When this phase of the overall compartmentalization is successfully completed, the concept would be extended to other areas. An integral part of the pilot schemes is to data collection, record keeping, and undertaking various studies to measure/investigate the cause and effect of successes and failures. It is of utmost importance for the CPP to develop a detailed plan for monitoring the indicators as soon as possible. Once the indicators are identified and the purpose for selecting them is well defined, the exact location of sites, the frequency of data collection and monitoring, and the responsible project personnel or relevant government/NGO institutions responsible for the monitoring should be selected and determined. The most appropriate method for data collection, monitoring and reporting would be the application of an adaptive Management Information System, preferably computerized.

8.2.3 Policy and Regulatory Compliance

An important component of monitoring plan is to identify what national policies relate and what regulations apply to the project. Unless otherwise stated, a monitoring plan normally requires the project to comply with those policies and regulations during the course of construction and operation. This section presents a brief overview of the existing policies and regulations in the context of the CPP mandate.

Environmental Policy

The Environment Policy of 1992 (GOB 1992) has identified six general objectives, out of which the following sectoral objectives are applicable to the CPP.

- Water Development, flood control and irrigation: environmentally sound and sustainable development and manage-

Table 8.1 Proposed Institutional Responsibilities in the Implementation of the CPP.

Agencies Involved	Mitigation/Compensation/ Enhancement/Extension program/- Monitoring
Department of Agricultural Extension; SRDI	Balanced use of fertilizer and insecticide. Intensified agricultural extension work in the project area;
Department of Public Health Engineering;	Increased number of Tubewells for drinking, cooking and bathing purposes for Human and livestock;
Department of Agricultural Extension; Department of Environment; Local Government Institutions	Integrated Pest Management program to reduce use of pesticide/insecticide and maintain surface water quality.
BARC; Department of Environment and Department of Forest; Local Government Institutions	Increased HYV cultivation; Increased cropping intensity; Increased vegetation yield from homestead by planting more economically profitable trees and vegetables/fodder.
FAP 20; Fisheries department; Department of Agricultural extension	Inclusion and monitoring of "fish friendly" regulators; Integrated farming of rice/fish with training of farmers; Increased culture fisheries production.
Ministry of Land; BWDB; Proposed Water Users Groups; NGO	The proposed "Beel" concept to be integrated with khas lands and Jalmahals that are leased out at present. These are to be taken out of the leasing system and reserved as Common Property Resources and habitat for spp. diversity.
FAP 20; Roads and Highways department, Local Government Institutions.	Better road communication, particularly metalled road inside the project; where possible allow for vehicles to cross over the structures. Cross-over arrangements also applies to structures blocking the navigation routes.
Ministry of Land; FAP 20; BWDB	Water Management to retain specified minimum amount of water in the khas land beels during the dry season; preventing of khas lands being settled as agricultural land.
BWDB, FAP 20; NGO	Culture fisheries coops or associations for landless with the help of NGO.
BWDB, Deputy Commissioner, Tangail; Ministry of Land, Ministry of Law and Justice	Financial compensation expedited; Provision for paying interest on compensation money for delayed payment.

ment of water development, drainage and irrigation projects involving both surface and groundwater; maintaining the inland waters free from pollution; arrangement for EIA prior to implementation of water development and management projects; removal of the adverse environmental effects of previous water resources management and flood control projects.

- Agriculture: agricultural development and self sufficiency in food is to be achieved through conservation of agricultural resource base by judicious use of appropriate development and management technology.
- Fisheries: protection, conservation and development of fish habitat; development of fisheries without adversely affecting the mangrove and other ecosystems; re-evaluation of those FCD/I projects found to cause adverse effects on fisheries resources.
- Land: adoption and extension of environmentally and ecologically sound land use practices and conservation of soil fertility; prevention of land erosion and strengthening of the land reclamation program; prevention of soil salinity and alkalinity.
- Forests, wildlife and biodiversity: forest conservation and afforestation programs in order to maintain ecological balance; conservation of wildlife and biodiversity; research program; exchange program of knowledge and experience; conservation and development of national wetlands and migratory bird sanctuaries.

In addition, the Constitution of Bangladesh embodies, among other fundamental principles, conservation of national cultural traditions and heritage, protection of national monuments, objects or places of special artistic or historic importance or interest. The constitution also provides that no property shall be compulsory acquired, nationalized or requisitioned save by authority of law, and with compensation. These policies and principles are to be taken into consideration at various stages of the CPP.

Land Acquisition and Compensation

Most of the peripheral structures proposed by the CPP would follow the present alignment. However, some sections would need upgrading and realignment. In addition, inlet and outlet structures, and erosion protection measures would be undertaken. All these activities would need land acquisition. Land acquisition is done primarily under Land Acquisition Act, 1894; however BWDB has been given the power to acquire land (East Pakistan Water and Power Development Authority Ordinance of 1958 and The Bangladesh Water and Power Development Boards Order of 1972). In addition, The Deputy Commissioner of the respective district has been empowered by the Ministry of Land Administration and Land Reforms to expedite finalization of the land acquisition case on the basis of project proposals. The Deputy Commissioner may proceed under Section 6 of the Acquisition and Requisition of Immovable Property Ordinance 1982 on the strength of a certificate issued by the BWDB or its authorized field unit to the effect that necessary funds have been provided to cover the cost of land acquisition and the same would be placed at their disposal on requisition. (Land Administration Manual, 1987).

However, during the distribution of compensation to interested parties, share of the actual owners of the land acquired has to be ascertained following the laws of inheritance of different religious communities. It is also important that the public be made aware of the provisions of The East Bengal Embankment and Drainage Act, 1952. The Act provides for compensation for damages to any land other than the land acquired for project if the land is injuriously affected, or the right of fishery, right of drainage, right to the use of water, or other right of property. The public is to be made aware that such compensation may be claimed within two years after completion of the project.

Common Property Resources

Common Property Resources are those resources or facilities shared by a community, subject to individual use but not to individual possession; and norms, conventions, institutional rules and other complex set of rules or arrangements specifying rights of joint use. In Bangladesh, it is customary to regard and use all public (i.e. owned by the government) resource as common Property Resources unless otherwise specified by the government. Government restrictions come in the form of provisions of acts and ordinances or in the form of lease arrangements. In the CPP area the Common Property Resources of concern are: jalmahals, khas land and BWDB land, roads under the Roads and Highways Department, Thana Parishad and Union Parishad.

Landless households and subsistence fishermen households are partly dependent on common property resources as a survival strategy. Pro-property resources as a survival strategy. Professional fishermen depend on jalmahals, as well as on private floodplain land for fishing on contractual basis. The Ministry of Land manages the jalmahals and the khas land. However, the customary rights of local people are respected and taken into consideration. These customary rights vary from place to place in Bangladesh as well as from time to time. Some references to these customary rights are to be found in the Easement Act of 1882. There are references to such rights in the lease arrangements of jalmahals and other sairat mahals as well. The Penal Code, 1860, refer to such incorporeal right. For example, in case of leasing out of jalmahals, provisions are to be made for protection of the rights and privileges of the boro land cultivators surrounding the jalmahals. Customary rights in jalmahal ponds that are less than 3 acres and where lease value is less than certain limiting value have been recognized by the government (Land Administration Manual of 1987).Changes in land types, as a result of the CPP, would reduce the size of the jalmahals, hence reducing (a) government revenue earnings through lease (b) access of local people to the jalmahals, and (c) "fugitive" resources such as fish and wildlife. However, total or partial trade off is with BWDB land and roads would increase.

Cultural Heritage/Historical Sites

The Atia Mosque and the Kadim Hammdani Mosque would most probably fall within the CPP or the impact area. Therefore, these two come under consideration within the provisions of Antiquities Act, 1968, and the list of archaeological resources of the Department of Archaeology and Museum of the Government of Bangladesh. The two mosques are on the national list of archaeological resources, and protected by law against misuse, destruction, damage, alteration, injury, defacement, mutilation, mining, quarrying, excavating, blasting, and movement of heavy vehicles. FAP 16 has not identified any other archaeological resources/ historical sites that may need to be considered under the above Act. However, the project area is an old settlement area; therefore while executing the project it would be appropriate to remember that any object or historical site, that is the product of human activity and is older than May 1857, would come under the provisions of this Act.

Chapter 9

CASE STUDY EVALUATION

The CPP EIA was the second case study undertaken by FAP 16 with the intent of developing a workable environmental assessment procedure for the FAP and testing the practicality of the EIA guidelines now available (FPCO 1992a). Overall, the case study was considered successful. The procedures and steps outlined in the EIA guidelines were found achievable and practical as a process. It is believed that the EIA process would serve to substantially achieve its objectives of establishing sound environmental planning and management for project development, and would provide the type of information required by decision makers and project managers to proceed on a firm basis with project implementation.

Some important issues related to technical procedures and to the valuation and management of impacts should be noted for attention and decisions for implementation in EIAs of future FAP projects.

9.1 Consistency in Water Level Computations

The underlying determinant used to make predictions of the CPP's impact on environmental components was the changes in "land types" under the "without-" and "with project" conditions. During the course of developing the land type maps and database for both scenarios, a number of issues and problems related to the interpretation of land types and flood depth were encountered.

Land types as defined by SRDI are the flood depth phases of floodplain soil series in Bangladesh. These soil phases have generally and conveniently, perhaps erroneously, become known as land types (FAO 1988). The depth limits between the flooding classes are not as rigid as the definitions might suggest. Flood levels in an area may vary by as much as a meter or more between different years. Conventionally, the flood depth phases are the level of flooding that farmers expect when they decide which crops to grow in the kharif season and it is based on their experience with a cultivated site (FAO 1988). For project planning purposes, BWDB has designated the assumed water levels to be those occurring in 1 in 5 year and having a duration of 3 days (ISPAN 1992a). This assumes that the likelihood of crop damage within any particular cropping pattern in the land types is about 1 in every 5 and that most rice crops will be damaged by flooding for a period exceeding 3 days. Classifications of land types adopted by MPO and FAO are slightly different and the computation of elevations that would be flooded to a ceratin depth is different. The MPO classification system has generally recommended for use in EIAs and agricultural assessment (ISPAN 1992a). In order to develop a land type map the following information is needed::

- the area:elevation curve of the project area; and
- the computed 1 in 5 year maximum water level of duration longer than 72 hour during monsoon season under the baseline and project conditions.

Such information is not easily obtained under typical field conditions and surrogate or modelling approaches are used to approximate these levels.

A land type data base and baseline map based on field land use survey and the MPO flood depth criteria for 1:5 year maximum water levels were developed in this case study. The information was processed by the FAP 19 GIS. Developing a similar map and data base under the with-project condition became problematic due to complexity in modelling the projections (see below). FAP 20 provided water levels based on 1:5 year rainfall data as an approximation for "with project condition" with the assumption that under full flood control the land inundation would be resulted from rain and runoff only, but warned that the results were statistically suspect and that this should not be taken as a valid approximation to the 1:5 flooding levels inside the CPP area under project conditions without further study and data collection (FAP 20 pers.

comm). FAP 20 suggested the use of the maximum water level as measured in July 1991 as an approximation to a 1:5 year flood depth under project conditions. This was the level use in the EIA projections, predictions and assessments for comparing with- and without project conditions as far as land types were concerned. The results (flood depth distribution in the project area) showed only minor differences of project impacts on flood depth between the 1:5 "rainfall only" data and the 1:5 flood depth approximation using the peak flood in July 1991.

FAP 20, in their feasibility studies, have used the approach to land type calculation of a flood depth for a "normal year". A normal year is defined as average or 1:2 year probability occurrence. The water levels measured and computed for July 1989 have been used to approximate this for the baseline and project condition. The results of FAP 20's approach, processed through GIS, are shown in map 9.1. Expectedly, there are significant differences between the baseline data on land types/flood depth between the FAP 16 and FAP 20 approaches. Also, expectedly, the results of projections under the project condition are different. When the impact maps of 1:5 year and 1:2 year flood depth were compared, the difference was primarily in F_0 and F_1 flood depth in subcompartments 9, 10, and 11. The 1989 (1:2) data/map shows higher F_0 areas in the baseline condition compared to a lower coverage of F_0 with 1:5 year data. The impacts thus become more pronounced in case of change in F_0 between the two approaches. Because of these differences, the projections pertaining to agricultural and fisheries impacts will also be different.

It is not the objective of this discussion to determine which approach is correct. Rather, it is a question of how flood depths for land type identification and mapping should be defined and measured. For future project designs and EIAs it is important to:

- develop standard and well-accepted definitions of land type and flood depth, "normal flooding" and "average flooding"; and
- to advise EIA practitioners as well as project engineers whether to adopt either a 1:2, 1:5 or some other flood depth computation for the baseline and the project conditions. Developing one concept for those terms will bring about consistency in data collection, interpretation, and projections in future water projects in Bangladesh.

9.2 Applicability of Hydrological Models and GIS Processing

9.2.1 Hydrological Models and Flood Depth Mapping

The hydrological model used in the CPP EIA was based on MIKE 11 software calibrated for the Tangail area. Output from the model includes water elevations at river cross sections. For each cross section a flood cell has been assigned that represents the area which would be inundated up to the output water level. From this water level information, a water surface can be calculated for a given scenario over the extent of the compartment. BWDB four inch to one mile mapping was used to obtain elevation data for creation of a digital elevation model (DEM) of the land surface. Spot heights were digitized from the BWDB maps to create a geo-referenced ARC/INFO computer file of point elevations across the compartment. This information was then transferred to a raster based ERDAS GIS system where the elevation surface was created by interpolation onto a 40 m by 40 m pixel grid. The water surface and the land surface were intersected to produce a digital map of flood depth and extent for the scenarios of interest to FAP 20 and FAP 16. The flood depth mapping and associated tables included in this report are only a selection from the numerous scenarios investigated. Model runs were available for 1989, 90 and 91 for May through to November. Water levels were also provided for a 1 in 5 year return period. The choice of water level to use makes a significant difference to computation of the project impact. Also it should be pointed out that the land type maps are only representative of a particular situation based on estimates that generally carry a significant

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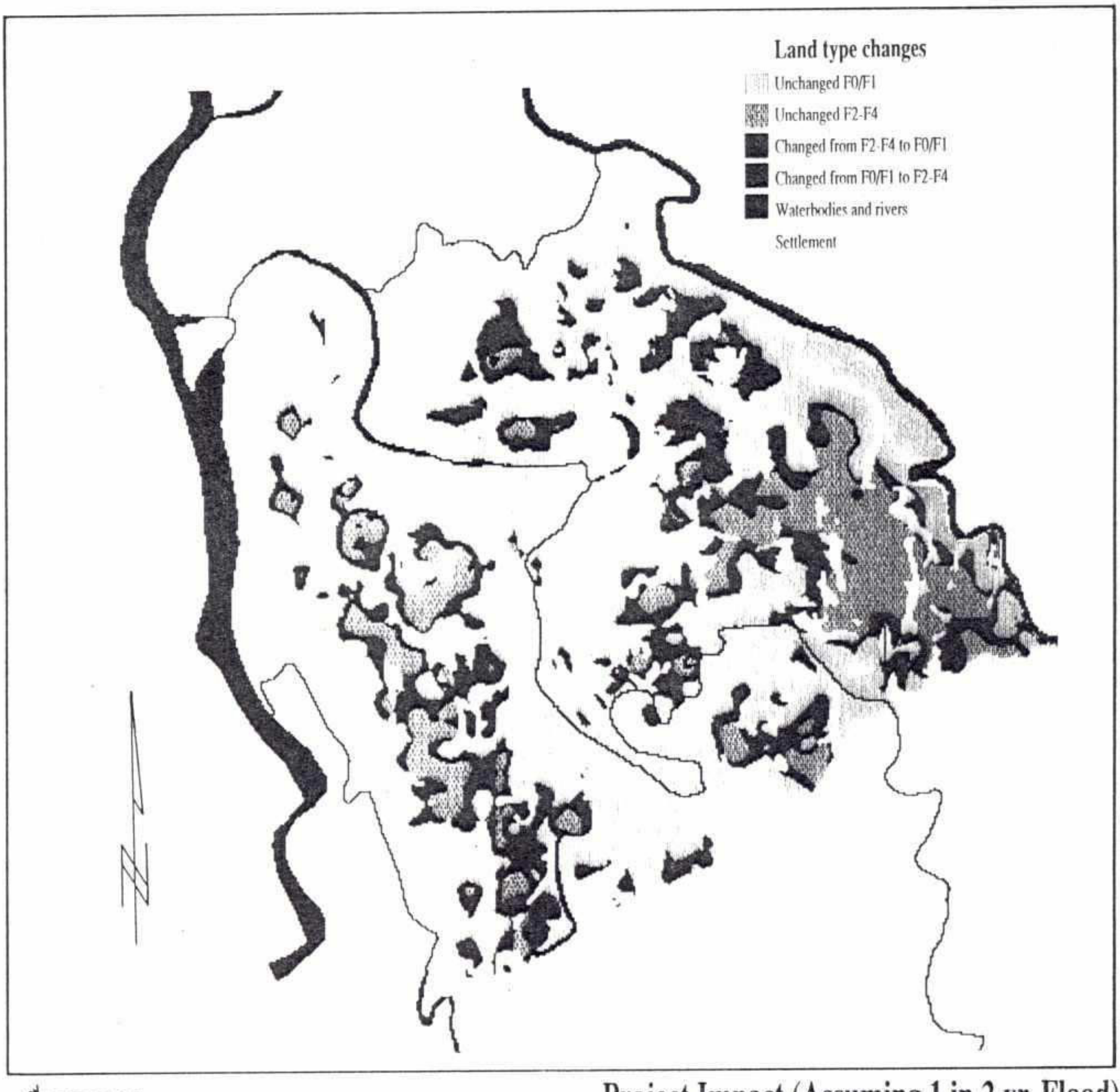
Map 9.1



ISPAN

Project Impact (Assuming 1 in 2 yr. Flood) margin of error.

The potential of error in flood depth mapping can be attributed to the following sources:

- The MIKE 11 computed water levels may be incorrect due to inadequate calibration of both the regional model that supplies the boundary conditions and the calibration of the model for the compartment; this error is believed to be about ± 20cm.
- Mapping used to create the DEM is out of date; the Tangail area was severely effected by the 1987 flood from the old Dhaleswari. The event led to some erosion and deposition in the major watercourses. In particular, it is suspected that levels have changed in subcompartments 12 and 13. On average the error in land elevation is estimated to be ± 10cm.
- The procedure used to generate the DEM from the mapping may also be error prone.
- The assumption of level pools within flood cells is incorrect; the level pool assumption should be valid for the CPP where the fall in water level over the area is of the order of 1 m in 40km; the difference in level across a 500ha cell would be approximately 5cm; Table 9.1 illustrates the possible effect of the cumulative error on the area estimates of different flood depths for subcompartment 2.

9.2.2 Utility of GIS for EIA

The CPP case study EIA marks the first GIS application on EIA in Bangladesh. The GIS was utilized as a platform for spatial data management and display. It was found very useful as a decision support tool and for production of thematic maps relevant to the EIA. GIS analysis can support several important EIA steps. Of the 11 steps in the EIA guidelines those listed below can definitely be enhanced by use of GIS.

- Environmental baseline description
- Assessment of impacts
- Quantify and value impacts
- Environmental management planning
- Feedback to improve project design

There are other spinoff applications of GIS such as improved graphic presentation for visual demonstration of the alternatives to project actions, use in review process and application in training. The CPP case study EIA fully utilized the GIS for almost all the applications listed above, and enhanced the following.

- Improved quality of information.
- Spatial modelling capability to show where impacts occur.
- Fast sensitivity analysis.
- Forces an integrated approach in a multidisciplinary team.

The major negative features of GIS use were found to be:

- costs
- time to capture relevant data, minimized by access to a national archive of digital data but still a limitation for the level of detail usually required.

GIS inputs were further limited by scheduling considerations and availability of FAP 19 resources. Cost could be a serious constraint to many smaller EIA studies. However with local consultancy companies now acquiring GIS capability and the availability of low cost software options, cost will decline as a factor in not using technology. A GIS should be scaled to the size of study and project budget. Skilled personnel are required and this is currently the main constraint in Bangladesh. Training in GIS is underway through FAP 19 and others such as BUET and SPARRSO but there is still only a small cadre of capable GIS specialists.

9.3 Economic Valuation of Impacts

One of the purposes of an EIA is to assist economic evaluation of a project by providing relevant insights and information on the values

Table 9.1 Possible Effect of Cumulative Error of Different Flood Depth for Subcompartment 2.

Land Type	Area Inundated (ha) Water Level 1:5 year	Water Level 1:5 - 30 cm	Water Level 1:5 year +30 cm	Range
F_0	70	48	115	67
F_1	175	67	281	213
F_2	731	478	816	338
F_3	304	687	68	620

of benefits derived and losses incurred so that these can be fully accounted for. In this case study a number of significant losses were not quantified in economic terms, these included the deleterious effects of increased water pollution and overall contamination levels of pesticides, losses of crops to rat damage, costs of extreme flood damage, costs of increased flooding outside the CPP area, the costs of having to deal with an increased incidence of kala-azar, the loss of fish protein derived from capture fisheries, and the loss of biological diversity. Some benefits were also not adequately quantified, i.e. the likely increased levels of home vegetable and fruit production.

The underlying reasons for the lack of quantification fall into three groups:

- lack of information and understanding of the magnitude of the potential loss, e.g. rat damage to crops
- costs which are complex and difficult to accurately quantify, e.g. impacts of increased levels of pesticides in soil, water and foods
- losses which are inherently difficult to quantify in economic terms, e.g. loss of species.

It has been the general experience in EIA and project appraisal that if disbenefits are not quantified in economic terms, they will tend to be overlooked in project evaluation and decision-making. This is likely to be the case in Bangladesh and in the FAP as well. To assign economic values to the losses mentioned above, they would have to be better quantified and better understood by the EIA team. Two avenues are open for improvement:

- improved assessment through better scoping and understanding of the environmental and social issues in FCD/I; this will develop through experience and the development of a body of knowledge and information within the local professional groups and will be enhanced by training and practice
- improved understanding of the environmental linkages and cause and effect relationships; this can only come about through applied research and data collection on the issues involved, e.g. the levels of pesticide contamination in existing environments and how these are influenced by agricultural practices, pesticide marketing practices, legal controls, etc.

Chapter 10

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ANNEX 1

PERCEPTION OF THE COMMUNITIES IN THE CPP AREA CONCERNING FLOOD

Sub. Com. No.	Name of Village	Perceived Problems				Suggested Solutions					Remarks
		DC	SF	SD	ER	EX	SG	CB	CE	CR	
01	Namdar Kumuli	*	*	*							Excavation of a new khal from Kumulli to Kamutia with outlet on Pungli. Re-excavation of Kata Khali Khal from Kumulli to Bhatkura. Raising of Kumulli-Korotia road level.
	Suruj	*				*					Re-excavation of Suruj Khals.
	Birnahali	*		*		*					Re-excavation of Kata Khali and Suruj Khal.
02	Goshaijoar	*				*					One culvert on the mid point of Goshaijoar village, another one on Suruj-Korotia road between Gharinda-Korotia Union.
	Bhatkura	*				*					Re-excavation of Khudiram Khal and link it with Lohajang River. Re-excavation of Bhatkura Khal.
03	Poila	*				*					Drying-up of water bodies and reduction of fish are the problems of professional fishermen. Culvert on Poila earthen road.
	Sarotia	*	*			*					Excavation of a new khal under Jalfai bridge with outlet on Lohajang. Re-excavation of Sarotia Khal.Culvert on Sarotia Khal in Sarotia village.
	Darun	*									
04	Garail	*				*				*	Excavation of a new Khal on the east side of the village and link it with Gorail beel.Raising of Gorail village road.
	Mirer Betka	*				*				*	Excavation of a new khal on the south-west side of the village and link it with Garail beel. Re-excavation of Nagar Jalfai Khal. Culvert on Nagor Jalfai Khal.

Continued

Sub. Comp. No.	Name of Village	Perceived Problems				Suggested Solutions					Remarks
		DC	SF	SD	ER	EX	SG	CB	CE	CR	
05	Panch Bet-hoir			*	*		*				Sluice gate Sadullapur and Rasulpur Khals. Bank protection on north-east and west side of the village for those people who live outside of the embankment
	Barashila	*	*			*		*			Re-excavation of Bartha Khal. Bridge and culvert on the road which was built on top of Bartha Khal.
	Aag Bethoir	*	*			*	*			*	Re-excavation of Bartha Khal from Burai lake to Pungli River. Raising of village road level.
	Kandila	*				*		*			Bridge on Kandila and Bartha Khal.
	Deola	*									
	Ghorinda	*				*		*			Re-excavation of Kandila Khal at its source near Gharinda bridge. Bridge on Gharinda Khal between Purkushia and Bamonkushia.
06	Porabari	*	*					*		*	People need road but they fear that road construction might block drainage outlet for growing cauliflower which is a major source of income.
07	Rabna	*					*	*		*	Sluice gate on Sadullapur Khal at Magur Ata. Raising Tangail-Madhupur linkage road-level.
	Sadullapur		*			*					Re-excavation of Gala Khal to protect over-flow from Lohajang. Linking of Sadullapur Khal with Pungli River from its source.
08	Pichuria ###			*	*	*	*				Excavation of a khal beside the existing embankment from Pichuria Eddgah to Dharerbari with outlet on Bhat Chanda beel. Sluice gate in Pichuria near Eddgah. Re-excavation of Gala Khal. Some 45 people live outside of the embankment. They face severe flooding every year.
	Enayetpur	*				*		*			Re-excavation of Magura Ata, Boilla and Jugni Khal. Bridge on Magura Ata Khal. Potters will be affected if any sluice gate is built on the Sadullapur khal because navigation will be obstructed.
	Bhatchanda	*				*					Re-excavation of Magur Ata Khal.

Continued

Sub. Comp No.	Name of Village	Perceived Problems				Suggested Solutions					Remarks
		DC	SF	SD	ER	EX	SG	CB	CE	CR	
09	Khordojugul	*				*		*		*	Re-excavation of Jugni and Kalibari Khal. Earthen road is creating communication problem. It needs to be pucca and a culvert constructed.
	Kathuajugni					*					Drying-up of water bodies and scarcity of fish are problems for fishermen. Re-excavation of Jugni Khal.
10	Dhalan ###	*				*	*				Re-excavation of Dhalon-Gopalpur Khal and construction of sluice gate. West side of the village face severe flooding every year.
	Dhalan Shibpur	*	*						*		Raising the level of Tangail -Omarpur embankment/road.
	Fatehpur	*									Drying out of water bodies and reduction of fish are the problems of fishermen.
11	Panch Kahonia	*	*	*		*				*	Re-excavation of Gaijabari - Ghoramara Khal. Two earthen roads need to be made pucca.
	Danya Shibram	*	*			*					Re-excavation of Ghoramara Khal.
	Danya Chowdhury	*	*	*	*	*	*				Re-excavation of Ghoramara- Gaijabari Khal. Need proper maintenance of Darjipara-Charabari and Fatehpur sluice gate and a new sluice gate on Jugni Khal in Baghil Union. Tangail-Omarpur road must be made pucca.

Continued

Sub. Comp No.	Name of Village	Perceived Problems				Suggested Solutions					Remarks
		DC	SF	SD	ER	EX	SG	CB	CE	CR	
13	Rupsi-jatra ###			*	*				*		Dredging the curves of Elanjani river to prevent erosion. Raising of existing embankment. People live outside of the embankment face severe flooding every year.
	Baruha	*		*	*	*	*				Re-excavation of Baruha Khal and construction of sluice gate.
14	Parijat-pur	*				*					Sluice gate needed on the source of Deojan Khal but navigation must not be obstructed. Re-excavation of Deojan Khal.
	Mangal-har	*	*			*	*			*	Re-excavation of Lohajang River and need two new khals. One on the north side, another one is on the south side of the village. Sluice gate on Deojan Khal.
15	Narunda	*				*	*	*	*		Embankment beside Lohajang River. Dredging of Lohajang River.
	Beljan					*	*	*			
Loha-jong Flood-plain	Vhaluk-Kandi	*	*	*		*					Re-excavation of Kazipur Beel.
	Kazipur		*	*		*			*		Dredging of Lohajang River. Re-excavation of remaining khals and construction of embankment.
	Galachar	*	*						*		Construction of an embankment on the north-side of Gala From Jugnidha to Kumuli
		33 79%	14 33%	11 26%	6 14%	30 71%	10 24%	13 31%	5 12%	10 24%	

Note: ### Indicates that discussions were held both inside and outside the embankment which forms the compartment boundary.

DC - drainage congestion; SF - seasonal flooding; SD - sand deposition; ER - erosion; EX - excavation & re-excavation of drainage channels/river; SG - sluice gate; CB - construction of bridge culvert; CE - construction of embankment; CR - construction of roads

ANNEX 2

PLANT SPECIES OF ECONOMIC IMPORTANCE IN THE CPP AREA

Economic Importance	Local Names	English Names	Scientific Names	Abundance	Main Location
Fruits, also other uses:	Am	Mango	*Mangifera indica*	High	Homestead
	Ata	Bullock heart	*Annona squamosa*	High	Homestead
	Bel	Wood apple	*Aegle marmelos*	High	Homestead
	Boroy	Plum	*Zizyphus jujuba*	Moderate	Roadside,M/land
	Deophal	-	*Artocarpus lacucha*	Moderate	Homestead
	Gua	Betelnut	*Areca catechu*	Moderate	homestead,Rds.
	Jalpai	Olive	*Olea europaea*	Low	Homestead
	Jam	Blackberry	*Eugenia spp.*	High	Homestead
	Jambura	Grapefruit	*Citrus grandis*	High	Homestead
	Kadbel	Custardapple	*Feronia elephantum*	Low	Homestead
	Kala	Banana	*Musa spp.*	High	Homestead,Rds.
	Kanthal	Jackfruit	*Artocarpus heterophyllus*	Moderate	Homestead,Rds.
	Khejur	Datepalm	*Phoenix sylvestris*	Low	Homestead,Rds.
	Labu	Lemon	*Citrus spp.*	High	Homestead
	Lichu	Lichi	*Lichi chinensis*	Low	Homestead
	Narikel	Coconut	*Cocos nucifera*	Low	Homestead
	Pepe	Papaya	*Carica papaya*	Moderate	Homestead
	Sabrinm	Guava	*Psidium guajava*	Moderate	Homestead
	Tal	Palms	*Borassus flabellifer*	Low	Homestead,Rds.
Timber, also Other Uses:	Babla	Acacia	*Acacia nilotica*	Moderate	Roadside,M/land
	Chambal	Chambal	*Artocarpus chaplasha*	Moderate	Homestead
	Chattim	Sevenleaf	*Alastonia scholaris*	Moderate	Homestead
	Debdaru	-	*Polyalthia longifolia*	High	Homestead
	Eucalyp	Eucalyptus	*Eucalyptus spp.*	Low	Homestd,M/land
	Gumari	-	*Gumelina arborea*	Moderate	Homestead
	Jarul	-	*Lagestroemia speciosa*	High	Homestead,Rds.
	Kadom	Cadamba	*Anthocephalus chinensis*	High	Homestead,Rds.
	Koroi	-	*Albizia spp.*	Moderate	Homestead,Rds.
	Mehogini	Mahogany	*Swietenia mahogany*	Moderate	Homestd.,M/land
	Pon/ShoraNeem	-	*Melia sempervirens*	High	Homestead
	Shegun	Teak	*Tectona grandis*	Low	Homestead
Fuel, also other uses:	Bansh	Bamboo	*Bambusa spp.*	High	Homestead
	Bandarlathi	-	*Cassia fistula*	Moderate	Homestead,Rds.
	Bannay	-	*Crataeva religiosa*	High	Homestead,Rds.
	Gub	Mongosteen	*Diospyros spp.*	Moderate	Homestead,Rds.
	Hijal	-	*Litsea angustifolia*	Moderate	Homestead,Rds.
	Jiga	-	*Lannea grandis*	High	Homestead,Rds.
	Kharajora	Coral tree	*Litsea monopetala*	High	Homestead,Rds.
	Mandar	-	*Erythrina variegata*	Moderate	Homestead,Rds.
	Shaora	Silk cotton	*Strebulus asper*	Moderate	Homestead,Rds.
	Shimul	Tamarind	*Salmalia malabaricum*	Moderate	Homestead,Rds.
	Tetul	-	*Tamarindus indica*	High	Homestead
	Pitadonga		-	High	Homestead,Rds.
Herbal Medicine also Other Uses:	Amrul Shak	-	*Oxalis corniculata*	Moderate	Homestd/M.land
	Arjun	-	*Terminalia arjuna*	Low	Homestead
	Dumur	Fig	*Ficus glomerala*	Moderate	Homestd/M.landd
	Kalmegh	-	*Andrographis paninculata*	Low	Homestead
	Kantanotey	Wildamarenth	*Amaranthus spinosus*	Moderate	Homestd/M/land
	Neem	Nim tree	*Melia azadirachta*	Moderate	Homestd/M/land
	Nishinda	-	*Vetex nigundo*	Low	Homestd/M.land
	Pitraj	-	*Agoora rohituca*	Moderate	Homestead
	Sajna	Round drum	*Moringa olifera*	Moderate	Homestd./M.land

Continued

Continued

Economic Importance	Local Names	English Names	Scientific Names	Abundance	Main Location
Shade, also Other Uses:	Aswtha	Banyan tree	*Ficus religiosa*	Moderate	Roadside
	Bot	-	*Ficus spp.*	Low	Roadside
	Krishnachura	-	*Delonix regia*	Moderate	Roadside
	Raintree	-	*Samanea saman*	Moderate	Roadside
Erosion Control also Other Use:	Bet	Cane	*Calamus spp.*	Moderate	Homestd. Mrg.land
	Patipata	Matleaf	*Clinogyne dichotoma*	Moderate	Homestd. Mrg.land
	Kash	-	*Saccharum spontaneum*	High	Roadside
	Dholkalmi	-	*Ipomea spp.*	Moderate	Homestd.Mrg.land
Vegetable and Spices	Ada	Zinger	*Zingiber officinate*	Moderate	Courtyard/H.stead
	Barbati	Cowpea	*Dolichos lablab*	Low	Courtyard
	Begun	Brinjal	*Solanum melongena*	High	Palan/Courtyard
	Chichinga	Snake gourd	*Trichosanthes anguina*	High	Courtyard
	Chalkumra	White gourd	*Benincasa hispida*	Low	Courtyard
	Darchini	Cinnamon	*Chinnamomum zeylanicum*	Low	Homestead
	Dhanya	Coriandrum	*Coriandrum sativum*	moderate	Palan/Mrg.land
	Dharas	Okra	*Hibiscus esculentus*	Low	Palan/Courtyard
	Gajar	Carrot	*Daucas carota*	Moderate	Palan/Courtyard
	Guamouri	-	*Foeniculum vulgare*	High	Palan/Mrg. land
	Halud	Turmeric	*Curcuma longa*	Moderate	Courtyard/H.stead
	Jhinga	Strippedgourd	*Luff acutangula*	Low	Courtyard
	Khira	Cucumber	*Cucumis sativus*	High	Palan/Courtyard
	Korolla	Bitter gourd	*Momordica chantea*	Low	Courtyard
	Kachu	Arum	*Colocasia esculenta*	High	Palan/H.stead
	Mistikumra	Sweet gourd	*Cucurbita maxima*	High	Palan/Courtyard
	Mula	Radish	*Raphanus sativus*	Moderate	Palan/H.stead
	Panikadu	Bottle gourd	*Lageneria siceraria*	Low	Couryard
	Patakapi	Cabbage	*Brassica oleracea*	High	Palan/Courtyard
	Phulkapi	Cauliflower	*Barassica oleracea*	High	Palan/Courtyard
	Piaj	Onion	*Allium cepa*	High	Palan/Courtyard
	Puishak	Indianspinach	*Basella alba*	Moderate	Palan/Courtyard
	Marich	Chili	*Capcicum spp.*	High	Homestead/Palan
	Rashun	Garlic	*Allium sativum*	High	Homestead/Palan
	Sim	Bean	*Vicia faba*	Moderate	Courtyd/Marg.land
	Shak	Amaranths	*Amaranthus spp.*	High	Palan/Courtyard
	Tejpata	Bayleaf	*Pimenta acris*	Low	Homestead
	Tomato	Tomato	*Lycopersicon lycopersicum*	Moderate	Palan/Courtyard

ANNEX 3

BIOLOGICAL RESOURCES OF THE CPP AREA

CODES:

Status:
Common = C, Uncommon = UC, Endangered = E, Threatened = T

Residence:
Resident = R, Migratory = M

Food behavior:
Insectivorous = I, Piscivorous = P, Granivorous = G, Predator = A, Molluscs/crustaceans = MO, Fructivorous = F, Aquatic vegetation = V, Scavenger = S, Herbivorous = H and Others = O.

Annex 3.1. Sample Areas for Terrestrial Habitat Study of Tangail CPP

Sl. No.	Sub com	Name of village	Area (Decimal)	TEZ	No of plant species	Dominant plant species
1	15	Akandapara	36	Climax	21	Banana, Jackfruit, Pati, Blackbari
2	14	Kumaria	68	Beel	18	Jackfruit, Neem, Mango, Betelnut
3	14	Baratia	32	Climax	14	Mango, Jiga, Bannya
4	13	Rupshijatra	90	River	20	Bamboo, Betelnut, Jack-fruit, Papaya
5	13	Baruha	40	River	20	Bambo, Betelnut, Coco-nut, Jackfruit
6	13	Charpara	45	River	11	Bamboo, Mango, Coconut
7	12	Aloabhabani	50	Climax	19	Mango, Banana, Jack-fruit, Jiga
8	12	Borobelta	26	Climax	14	Banana, Mango, Bamboo
9	11	D. Shibram	70	Beel	23	Betelnut, Bamboo, Gub, Banana, Jackfruit, Nona-fol
10	11	D. Chowdhur y	70	Beel	21	Bamboo, Betelnut, Ba-nana, Mango
11	10	Alishakanda	50	River	20	Bamboo, Betelnut, Jack-fruit, Banana
12	9	Goalpara	54	Climax	21	Betelnut, Mango, Jack-fruit
13	9	Krisnapur	28	Beel	18	Betelnut, Jackfruit, Man-go, Nonafol
14	9	Ramdebpur	59	River	19	Betelnut, Bamboo, Jack-fruit
15	8	Pichuria	28	River	16	Bamboo, Jackfruit, Man-go, Papaya
16	7	Sadullahpur	30	River	17	Betelnut, Bamboo, Jack-fruit, Banana
17	5	Bartta	70	Beel	19	Bamboo, Banana, Mango, Gub, Jiga

Continued

Annex 3.1 continued

18	5	Bamon Kushia	141	Climax	10	Bamboo, Mango, Jarul, Banana, Guava
19	4	Mirer Betka	99	River	11	Jarul, Betelnut, Mango, Jackfruit, Mahagoni, Pitraj
20	3	Charjana	40	Beel	15	Mango, Banana, Guava, Woodapple, Datepalm, Tamarind
21	2	Bhatkura	90	Climax	15	Debdaru, Mango, Betel-nut, Bamboo, Tamarind, Guava
22	1	Ghoaijoair	72	River	21	Betelnut, Papaya, Jack-fruit, Mango
23	1	Kumulinan-dair	68	Climax	13	Shimul, Banana, Bamboo, Mango
24	16	Tantail Town	30	Urban	22	Mahagoni, Mango, Euca-lyptus, Teak
25	11	Santosh	48	Urban	21	Babla, Mahagoni, Teak, Sissu, Banana

Source : FAP - 16 Field Study 1992

Annex 3.2. Fish Species Observed in CPP Area, April - June 1992.

Family Name	Scientific Name	Local Name
Cyprinidae	*Catla catla*	Catla
	Labeo rohita	Rui
	Labeo calbasu	Kalibaus
	Labeo gonius	Gonia
	Labeo bata	Bhangra
	Cirrhinus mrigala	Mrigal
	Cirrhinus reba	Tatkini
	Puntius sharana	Sharputi
	Puntius chola	Chalapunti
	Puntius ticto	Titpunti
	Puntius sophore	Jatpunti
	Salmonasta phulo	Fulchela
	Chela laubuca	Chepchela
	Esomus danricus	Darkina
	Rasbora daniconius	Darkina
	Rasbora elanga	Ellong
	Amblypharyngodon mola	Mola
	Aspiropadia jaya	Piali
Clariidae	*Clarias batrachus*	Magur
Siluridae	*Wallago attu*	Boal
	Ompok bimaculatus	Kanipabda
	Ompok pabda	Pabda
Heteropneustidae	*Heteropneustes fossolis*	Shingi
Schilbeidae	*Ailiichthys punctatus*	Baspata
	Pseudeutropius atherinoides	Batasi
	Eutropiichthys vacha	Bacha
Bagridae	*Mystus aor*	Aair
	Mystus tengara	Bajari Tengra
	Mystus vittatus	Tengra
	Mystus cavasius	Gulsha
Sisoridae	*Gagata spp*	Gang Tengra
	Channa marulias	
Channidae	*Channa striatus*	Gojar
	Channa punctatus	Shol
		Taki
Cobitidae	*Nemacilus(2 spp.)*	Balichata
	Lepidocephalus (2 spp.)	Gutum
Notopteridae	*Notopterus chitala*	Chital
	Notopterus notopterus	Foli
Clupeidae	*Gudusia chapra*	Chapila

Continued

Annex 3.2 continued

Family Name	Scientific Name	Local Name
Mastacembelidae	*Mastacembelus armatus*	Baim
	Mastacembelus pancalus	Guchi Baim
	Macrognathus aculeatus	Tara Baim
Mugilidae	*Rhinomugil corsula*	Khorsula
	Anabas testudineus	
Anabantidae	*Colisa fasciatus*	Koi
	Colisa sota	Khalisha
	Colisa lalius	Boicha
		Lal Kholisha
Gobiidae	*Glossogobius giuris*	Bele
Nandidae	*Nandus nandus*	Meni
Centropomidae	*Chanda nama*	Chanda
	Chanda ranga	Lal chanda
	Chanda beculis	Chanda
Tetradontidae	*Tetrodon sp.*	Potka
Belonidae	*Xenentodon cancila*	Kakila

Source : Fisheries Special Study FAP-16, 1992

Annex 3.3 (a). Amphibians:

Bangla Name	Common Name	Scientific Name	Remarks
Sona bang	Bull frog	*Rana tigrina*	T R I (Export item)
Kotkoti bang	Cricket frog	*R. cynophyctis*	C R I
Kotkoti bang	Skiper frog	*R. limnecharis*	C R I (Above 2 frogs help in wetland nutrient loading)
Gecho bang	Tree frog	*Racophorus sp*	UC R I
Kuno bang	Toad	*Bufo melanostictus*	C R I

Annex 3.3 (b) REPTILES :

TERRESTRIAL

Bangla Name	Common Name	Scientific Name	Remarks
Kochop	Tortoise	*Kachuga tecta*	C R H
Tiktikee	Wall lizard	*Hemidactylus*	C R I
Tokkhok	Gecko	*Gecko gecko*	UC R I
Roktochosa	Garden lizard	*Calotes sp*	C R I
Angila	Skink	*Mabuya carinata*	C R I
Kalo gui	Monitor lizard	*Varanus bengalensis*	T R A (Export item/control rat population)
Atail kacho	Blind snake	*Typlina porrectus*	C R I
Tashira	Striped K.back	*Amphiesma stolata*	C R I
Nila sap	B.B.tree snake	*Dendrilaphis tristis*	C R I
Draj sap	Rat snake	*Ptyas mucosus*	C R A (Illegal export item/ control rat population)
Gokhra sap	Cobra	*Naja naja*	C R A (Export item)
Shonkhine	Banded krait	*Bungarus fasciatus*	C R A (snakes)

AQUATIC

Kasim	Flap shell turtle	*Lissemys punctata*	C R P
Kasim	Soft shell turtle	*Chitra indica*	C R P
Sona gui	Yellow lizard	*Varanus flaviscence*	T R P/A (Export item)
Dora sap	C.K.water snake	*Xenochrophis piscator*	C R P
Matia sap	C. water snake	*Enhydris enhydris*	C R P
Lal dora	Dark B.M.snake	*Xenochrophis cerasogaster*	c r p

Annex 3.3 (c) BIRDS :

TERRESTRIAL

Bangla Name	Common Name	Scientific Name	Remarks
Bhuban cheel	Black kite	*Milvus migrans*	C M/R S (Consume urban waste)
Sada Cheel	Black wing kite	*Elanus cacruleus*	E R I/A
Showkoon	Vulture	*Gyps bengalensis*	T R S (Consume cattle dead bodies)
Gaduni	King vulture	*Sarcogyps calvus*	EXTINCT/Reported by local people
Tilla baz	Crested serpent eagle	*Spilornis cheela*	C R A
Baz	Kestrel	*Falco tinnunculus*	C R/M A
Baz	Shikra	*Accipiter badius*	UC R A
Lal ghughu	Red turtle dove	*Streptopelia tranquebarica*	C R G
Jalali cobutor	Blue R. Pegion	*Columba libia*	C R G
Mala gugu	Ring dove	*Streptopelia decaocto*	C R G
Shobuz gugu	Emerald dove	*Chalcophaps indica*	C R G
Botcol	Green pegion	*Treron pompadora*	C R G/F
Tila ghughu	Spotted dove	*Streptopelia chinensis*	C R G
Teya	Parrakeet	*Psittacula krameri*	C R G
Chok galoo	Hawk cuckoo	*Cuculus varius*	C R I
	Plaintive cuckoo	*Cacomantis merulinus*	C R I
Kokil	Koel	*Eudynamys scolopacea*	C R I
Papiya	Pied C. cuckoo	*Clamator jacobinus*	UC R I
Kanakoka	L.coucal	*Centropus bengalensis*	C R A
Lokhipacha	Barn owl	*Tyto alba*	UC R A
	Scops owl	*Otus sunia*	C R A
	Brown hawk owl	*Ninox scutulata*	C R A
Bhutum pacha	Spotted owlet	*Athena brama*	C R A (These owls/owlets control rat population)
	Indian pita	*Pitta brachyura*	UC R I (Exclusively Sal forest bird)
	Red wing lark	*Mirafra erythroptetra*	C R I
	Bush lark	*Mirafra assamica*	C R I

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Annex 3.3(c) continued

	Tree pipit	*Anthus trivialis*	C R I
	C.Wood shrike	*Tephrodornis pondicerianus*	C R I
	Black W. cuckoo shrike	*Coracina melaschistos*	C M I
	Small minivet	*Pericrocotus cinnamomeus*	C R I
	Orangeheaded ground thrush	*Zoothera citrina*	UC R I (Exclusively Sal forest bird)
	White T. fantail flycatcher	*Rhipidura albicollis*	C R I
	Monarch	*Hypothymis azurea*	C R I
	Grey H. flycatcher	*Culicicapa ceylonensis*	C R I
Shahi bulbul	Pradise flycatcher	*Terpsiphone paradisi*	T R I
Nishi chor	Night jar	*Caprimulgus macrunus*	UC R I
Hud hud	Ashy swallow shrike	*Cypsiurus balasiensis*	C M I
	Chestnut H. bee eater	*Merops leschenaulti*	C R I
Sui chora	Common bee eater	*Merops orientalis*	C R I
	Dusky leaf warbler	*Phylloscopus fuscatus*	C M I
	Fantail warbler	*Cisticola exilis*	C R I
	Inornate warbler	*Phylloscopus inornatus*	C M I
	Greenish warbler	*Phylloscopus trochiloides*	C M I
	Collared bush chat	*Saxicola torquata*	C M I
	Pied bush chat	*S. jerdoni*	C M I
Nilkotho	Roller	*Coracias bengalensis*	C R I
Huopu	Hoopoe	*Upupa epops*	C R I
	Lineated barbet	*Megalaima lineata*	UC R F
Boshonto baure	Coppersmith barbet	*Megalaima haemacephala*	C R F
	Rufous woodpecker	*Micropternus brachyurus*	C R I

Annex 3.3(c) continued

Kat thokra	Golden back woodpecker	*Dinopium javanense*	C R I
Shobuz kat thokra	Scaly bellied green woodpecker	*Picus myrmecophoneus*	C R I
Abbabil	Common swallow	*Hirundo rustica*	C M I
	House swift	*Apus affinis*	C R I
	Palm swift	*Cypsiurus parvas*	C R I
Shipahi bulbul	Red whiskered bulbul	*Pycnonotus jocosus*	C R I
Bulbul	Red vented bulbul	*Pycnonotus cafer*	C R I/F
Doyal	Magpie robin	*Copsychus saularis*	C R I (National bird of Bangladesh)
Taowfique	Iora	*Aegithina tiphia*	C R I
	Grey tit	*Parus major*	UC R I
Tuntune	Tailor bird	*Orthotomus sutorius*	C R I
Sat bhai	Common babbler	*Turdoides striatus*	C R I
Tila munia	Spotted munia	*Lonchura punctulata*	C R G (Ag-pest)
Kalo munia	Blackheaded munia	*Lonchura malacca*	C R G (Ag-pest)
	Purple rumped sunbird	*Nectarinia zeylonica*	C R O
Mautushi	Purple sun bird	*Nectarinia asiatica*	C R O
Kutum	Black headed oriole	*Oriolus chinensis*	C R I/F
	Long tailed shrike	*Lanius schach*	C R I
	Brown shrike	*Lanius cristatus*	C M I
	Asy drongo		
Finga	Black drongo	*Dicrurus macrocercus*	C R I (Control agricultural insect population)
Harichacha	Tree pie	*Dendrocitta vagabunda*	C R I
Pati kak	House crow	*Corvus splendens*	C R S (Consume urban waste)
Dar kak	Jungle crow	*Corvus macrorynchos*	C R S (Consume urban waste)
Bhat salik	Common myna	*Acridotheres tristis*	C R G

Annex 3.3 (c) continued.

Go salik	Pied myna	*Sturnus contra*	C R I (Control insect population)
Gang salik	Bank myna	*Acridotheres ginginianus*	C R I (Play highest role in isect pest control)
Jhuti salik	Jungle myna	*Acridotheres fuscus*	C R I
Kat shalik	Grey H. myna	*Sturnus malabaricus*	C R I
Chorui	House sparrow	*Passer domesticus*	C R G
	Paddy field pipit	*Anthus novaeseelandiae*	C R I
	Yellow B.bunting	*Emberiza aureola*	C R G
Babui	Buya	*Ploceus philippinus*	UC R G

AQUATIC

Pancowri	Little Cormorant	*Phalacrocorax carto*		R	P
Go bok	Cattle Egret	*Bubulcus ibis*	C	R	I
Boro bok	Great Egret	*Egretta alba*	C	R	P
Sada bok	Little Egret	*Egretta garzetta*	C	R	I/P
Sada bok	Intermediate Egret	*Egretta intermedia*	C	R	I/MO

Annex 3.3(c) continued.

Kali bok	Black bittern	*Ixobrychus flavicollis*	UC	R	P
Lal bok	Cinnamon Bittern	*Ixobrychus cinnanmeocus*	UC	R	I/P
Kani bok	Pond Heron	*Ardeola grayii*	C	R	P/I/MO
Nishi bok	Night heron	*Nycticorax nycticorax*	UC	R	P
Nol bok	Grey Heron	*Ardea cinerea*	T	R	P
Chonkho cheel	Brahminy kite	*Haliaster indus*	C	R	P
Shamuk khor	Openbill stork	*Anastomus oscitans*	E	R	MO
Bali hash	Large whistling teal	*Dendrocygna bicolor*	E	R	P
Bali hash	Lesser whistling teal	*Dendrocygna javanica*	C	R	P
Choto duburi	Little grebe	*Podiceps ruficollis*	T	R	V
Mechopacha	Brown fish owl	*Bubo zeylonensis*	E	R	P
	Pallas's F.Eagle	*Halieetus leucoryphus*	E	R	P
Kura	Grey headed fishing eagle	*Icyhthophaga ichthyaetus*	T	R	P

Annex 3.3(c) continued.

	Marsh harrier	*Circus spilonotus*	C M P/O (Frog, snake)
	Pied harrier	*Circus melanoleucos*	C M O/P(Frog)
	Pheasant tail jacana	*Hydrophasianus chirurgus*	UC R MO (Nutrient loading)
Jal pipi	Bronze winged jacana	*Metopidius indicus*	C R V (Nutrient loading)
Dahuk	Water hen	*Gallicrex cinerea*	C R P (Nutrient loading)
Kalim	Purple moorhen	*Porphyrio porphyrio*	UC R P (Nutrient loading)
Kalim	Common moorhen	*Gallinula chloropus*	C R P (Nutrient loading)
Kalo pipi	Coot	*Fulica atra*	UC R V (Nutrient loading)
Hot titi	Redwattled lapwing	*Vanellus indicus*	C R V/Seed
	Golden plover	*Pluvialis fulva*	C M I
	Little ring plover	*Charadrius dubius*	C M V/MO
	Pin tail snipe	*Gallinago stenura*	C M V/MO
	Fan tail snipe	*Gallinago gallinago*	C M V/MO

Annex 3.3(c) continued

	Woodcock	*Scolopax rusticola*	C M V/MO
	Common sandpiper	*Tringa hypoleucos*	C M V/MO
	Wood sandpiper	*Tringa glareola*	C M V/MO
	Common red shank	*Tringa totanus*	C M I
	Common green shank	*Tringa nebularia*	C M I
	River tern	*Sterna hirundo*	UC R P
Choto machranga	Common kingfisher	*Alcedo atthis*	C R P
Machranga	White throated kingfisher	*Halcyon pileata*	C R P
Dora mach ranga	Pied kingfisher	*Ceryle rudis*	UC R P
	White wagtail	*Motacilla alba*	C R/M I
	Pied wagtail	*Motacilla maderaspatensi*	UC M MO
	Grey wagtail	*Motacilla cinerea*	C M V
	Yellow wagtail	*Motacilla flaya*	C M MO
	Yellow headed wagtail	*Motacilla citreola*	C M V

Annex 3.3 (d) MAMMALS :

Bangla Name	Common Name	Scientific Name	Remarks
Boro badur	Flying fox	*Pteropus giganteus*	[illegible]C R F
Badur	False vampire	*Megaderma lyra*	[illegible] R I
Chamchika	Pipstral		
Khak shial	Jackal	*Canis aureus*	[illegible] R A ([illegible]lent control)
Shial	Fox	*Vulpes bengalensis*	[illegible] R O ([illegible]lent control)
Kattas	S.I.Civet	*Viverina malaccensis*	C R A
	L.I.Civet	*Viverrea zibetha*	F [illegible] A
Bonbiral	Jungle cat	*Felis chaus*	T [illegible] A
Mecho bagh[illegible]	Fishing cat	*Felis viverrina*	F [illegible] P
Beje	Mongoose	*Herpestes edwardsi*	C [illegible] A
Indur	L.Bandicoot rat	*Bandicota bengalensis*	C [illegible] G (da[illegible] crops)
	G.Bandicot rat	*Bandicota indica*	C [illegible] G (da[illegible] crops)
	House rat	*Rattus rattus*	C [illegible] O
Chika	I.Shrew	*Suncus murinus*	C [illegible] S
Sehsu	Gangetic dolphin	*Platanista gangitica*	Obs[illegible]d outside the project area [illegible]haleswari River).

ANNEX 4

WATER QUALITY IN WETLANDS OF THE CPP AREA

Name of wetland	Date Time	Tem oF	Ter	pH	O_2 mg/l	Co_2 mg/l	Nit mg/l	Amo mg/l	Chlo mg/l	Hard mg/l	Alka mg/l
Louhajang River (Kag-mari)	24-3 1330	87	M	8.0	9.0	20.0	.02	1.0	22.5	222.3	143.6
Elanjani River (Belta gate)	26-3 1320	86	M	8.0	8.0	15.0	-	1.0	22.5	632.7	253.7
Pungli River	27-3 0800	88	M	8.0	9.0	10.0	-	1.0	-	205.2	157.3
Dhaleswari River (Kasinagor)	26-3 1020	81	L	8.0	9.0	20.0	.02	0.6	-	188.1	198.4
Jamuna River (Factory outlet)	29-3 1300	88	C	6.5	6.0	75.0	EXT	EXT	45.0	513.0	102.6
Jamuna River (1Km down)	29-3 1330	8o	L	9.0	8.0	10.0	.01	1.0	15.0	85.5	68.4
Patnibari Beel	20-5 0930	82	H	9.0	7.0	15.0	-	0.2	22.5	102.6	88.9
Gharinda Beel	21-5 0700	76	C	7.3	4.0	10.0	-	0.8	15.0	102.6	116.3
	24-3 1500	86	C	7.5	9.0	20.0	.01	0.8	22.5	119.7	123.1
Varchanda Beel	22-5 0915	78	M	6.7	8.0	10.0	-	0.8	15.0	51.3	34.2
Boro Beel	22-5 1730	88	M	8.3	10.0	1.0	-	0.4	22.5	102.6	102.6
Juginidoho Beel	23-5 0720	82	L	7.4	8.0	10.0	-	0.7	22.5	85.5	68.4
	1020	85	L	7.5	7.0	15.0	-	0.7	22.5	85.5	82.0
	1320	86	L	7.5	8.0	10.0	-	0.7	30.0	85.5	88.9
	25-3 0730	78	L	7.0	7.0	5.0	-	1.0	15.0	68.4	61.6
Dighla Beel	28-3 1135	86	L	7.2	7.0	10.0	-	[illegible]	22.5	119.7	102.6
Gornildoho baor	24-5 0730	85	L	8.5	8.0	10.0	.01	[illegible]	30.0	136.8	129.9
Kazipur baor	24-5 0930	86	L	7.5	7.0	90.0	-	[illegible]	37.5	188.4	129.9
Atia kumaria baor (MIDDLE)	25-5 0800	84	L	6.6	2.0	20.0	-	1.2	22.5	68.4	54.7
(SOUTH)	0900	87	M	6.9	5.0	15.0	-	0.3	22.5	85.5	88.9
(NORTH)	1200	88	L	7.5	8.0	10.0	-	[illegible]	22.5	85.5	75.2
	25-3 1410	84	L	7.0	6.0	15.0	-	0[illegible]	15.0	68.4	61.6
Duron Beel (baor)	28-5 0845	82	L	7.0	2.5	35.0	-	1.[illegible]	75.0	171.0	157.3
Aghetor Kum	21-5 1300	84	C	7.0	5.0	15.0	-	0	22.5	68.4	68.4

Continued

Continued

Name of wetland	Date Time	Tem oF	Ter	pH	O_2 mg/l	Co_2 mg/l	Nit mg/l	Amo mg/l	Chlo mg/l	Hard mg/l	Alka mg/l
Shakrail (POND)	20-5 1200	92	C	9.2	13.0	10.0	-	0.8	30.0	85.5	6.8
Kendua hospital (POND)	22-5 1130	90	L	7.0	13.0	10.0	.04	1.2	67.5	51.3	95.8
Dhorarerbari (POND)	23-5 1130	87	C	9.0	10.0	-	-	0.8	52.5	51.3	82.0
Sontos (POND)	24-5 1200	92	L	8.8	10.0	-	-	0.9	22.5	119.7	-
Atia mosque (POND)	25-5 1430	90	L	7.0	80.0	10.0	-	1.8	30.0	68.4	47.8
Borobelta (PAGAR)	22-5 1330	97	M	7.2	12.0	5.0	-	1.0	52.5	85.5	
Rokhitbelta (PAGAR)	25-5 1300	95	L	6.5	6.0	20.0	-	0.9	60.0	85.5	34.2

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ANNEX 5

INFORMATION PERTAINING TO HUMAN RESOURCES IN THE CPP AREA

Annex 5.1 Credit Needs and Availability by Farmers Category (All Figures in Taka)

Farmers Category	Household Number	HH Needing Credit (Percent)	HH Credit Receiving (Percent)	Average Credit From Formal Sources	Average Credit From Non-Formal Sources	Average Credit (Total)
Pure Share Cropper	5	80.0	20.0	-	5000.0	5000.0
Marginal Farmer	31	83.9	32.3	2860.0	3700.0	4000.0
Small Farmer	69	81.2	42.0	5382.9	5291.7	5345.2
Medium Farmer	20	55.0	20.0	4375.0	-	4375.0
Large Farmer	7	100.0	14.3	-	3500.0	35000.0
All Farmers	132	78.8	31.1	5019.6	6421.0	5611.3

Source : FAP 20 Household Survey, Project Area Annex 8.3

Annex 5.2. Interest Rate by Type of Credit Sources

Rate of Interest (Percent)	Percent of Household							
	Farm (N=41)		Non-Farm (N=46)		Fishermen (N=15)		Urban (N=8)	
	Non-Formal	Formal	Non-Formal	Formal	Non-Formal	Formal	Non-Formal	Formal
Upto 10	14.6	-	39.1	-	46.7	-	75.0	-
11-15	-	-	-	-	-	-	-	-
16-20	4.9	65.9	2.2	67.4	-	86.7	-	62.5
21-30	-	-	-	-	-	-	-	-
31-50	4.9	-	4.3	-	-	-	-	-
51-100	14.6	-	6.5	-	26.7	-	-	-
100 +	41.5	-	26.1	-	-	-	-	-

Source : FAP 20 Household Survey, Project Area Annex 8.2

Annex 5.3. Sources of Credit by Type of Institution (%)

	Farm (T=230063)	Non-Farm (T=153470)	Fishermen (T=51084)	Urban (T=40500)
Non-Formal				
Money Lender	13.3	5.5	5.6	-
Friends/Relatives	24.4	29.1	11.1	62.5
Traders	2.2	7.3	5.6	-
Others	2.2	7.3	5.6	-
Sub-Total	42.2	49.1	27.8	62.5
Formal				
Commercial Bank	11.1	1.8	-	-
Krishi Bank (BKB)	22.2	5.5	22.2	12.5
Grameen Bank	17.8	38.2	50.0	25.0
Cooperatives	6.6	1.8	-	-
NGO		3.6	-	-
Sub-Total	57.8	50.9	72.2	37.5

T is the Total Amount of Taka Borrowed

Source : FAP 20 Household Survey, Project Area Annex 8.4

Annex 5.4. Purpose of credit taken by Type of Household

Purpose	Farm (N=41) Formal	Farm (N=41) Actual Use	Non-Farm (N=46) Formal	Non-Farm (N=46) Actual Use	Fisherman (N=15) Formal	Fisherman (N=15) Actual Use	Urban (N=8) Formal	Urban (N=8) Actual Use
Crop Input/Raw Material Collection	41.5	41.5	6.5	6.5	6.7	-	-	-
Implement/Equipment Collection	2.4	2.4	4.3	4.3	13.3	-	-	-
Animal Collection	26.8	24.5	4.3	4.3	-	-	-	-
Food Collection	9.8	12.2	17.4	32.7	-	26.7	12.5	25.0
Social Obligations	2.4	2.4	-	-	-	-	12.5	12.5
Children's Education	-	-	-	-	-	-	-	-
Debt Repayment	-	-	6.5	2.2	-	-	12.5	12.5
Land Purchase	-	2.4	4.3	4.3	-	-	25.0	12.5
Business Capital	4.9	2.4	34.9	23.9	60.0	53.3	12.5	12.5
Dowry	-	-	4.3	4.3	-	-	12.5	12.5
Fishing Gears and Equipment Collection	-	-	-	-	20.0	20.0	-	-
House Construction/ Reconstruction	-	-	-	-	-	-	12.5	12.5
Others	12.2	12.2	17.5	17.5	-	-	-	-

N is the number of household taken credit
Source: FAP 20 Household Survey, Project Area Annex 8.5

Annex 5.5. Literacy Rate (%) by Sex in the Project Area

Household Type	Project Area Male	Project Area Female	Project Area Total	Impact Area Male	Impact Area Female	Impact Area Total
Farm	54.2	32.6	44.3	45.6	26.7	37.0
Non Farm	47.0	25.0	36.3	30.7	17.0	23.8
Fisherman	21.3	10.3	16.0	16.5	2.8	9.7
Urban	75.6	54.0	65.5	50.5	27.7	38.1

Source : FAP 20 Household Survey 1992.

Annex 5.6. NGO's in the Project Area and Type of Program

NGOs	Type of Program	Target Group
Grameen Bank	a. Savings and Loan Distribution b. Literacy Program c. Distributing Sanitary Latrine	Landless and Women
CARE	a. Savings and Loans for Income Generation Activities b. Literacy Program c. Training on Health Care and Sanitation d. Homestead Gardening e. Vaccination	Landless and other Non-targets
SDS	a. Savings b. Training on Health Care and Sanitation c. Medicine and Book Distribution	Women and Children
BURO	a. Savings and Loan for Income Generation Activities b. Literary Program c. Physical Exercises	Landless and Women
BRDB	a. Savings Habit Creation b. Literacy Program c. Giving Training on Family Planning, Primary Health Care for Children and Pregnant Mothers	Landless and other Non-targets
SSS	a. Savings Habit Creation b. Income Generation Activities	Landless and Women
UNICEF	a. Saving b. Sports and Culture	Children
FOOD FOR ALL	a. Savings Habit Creation	Landless and Women

Source : MDSC Survey FAP 20 and FAP 16 field notes

Annex 5.7. Enrollment and Attendance of Children at Primary School in Tangail Thana

Total No. of Children 6-10 Year	No. Enrolled			No. of Enrolled Children Regularly Attending	Percentage of Total Children Regularly Attending
	Total	Boys	Girls		
56,395	44,999 (80%)	25,029 (55.6%)	19,970 (44.4%)	20,249 (45%)	35.9%

Source : Tangail Thana Education Department 1992.

Annex 5.8. Existing and Proposed Land Use By Year 2001

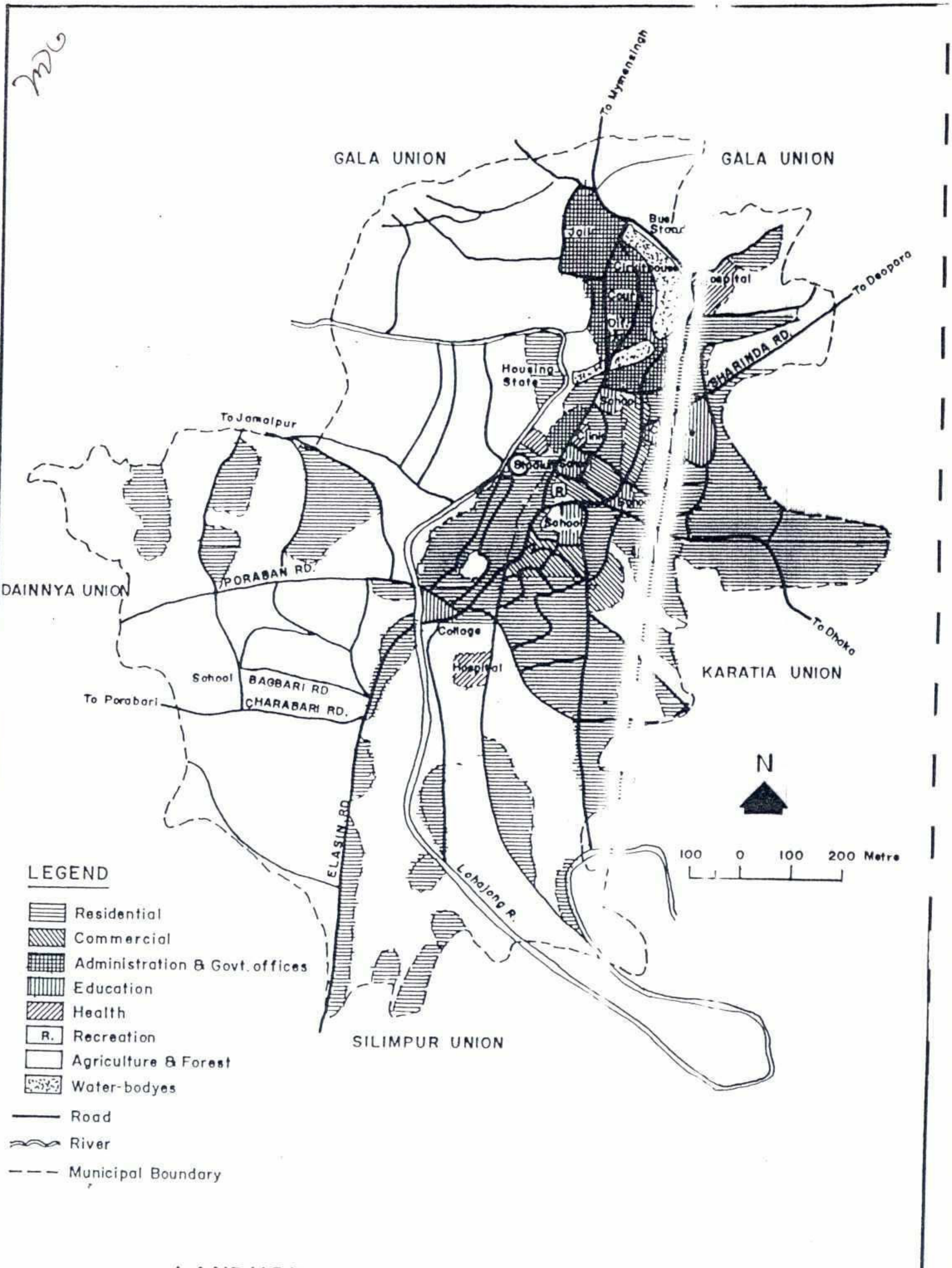
Land Use	Existing Area (ha.)	Percentage	Proposed Including Existing Area by 2001. (ha.)	Percentage
Agriculture/ Forestry	4995.23	69.63	3092.83	41.98
Commerce	31	1.79	70.00	1.99
Industry	25	0.35	95.00	1.71
Educational Institutions	115.67	1.65	152.00	2.17
Health/ Hospital	37	0.53	57.00	0.81
Administra-tion	54.00	0.77	54.00	0.77
Recreation	27.15	0.38	50.00	1.55
Socio-Cultural	31.00	0.44	53.00	0.76
Urban Service	61.35	0.87	113.00	1.61
Residential	1470.00	20.96	2770.00	39.50
Urban Deferred	-	-	290.00	4.13
Road	123.00	1.75	155.57	2.23
Water bodies	62.00	0.88	62.00	0.88
TOTAL	7014.40	100.00	7014.40	100.00

Source: Report on land Use/Master Plan Tangail Pourashava, Urban Development Directorate, July, 1989

Annex 5.9. Flood Related Hazards in Each Subcompartment in the Project Area

Sub-com. No.	Drainage congestion (% area)	Erosion (Acres)	Dike Breaching No. spots	Sand cover (%area)	Ground Water draw down	Siltation in canal
1	0	5	0	40	No	Yes
2	5	No	0	10	No	Yes
3	10	No	0	No	Yes	No
4	40	No	0	No	No	No
5	20	5	0	40	Yes	Yes
6	0	10	0	No	No	Yes
7	25	3	0	No	No	Yes
8	0	10	0	30	Yes	No
9	[illegible]0	0	0	20	Yes	Yes
10	0	5	2 spots Fatepur	60	Yes	Yes
11	40	8	1 spot Chilabari	5	No	Yes
12	10	3	0	No	No	No
13	10	5	1 spot at Rusijatra	10	Yes	No
14	25	No	0	No	Yes	No
15	15	5	0	No	Yesw	Yes

Source: Field Observations and FAP 20 (1992c).



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ANNEX 6

ECONOMIC EVALUATION OF THE CPP

The environmental and social costs and benefits are analyzed in this annex. The impact of the project on incomes and employment is broken down into sub-sections covering 1) direct employment in project construction, 2) project operation and maintenance, 3) agriculture, and 4) fisheries. Income and employment impacts in the transportation sector are not covered because they appear to be insignificant.

1. Project Construction

The total project construction cost is Tk 303 million of which Tk 179 million is for local costs. About 80 percent (Tk 143 million) of the local cost is for employment of unskilled laborers. Assuming a wage rate of Tk 50 per day and 300 work days per full time job, the amount of construction employment is equivalent to 9533 person years. Construction is spread over a three year period. Assuming employment is distributed in the same proportion as total annual expenditures, the number of full time equivalent jobs will be year 1 - 2578, year 2 - 5230, and year 3 - 1725.

2. Project Operation and Maintenance

The plan for operation and maintenance (O&M) of the project has a long term objective that the maintenance costs of the sub-compartmental specific structures will become the responsibility of the Sub-Compartmental Water Committee (SCWC) wherein labor will be provided as a local contribution. BWDB and LGED will maintain the more sophisticated structures at sub-compartment level, and BWDB will be responsible for maintenance at the compartmental level without any local contribution. Thus some amount of the employment in project maintenance will eventually be contributed by project beneficiaries, but the amount has yet to be determined. For this assessment, it will be assumed that all O&M employment represents additional paid employment in the project area.

O&M costs after the third year of implementation for erosion control, embankments, drainage, culverts, bridges, and roads are Tk 11 million. Most of this maintenance will be earthwork involving a high component of unskilled labor. Estimating that about 70 percent of this cost will be for labor, an average wage rate of Tk 50 per day, and 300 working days annually, the project will provide the equivalent of about 500 person/years of full time employment in maintenance. Most of this maintenance work is during the non-flood season, so the actual employment will be about 750 persons over an eight month period.

In addition to the preceding maintenance employment, the project will also provide jobs for 92 technical staff as broken down in Table 1.

Table 1. Operation and Maintenance Technical Staff

Position	No.	Wage (Tk/m)	Annual Cost (mTk)
Sluice Kalashi*	26	2000	0.26
Assistant	9	3000	0.32
Emb. Kalashi	40	2000	0.96
Assistant	4	3000	0.14
Section Officer	2	5000	0.12
Surveyor	2	3000	0.07
Other	2	2000	0.05
Subdiv. Officer	1	7000	0.08
Office Assist.	2	3000	0.07
Other	4	2000	0.10
Total	92		2.18

* Five months per year

The sluice kalashi jobs are only five months duration, so the 92 technical staff positions convert to 77 full time jobs. Altogether, the project will provide additional employment in O&M work of about 580 full time jobs. The distribution of employment will consist of 66 full year technical jobs, an additional 26 technical jobs during monsoon only, and 750 unskilled labor jobs for eight months during the flood free season.

3. Agriculture

The analysis in this section is based on crop budgets and cropping patterns under with and without project conditions that are presented at the end of the annex as Tables 5 to 8.

Employment

Employment in agriculture will increase by

320,000 person days, about 9 percent higher than under without project conditions. Employment will be about 80,000 person days less during May, and 100,000 person days higher during July and August as a result of the change in cropping from B. Aman and Mixed Aus/Aman to T. Aman varieties. Thus in terms of seasonality, the distribution of employment is somewhat more evenly spread over the summer months with the project.

About 190,000 person days of the additional employment will be supplied by farm family labor, leaving 130,000 person days of additional hired labor. Assuming six work days per week, this is equivalent to 417 additional full time jobs for hired labor. However, since the additional employment is concentrated in July and August, the number of additional hired laborers employed during these peak months will be about 1800 persons. Considering the high rate of unemployment in the project area, the additional jobs will not cause an increase in the wage rate paid for labor.

Income

The gross value of crops, including byproducts, will increase from Tk 358 million to Tk 448 million, or about 25 percent. Of the Tk 89 million increased gross crop value, Tk 11.3 million will be used to purchase additional production inputs, and Tk 6.5 million will be paid for hired labor. The residual Tk 72.3 million of net farm income will accrue to family labor and landowners. Assuming family labor is valued at Tk 50 per day, and evenly distributed by households, the distribution of the net farm income by size of farm class will be approximately as shown in Table 2.

Of the total Tk 72.3 million annual increase in net farm income, Tk 33.5 million (46 percent) will go to the medium and large farmers which constitute 20 percent of the rural households. Small farmers, marginal farmers and landless together will receive the remaining Tk 38.8 million (54 percent). The additional Tk 6.5 million paid for hired farm labor as a production cost will also probably accrue to the landless, marginal and small farmers group . hereby increasing their total annual income y k 45.3 million.

4. Fisheries

Implementation of the project w ause a reduction in the level of capture f ry from 380 tons in 1992 to 219 tons (p.7 , which amounts to a loss of 161 tons per r. Under the no intervention scenario, a proj n of past trends indicates capture fishery pr tion will decline to 215 tons in the year (p.7-3). However, the factors contributi the past rate of decline in capture fisher y be alleviated without the project, so tha production level of 380 tons will be mai ed. No estimate has been made of what th vel of production will be in the year 2012 u the combination of with project condition d continuation of the factors which have ca the past rate of decline. Therefore, the impa the project was estimated under two assum s, a) production remains constant at 219 to er year with the project, and b) producti eclines with the project at the same annual as was projected for conditions without the ject, i.e. an annual rate of decline of 2.81 p nt. The results are shown in Table 8 at the of the annex. At a discount rate of 12 perc the annual equivalent of the loss in fish production ranges from 117 to 155 ton epending on which assumption is believed.

The value of these fish 1991 market prices is estimated at Tk 50 p kg, amounting to an annual loss ranging fr Tk 7.75 million to Tk 5.85 million. This los ill be partially offset by an increase in the pro ction of culture fish.

The estimated produ on of culture fish is 49 tons per year in 1992, rojected to be 66 tons in 2012 without the proj ct. Production with the project is estimated to be 82 tons per year, but it will take some time to build up to this level, say five years after the project is implemented in 1995. Again at 12 percent interest, the average annual value of the difference between the projected with and without project rates of production is 12 tons as shown in Table 10 at the

Table 2. Distribution of Incremental Farm Income

Category (Ha)	Percent of HH	Percent of Land	Net Farm Income (mTk) Labor	Net Farm Income (mTk) Land	Net Farm Income (mTk) Total	Net Farm Income (mTk) Percent
Landless (0 - 0.202 ha)	12.9	1.5	1.2	1.0	2.2	3.0
Marginal Farmers (0.206-0.405)	25.8	11.6	2.4	7.3	9.8	13.5
Small Farmers (0.409-1.012)	40.9	36.4	3.9	22.9	26.8	37.0
Medium Farmers (1.016-2.024)	15.9	31.2	1.5	19.6	21.1	29.2
Large Farmers (>2.028)	4.5	19.1	0.4	12.0	12.4	17.2
Total	100.0	100.0	9.5	62.8	72.3	100.0

Source: The distribution of land ownership is from FAP 20 (1992e)

end of the annex. Major carp are valued at Tk 60/kg. Therefore the increased value of culture fishery attributed to the project is Tk 0.72 million and the net loss in value of fish production will be between Tk 7.03 million and Tk 5.13 million.

The distributional impact of the income loss in fisheries will fall more heavily on the landless and small farm households because most of the professional fishermen and subsistence fishing households fall within this group. The partially offsetting increase in value of culture fishery will more likely accrue to the large landowner households as they are more likely to own the ponds and have the resources to invest in culture fishery.

It was estimated earlier (Section 7.2) that 38 percent of the capture fishery is caught by 17,000 subsistence fishing households, and the remaining 62 percent of the annual catch is harvested by 325 professional fishing households. Assuming the loss in capture fishery under with project conditions is shared in the same proportion, the loss of value of catch to subsistence fishing households will be between Tk 2.22 to Tk 2.95 million. Professional fishermen will lose between Tk 3.63 and Tk 4.81 million.

Most of the subsistence fishing catch is for home consumption. The loss to each household is between 2.6 and 3.5 kg of fish per year, valued at Tk 125 to Tk 175. Although the monetary loss per household seems small, it should be understood that this loss is most likely to be manifested as a direct nutritional loss to the family that will not be offset or compensated for by an increase in culture fishery.

The loss in value of catch to professional fishermen can be considered totally as a loss of net income, because there will not be a proportionate savings in the effort or costs expended in fishing. Therefore, the loss of net income is between Tk 11,169 to Tk 14,785 per household.

The cost of raising culture fish is about Tk 20 per kg. Therefore, the net income gain from the increase in culture fishery is
about Tk 0.5 million, mostly accruing to the large farmer households.

5. Unquantified Economic Impacts

Other impacts identified in the project assessment will also have economic consequences. These include:

Gains:

- productivity of homestead gardens and vegetation
- improved access to health care
- reduced infections from stagnant, contaminated water

Losses:

- agricultural pollution of surface and groundwater

- pesticide induced mortalities in beneficial wildlife
- agricultural and social losses resulting from increases in rat populations
- increased damages inside the project from extreme flood events
- increased flooding outside the project
- costs related to increased risks of kala-azar transmission
- loss of wetland habitats and associated loss of fish and wildlife species

Omission of these impacts from the economic evaluation is not intended to diminish their significance. There is insufficient information to quantify the impacts at this time.

6. Summary

In summary, the project will result in an increase in employment amounting to an average of 3,200 (9533/3) full time jobs over the three year construction period for unskilled labor. Thereafter, under with project conditions there will be an increase in employment in agriculture and project O&M equivalent to about 1600 full time jobs. About 600 of these jobs will be absorbed by farm family labor, leaving 1,000 jobs to be filled by hired labor.

As summarized in Table 3, total income will increase by Tk 81.2 million under with project conditions. This includes the high estimate of income loss from fisheries of Tk 8 million. Assuming the loss of fisheries income and the gains from O&M employment accrue to landless, marginal and small farmers, the total income change to this group is Tk 47.2 million. Medium and large farmers will gain about Tk 34 million from agriculture and culture fisheries. In terms of relative distribution, the landless, marginal and small farms which constitute 80 percent of households in the project will receive 58 percent of the increase in project income. The medium and large farmers which are about 20 percent of households will receive the remaining 42 percent of the additional income generated by the project.

Table 4 summarizes the major costs and benefits estimated for the CPP. The ratio of total benefits to total costs is approximately 1.4:1. However, substantial environmental and social costs, including pesticide and pollution effects and the costs of epidemic disease health control programs have not been included in these computations because of the lack of pertinent data.

Table 3. Annual Change in Income by Recipient Class (mTk)

Landless, marginal and small farmers	
Net farm income	38.8
Hired farm labor	6.5
Subsistence fishery	-3.0
Commercial fishery	-5.0
Project O&M employment	9.9
Subtotal	47.2
Medium Farmers	
Net farm income	21.1
Large Farmers	
Net farm income	12.4
Culture fishery	0.5
Subtotal	12.9
Total	81.2

Table 4. Comparison of Benefits and Costs, Tangail CPP Project (mTk, 1991 Financial Prices, 12 percent interest)

	Present Value 1993	Annual Value*1 1993 - 2025
Benefits		
Net Farm Income	563.4	69.3
Farm Hired Labor	50.5	6.2
Culture Fishery	3.9	0.5
Project Labor	203.5	25.0
Gardens/Vegetables	NQ*2	NQ
Improved health care	NQ	NQ
Total	821.3	101.0
Costs		
Project Investment and O & M*3	555.0	68.2
Capture Fishery	42.7	5.3
Agric. water pollution	NQ	NQ
Pesticide damages	NQ	NQ
Rat damage to crops	NQ	NQ
Extreme flood damages	NQ	NQ
Flooding outside area	NQ	NQ
Kala-azar control	NQ	NQ
Loss of biodiversity	NQ	NQ
Total	597.7	73.5

*1 Present value amortized at 12 percent over 33 years.
*2 Not quantified in economic terms
*3 Includes investment, O&M, land acquisition, production foregone, and non-structural intervention.

Table 5. Crop Budget Without Project (per ha, 1991 Financial Prices a/)

Crop	Yield b/ (mt)	Tk/mt	ByProd (mt) c/	Tk/mt	Labor Total (Person Days) d/	Labor Family	Labor Hired	Tk/day	Pair Oxen Days	Tk/day	Seed (kg)	Tk/kg
B.Aus	1.3	6074	2.7	950	150	93	57	50	45	45	100	11
M.Aus & Aman	1.8	6256	1.8	950	150	93	57	50	45	45	100	11
B.Aman	1.5	6438	1.5	950	125	78	48	50	45	45	100	10
T.Aman (L)	1.8	6438	3.7	950	160	107	53	50	42	45	30	10
T.Aman (H)	2.7	6438	2.7	715	175	105	70	50	44	45	30	9
T.D.Aman	0.8	6438	0.8	950	150	92	59	50	40	45	30	10
Boro (H)	4.4	6212	4.4	715	220	125	95	50	50	45	30	10
Boro (L) d/	2.5	6212	5.0	950	132	88	44	50	40	45	90	10
Jute	1.8	8012	3.6	2550	180	90	90	50	45	45	9	24
Wheat	2.0	6312	2.0	715	105	72	33	50	44	45	130	12
Potato d/	9.5	4580	-		120	68	52	50	38	45	1500	9
Sugarcane	40.0	1012	-		275	110	165	50	40	45	5000	1
Oilseeds	0.8	13466	1.0	715	80	66	14	50	30	45	10	19
Pulses	1.0	14919	1.0	715	50	42	9	50	30	45	30	25
Vegetables f/	8.0	4100	-		240	101	139	50	48	45	1	400

Table 5. Crop Budget Without Project (continued)

Crop	Fertilizer (kg) Urea	Tk/kg	TSP	Tk/kg	MP	Tk/kg	Pesticides (kg)	Tk/kg	Irrig. (Tk) d/	Total Cost e/	Crop Income
B.Aus	70	5	40	5	-	4	-	504	-	6785	3891
M.Aus & Aman	70	5	40	5	-	4	-	504	-	6785	6039
B.Aman	70	5	-	5	-	4	-	504	-	6007	4962
T.Aman (L)	90	5	50	5	30	4	-	504	-	5915	9437
T.Aman (H)	170	5	90	5	40	4	0.2	504	1550	9269	9970
T.D.Aman	90	5	-	5	-	4	-	504	-	5709	448
Boro (H)	220	5	110	5	60	4	0.7	504	5000	15201	14944
Boro (L) d/	60	5	29	5	7	4	0.1	504	2400	8178	12102
Jute	80	5	50	5	40	4	-	504	-	7916	15685
Wheat	150	5	70	5	50	4	-	504	600	7387	6667
Potato d/	140	5	70	5	50	4	0.8	504	800	20438	23072
Sugarcane	120	5	100	5	70	4	-	504	3000	20394	20086
Oilseeds	90	5	60	5	30	4	-	504	600	3862	7626
Pulses	-	5	-	5	-	4	-	504	600	3281	12353
Vegetables f/	120	5	50	5	30	4	0.5	504	4000	15449	17351

a/ Prices are from Q. Shahabuddin & K. Mustahidur Rahman, "Estimation of Economic Prices of Selected Commodities for use in FAP Planning Studies," except vegetable price is from FAP 20 Interim Report.
b/ Master Plan Organization, "Agriculture Production Systems," TR No. 14, 1987.
c/ Production inputs for percentage of hired labor and irrigation costs are from Tangail CPP Interim Report, Annex 2: Agriculture, September, 1992.
d/ Total cost includes 5% miscellaneous cost.
e/ Yield and production inputs for vegetables are from Tangail CPP Interim Report.
Source: FAP 16 Field Survey, except as noted.

Table 6. Net Crop Income and Production Inputs Without Project

Crop	Area (ha)	Prod. (t)	Value (mTk)	ByProd (t)	Value (mTk)	Labor: Total	Labor: Family	Labor: Hired (mill Person Days)	Labor: Cost (mTk)	Oxen Days (000)	Cost (mTk)	Seed (t)	Cost (mTk)
B.Aus	484	648	3.9	1296	1.23	0.07	0.05	0.03	1.38	22	0.98	48	0.51
M. Aus & Aman	523	931	5.8	931	0.88	0.08	0.05	0.03	1.49	24	1.06	52	0.55
B.Aman	585	869	5.6	869	0.83	0.07	0.05	0.03	1.39	26	1.18	59	0.59
T.Aman (L)	1803	3320	21.4	6640	6.31	0.29	0.19	0.10	4.76	76	3.41	54	0.54
T.Aman (H)	290	780	5.0	780	0.56	0.05	0.03	0.02	1.02	13	0.57	9	0.08
T.D.Aman	3447	2873	18.5	2873	2.73	0.52	0.32	0.20	10.08	138	6.20	103	1.03
Boro (H)	6476	28183	175.1	28183	20.15	1.42	0.81	0.61	30.63	324	14.57	194	1.94
Boro (L)	104	260	1.6	520	0.49	0.01	0.01	0.00	0.23	4	0.19	9	0.09
Jute	703	1265	10.1	2531	6.45	0.13	0.06	0.06	3.16	32	1.42	6	0.15
Wheat	873	1746	11.0	1746	1.25	0.09	0.06	0.03	1.42	38	1.73	113	1.36
Potato	300	2850	13.1	0	0.00	0.04	0.02	0.02	0.77	11	0.51	450	3.83
Sugarcane	506	20240	20.5	0	0.00	0.14	0.06	0.08	4.17	20	0.91	2530	2.53
Oilseeds	1439	1151	15.5	1439	1.03	0.12	0.10	0.02	0.98	43	1.94	14	0.27
Pulses	350	350	5.2	350	0.25	0.02	0.01	0.00	0.15	11	0.47	11	0.26
Vegetables	100	800	3.3	0	0.00	0.02	0.01	0.01	0.70	5	0.22	0	0.04
Total	17983	37863 *	315.6	48156	42.16	3.07	1.82	1.25	62.33	786	35.38	3654	13.78

* Paddy only.

Table 6. Net Crop Income and Production Inputs Without Project (continued)

Crop	Fertilizer Urea (t)	Cost (mTk)	TSP (t)	Cost (mTk)	MP (t)	Cost (mTk)	Pesticides (kg)	Cost (mTk)	Irrig. (mTk)	Total Cost (mTk)	Crop Income (mTk)
B.Aus	34	0.16	19	0.10	0	0.00	0	0.00	0.0	3.3	1.9
M. Aus & Aman	37	0.17	21	0.11	0	0.00	0	0.00	0.0	3.5	3.2
B.Aman	41	0.19	0	0.00	0	0.00	0	0.00	0.0	3.5	2.9
T.Aman (L)	162	0.74	90	0.49	54	0.22	0	0.00	0.0	10.7	17.0
T.Aman (H)	49	0.23	26	0.14	12	0.05	58	0.03	0.4	2.7	2.9
T.D.Aman	310	1.42	0	0.00	0	0.00	0	0.00	0.0	19.7	1.5
Boro (H)	1425	6.53	712	3.85	389	1.57	4533	2.28	32.4	98.4	96.8
Boro (L)	6	0.03	3	0.02	1	0.00	10	0.01	0.2	0.9	1.3
Jute	56	0.26	35	0.19	28	0.11	0	0.00	0.0	5.6	11.0
Wheat	131	0.60	61	0.33	44	0.18	0	0.00	0.5	6.4	5.8
Potato	42	0.19	21	0.11	15	0.06	240	0.12	0.2	6.1	6.9
Sugarcane	61	0.28	51	0.27	35	0.14	0	0.00	1.5	10.3	10.2
Oilseeds	130	0.59	86	0.47	43	0.17	0	0.00	0.9	5.6	11.0
Pulses	0	0.00	0	0.00	0	0.00	0	0.00	0.2	1.1	4.3
Vegetables	12	0.05	5	0.03	3	0.01	50	0.03	0.4	1.5	1.7
Total	2496	11.43	1131	6.11	623	2.52	4892	2.47	36.8	179.4	178.4

* Paddy only.

Table 7. Crop Budget With Project (per ha, 1991 Financial Prices a/)

Crop	Yield (mt)	Tk/mt	ByProd (mt) b/	Tk/mt	Labor Total	Labor Family	Labor Hired (Person Days) c/	Tk/day	Pair Oxen Days	Tk/day	Seed (kg)	Tk/kg
B.Aus	1.5	6074	3.0	950	150	93	57	50	45	45	100	11
M. Aus & Aman	-	-	-	-	-	-	-	-	-	-	-	-
B.Aman	1.6	6438	1.6	950	125	78	48	50	45	45	100	10
T.Aman (L)	2.2	6438	4.4	950	160	107	53	50	42	45	30	10
T.Aman (H)	3.0	6438	3.0	715	175	105	70	50	44	45	30	9
T.D.Aman	1.7	6438	1.7	950	150	92	59	50	40	45	30	10
Boro (H)	4.5	6212	4.5	715	220	125	95	50	50	45	30	10
Boro (L)	-	-	-	-	-	-	-	-	-	-	-	-
Jute	1.8	8012	3.6	2550	180	90	90	50	45	45	9	24
Wheat	2.0	6312	2.0	715	105	72	33	50	44	45	130	12
Potato b/	9.5	4580	-		120	68	52	50	38	45	1500	9
Sugarcane	40.0	1012	-		275	110	165	50	40	45	5000	1
Oilseeds	0.8	13466	1.0	715	80	66	14	50	30	45	10	19
Pulses	1.0	14919	1.0	715	50	42	9	50	30	45	30	25
Vegetables e/	8.0	4100	-		240	101	139	50	48	45	1	400

Table 7. Crop Budget With Project (continued)

Crop	Fertilizer (kg) Urea	Tk/kg	TSP	Tk/kg	MP	Tk/kg	Pesticides (kg)	Tk/kg	Irrig. (Tk) c/	Total Cost d/	Crop Income
B.Aus	70	5	40	5	-	4	-	504	-	6785	5176
M.Aus & Aman	-	-	-	-	-	-	-	-	-	-	-
B.Aman	70	5	-	5	-	4	-	504	-	6007	5814
T.Aman (L)	90	5	50	5	30	4	-	504	-	5915	12428
T.Aman (H)	170	5	90	5	40	4	0.2	504	1550	9269	12190
T.D.Aman	90	5	-	5	-	4		504	-	5709	6851
Boro (H)	220	5	110	5	60	4	0.7	504	5000	15201	15970
Boro (L)	-	-	-	-	-	-	-	-	-	-	-
Jute	80	5	50	5	40	4	-	504	-	7916	15685
Wheat	150	5	70	5	50	4	-	504	600	7387	6667
Potato b/	140	5	70	5	50	4	0.8	504	800	20438	23072
Sugarcane	120	5	100	5	70	4	-	504	3000	20394	20086
Oilseeds	90	5	60	5	30	4	-	504	600	3862	7626
Pulses	-	5	-	5	-	4	-	504	600	3281	12353
Vegetables e/	120	5	50	5	30	4	0.5	504	4000	15449	17351

a/ Prices are from Q. Shahabuddin & K. Mustahidur Rahman, "Estimation of Economic Prices of Selected Commodities for use in FAP Planning Studies," except vegetable price is from FAP 20 Interim Report.
b/ Master Plan Organization, "Agriculture Production Systems," TR No. 14, 1987.
c/ Production inputs for percentage of hired labor and irrigation costs are from Tangail CPP Interim Report, Annex 2: Agriculture, September, 1992.
d/ Total cost includes 5% miscellaneous cost.
e/ Yield and production inputs for vegetables are from Tangail CPP Interim Report.
Source: FAP 16 Field Survey, except as noted.

Table 8. Net Crop Income and Production Inputs With Project

Crop	Ha	Prod. (t)	Value (mTk)	ByProd (t)	Value (mTk)	Labor Total	Labor Family	Labor Hired (mill Person Days)	Cost (mTk)	Oxen Days (000)	Cost (mTk)	Seed (t)	Cost (mTk)
B.Aus	612	918	5.6	1836	1.74	0.09	0.06	0.03	1.74	28	1.24	61	0.64
M. Aus & Aman	-												
B.Aman	148	237	1.5	237	0.22	0.02	0.01	0.01	0.35	7	0.30	15	0.15
T.Aman (L)	3256	7163	46.1	14326	13.61	0.52	0.35	0.17	8.60	137	6.15	98	0.98
T.Aman (H)	1506	4518	29.1	4518	3.23	0.26	0.16	0.11	5.27	66	2.98	45	0.41
T.D.Aman	2125	3613	23.3	3613	3.43	0.32	0.19	0.12	6.22	85	3.83	64	0.64
Boro (H)	6574	29583	183.8	29583	21.15	1.45	0.82	0.62	31.10	329	14.79	197	1.97
Boro (L)	-												
Jute	1505	2709	21.7	5418	13.82	0.27	0.14	0.14	6.77	68	3.05	14	0.33
Wheat	1117	2234	14.1	2234	1.60	0.12	0.08	0.04	1.82	49	2.21	145	1.74
Potato	400	3800	17.4	0	0.00	0.05	0.03	0.02	1.03	15	0.68	600	5.10
Sugarcane	506	20240	20.5	0	0.00	0.14	0.06	0.08	4.17	20	0.91	2530	2.53
Oilseeds	1303	1042	14.0	1303	0.93	0.10	0.09	0.02	0.89	39	1.76	13	0.25
Pulses	500	500	7.5	500	0.36	0.03	0.02	0.00	0.21	15	0.68	15	0.38
Vegetables	100	800	3.3	0	0.00	0.02	0.01	0.01	0.70	5	0.22	0	0.04
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Total	19652	46032	387.8	63568	60.10	3.39	2.01	1.38	68.86	862	38.80	3797	15.14
Incremental	1669	8169	72.2	15412	17.94	0.32	0.19	0.13	6.53	76	3.42	143	1.37

* Paddy only.

Table 8. Net Crop Income and Production Inputs With Project (continued)

Crop	Fertilizer Urea (t)	Cost (mTk)	TSP (t)	Cost (mTk)	MP (t)	Cost (mTk)	Pest-icides (kg)	Cost (mTk)	Irrig. (mTk)	Total Cost (mTk)	Crop Income (mTk)
B.Aus	43	0.20	24	0.13	0	0.00	0	0.00	0.0	4.2	3.2
M. Aus & Aman											
B.Aman	10	0.05	0	0.00	0	0.00	0	0.00	0.0	0.9	0.9
T.Aman (L)	293	1.34	163	0.88	98	0.40	0	0.00	0.0	19.3	40.5
T.Aman (H)	256	1.17	136	0.73	60	0.24	301	0.15	2.3	14.0	18.4
T.D.Aman	191	0.88	0	0.00	0	0.00	0	0.00	0.0	12.1	14.6
Boro(H)	1446	6.62	723	3.90	394	1.60	4602	2.32	32.9	99.9	105.0
Boro (L)											
Jute	120	0.55	75	0.41	60	0.24	0	0.00	0.0	11.9	23.6
Wheat	168	0.77	78	0.42	56	0.23	0	0.00	0.7	8.3	7.4
Potato	56	0.26	28	0.15	20	0.08	320	0.16	0.3	8.2	9.2
Sugarcane	61	0.28	51	0.27	35	0.14	0	0.00	1.5	10.3	10.2
Oilseeds	117	0.54	78	0.42	39	0.16	0	0.00	0.8	5.0	9.9
Pulses	0	0.00	0	0.00	0	0.00	0	0.00	0.3	1.6	6.2
Vegetables	12	0.05	5	0.03	3	0.01	50	0.03	0.4	1.5	1.7
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Total	2774	12.70	1361	7.35	766	3.10	5273	2.66	39.2	197.2	250.7
Incremental	278	1.27	230	1.24	143	0.58	381	0.19	2.4	17.8	72.3

* Paddy only.

Table 9. Estimated Annual Fishery Losses (tonnes)

		----No Decline w/project----				---- Decline w/project ----		
Year	Period	w/o Proj.	with Proj.	Loss	PV of Loss @ 12%	with Proj.	Loss	PV of Loss @ 12%
1992	0	380	219	161	161	219	161	161
1993	1	369	219	150	134	213	156	140
1994	2	359	219	140	112	207	152	121
1995	3	349	219	130	92	201	148	105
1996	4	339	219	120	76	195	144	91
1997	5	330	219	111	63	190	140	79
1998	6	320	219	101	51	185	136	69
1999	7	311	219	92	42	179	132	60
2000	8	303	219	84	34	174	128	52
2001	9	294	219	75	27	169	125	45
2002	10	286	219	67	21	165	121	39
2003	11	278	219	59	17	160	118	34
2004	12	270	219	51	13	156	114	29
2005	13	262	219	43	10	151	111	25
2006	14	255	219	36	7	147	108	22
2007	15	248	219	29	5	143	105	19
2008	16	241	219	22	4	139	102	17
2009	17	234	219	15	2	135	99	14
2010	18	227	219	8	1	131	96	13
2011	19	221	219	2	0	127	94	11
2012	20	215	219	-4	-0	124	91	9
				Total	873		Total	1156
		Annual Value @ 12%			117	Annual Value @ 12%		155

Note: Historical annual rate of decline = 2.81%

Table 10. Estimated Annual Increases in Culture Fishery (tonnes)

Year	Period	w/o Proj.	with Proj.	Incr.	PV of Incr. @ 12%
1992	0	49	49	0	0
1993	1	50	50	0	0
1994	2	50	50	0	0
1995	3	51	51	0	0
1996	4	52	56	4	3
1997	5	53	62	9	5
1998	6	54	68	15	7
1999	7	54	75	21	9
2000	8	55	82	27	11
2001	9	56	82	26	9
2002	10	57	82	25	8
2003	11	58	82	24	7
2004	12	59	82	23	6
2005	13	59	82	23	5
2006	14	60	82	22	4
2007	15	61	82	21	4
2008	16	62	82	20	3
2009	17	63	82	19	3
2010	18	64	82	18	2
2011	19	65	82	17	2
2012	20	66	82	16	2
				Total	91
		Annual Value @ 12%			12

Table 11. CPP: Computation of Present Value (PV) and Annual Value (AV) of Benefits and Costs (Taka mill, 1991 Financial Prices)

Year	Period	Project Cost[*1]	PV12% 1996	Fish Loss	PV12% 1996	Agric. Ben.	PV12% 1996	Cult. Fish	PV12% 1996	Agric. Hired Labor	PV12% 1996	Proj. Labor	PV12% 1996
1993	0	152.9	152.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.1	39.1
1994	1	233.3	208.3	0.0	0.0	61.5	54.9	0.0	0.0	5.4	4.8	82.2	73.4
1995	2	92.5	73.7	0.0	0.0	65.1	51.9	0.0	0.0	5.9	4.7	34.4	27.4
1996	3	.18.7	13.3	8.1	5.7	66.5	47.3	0.0	0.0	6.0	4.3	9.9	7.0
1997	4	18.7	11.9	7.8	5.0	68.7	43.7	0.2	0.1	6.2	3.9	9.9	6.3
1998	5	18.7	10.6	7.6	4.3	70.1	39.8	0.4	0.2	6.3	3.6	9.9	5.6
1999	6	18.7	9.5	7.4	3.7	72.3	36.6	0.6	0.3	6.5	3.3	9.9	5.0
2000	7	18.7	8.5	7.2	3.2	72.3	32.7	0.8	0.4	6.5	2.9	9.9	4.5
2001	8	18.7	7.6	7.0	2.8	72.3	29.2	1.1	0.4	6.5	2.6	9.9	4.0
2002	9	18.7	6.7	6.8	2.4	72.3	26.1	1.0	0.4	6.5	2.3	9.9	3.6
2003	10	18.7	6.0	6.6	2.1	72.3	23.3	1.0	0.3	6.5	2.1	9.9	3.2
2004	11	18.7	5.4	6.4	1.8	72.3	20.8	1.0	0.3	6.5	1.9	9.9	2.8
2005	12	18.7	4.8	6.2	1.6	72.3	18.6	0.9	0.2	6.5	1.7	9.9	2.5
2006	13	18.7	4.3	6.1	1.4	72.3	16.6	0.9	0.2	6.5	1.5	9.9	2.3
2007	14	18.7	3.8	5.9	1.2	72.3	14.8	0.9	0.2	6.5	1.3	9.9	2.0
2008	15	18.7	3.4	5.7	1.0	72.3	13.2	0.8	0.2	6.5	1.2	9.9	1.8
2009	16	18.7	3.1	5.6	0.9	72.3	11.8	0.8	0.1	6.5	1.1	9.9	1.6
2010	17	18.7	2.7	5.4	0.8	72.3	10.5	0.8	0.1	6.5	0.9	9.9	1.4
2011	18	18.7	2.4	5.2	0.7	72.3	9.4	0.7	0.1	6.5	0.8	9.9	1.3
2012	19	18.7	2.2	5.1	0.6	72.3	8.4	0.7	0.1	6.5	0.8	9.9	1.1
2013	20	18.7	1.9	5.0	0.5	72.3	7.5	0.6	0.1	6.5	0.7	9.9	1.0
2014	21	18.7	1.7	4.8	0.4	72.3	6.7	0.6	0.1	6.5	0.6	9.9	0.9
2015	22	18.7	1.5	4.7	0.4	72.3	6.0	0.6	0.0	6.5	0.5	9.9	0.8
2016	23	18.7	1.4	4.6	0.3	72.3	5.3	0.5	0.0	6.5	0.5	9.9	0.7
2017	24	18.7	1.2	4.4	0.3	72.3	4.8	0.5	0.0	6.5	0.4	9.9	0.7
2018	25	18.7	1.1	4.3	0.3	72.3	4.3	0.4	0.0	6.5	0.4	9.9	0.6
2019	26	18.7	1.0	4.2	0.2	72.3	3.8	0.4	0.0	6.5	0.3	9.9	0.5
2020	27	18.7	0.9	4.1	0.2	72.3	3.4	0.4	0.0	6.5	0.3	9.9	0.5
2021	28	18.7	0.8	3.9	0.2	72.3	3.0	0.3	0.0	6.5	0.3	9.9	0.4
2022	29	18.7	0.7	3.8	0.1	72.3	2.7	0.3	0.0	6.5	0.2	9.9	0.4
2023	30	18.7	0.6	3.7	0.1	72.3	2.4	0.2	0.0	6.5	0.2	9.9	0.3
2024	31	18.7	0.6	3.6	0.1	72.3	2.2	0.2	0.0	6.5	0.2	9.9	0.3
2025	32	18.7	0.5	3.5	0.1	72.3	1.9	0.1	0.0	6.5	0.2	9.9	0.3
PV @ 12% in 1993			555.0		42.7		563.4		3.9		50.5		203.5
AV @ 12%, 1993 - 2025			68.2		5.3		69.3		0.5		6.2		25.0

*1 Includes investment, O&M, land acquisition, production foregone, and non-structural intervention.

Source: Costs are from the MIWDFC, Compartmentalization Pilot Project (FAP 20), Tangail CPP Interim Report, Annex 6, Tables 6 and 7, p.51, September, 1992.