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Government of the People's Republic of Bangladesh
Ministry of Water Resources
Bangladesh Water Development Board
Water Resources Planning Organization

COMPARTMENTALIZATION PILOT PROJECT TANGAIL



FINAL REPORT

Annex G-Flood Mitigation Benefits
Annex H-Women in Development
Annex I-Environmental Issues

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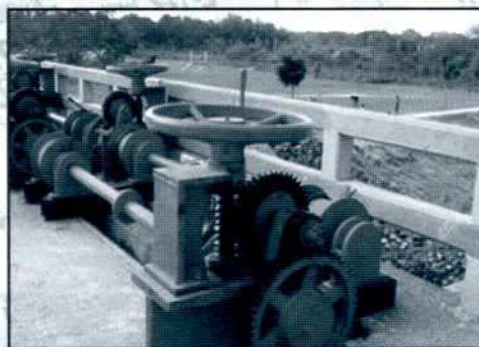
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Acronyms and Abbreviations

AA	-	Adjacent Area
AARC	-	Adjacent Area Represent Committee
ADAB	-	Association of Development Agencies in Bangladesh
ADB	-	Asian Development Bank
ADP	-	Annual Development Plan
AEP	-	Agriculture Extension Program
AEZ	-	Agro- Ecological Zone
AIT	-	Asian Institute of Technology
ARC/INFO	-	GIS Software program
ASSP	-	Agricultural Support Services Project
ATAP	-	Annual Technical Assistance Program
BADC	-	Bangladesh Agricultural Development Corporation
BAE	-	Bilateral Associate Expert (GoN)
BAFRU	-	Bangladesh Aquaculture and Fisheries Resources Unit
BARI	-	Bangladesh Agricultural Research Institute
BARD	-	Bangladesh Academy for Rural Development
BBS	-	Bangladesh Bureau of Statistics
BCAS	-	Bangladesh Center for Advanced Studies
B/C ratio	-	Benefit/Cost ratio
BELA	-	Bangladesh Environmental Lawyers Association
BFRSS	-	Bangladesh Fisheries Resources Survey System
BKB	-	Bangladesh Krishi Bank
BLE	-	Bangladesh Left Embankment
BM	-	Bench Mark
BMD	-	Bangladesh Meteorological Department
BMDC	-	Bangladesh Management Development Centre
BPIS	-	Buried Pipe Irrigation System
BR	-	Bangladesh Rice
BRAC	-	Bangladesh Rural Advancement Committee
BRDB	-	Bangladesh Rural Development Board
BRE	-	Bangladesh Right Embankment
BS	-	Block Supervisor
BSS	-	Bittahin Samabay Samity (Landless Cooperative Society)
BURO	-	Bangladesh Unemployment Rehabilitation Organization
BUET	-	Bangladesh University of Engineering & Technology
BWDB	-	Bangladesh Water Development Board
BWFMS	-	Bangladesh Water and Flood Management Strategy
CA	-	Command Area
CARE	-	Co-operative for American Relief Everywhere
CC	-	Chawk Committee
CDS	-	Controlled Drainage Structure
CE	-	Chief Engineer
CFD	-	Controlled Flooding & Drainage
ChWMC	-	Chawk Water Management Committee
CMG	-	Canal Maintenance Group

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CPP	-	Compartmentalization Pilot Project
CPPSC	-	Compartmentalization Pilot Project Steering Committee
CPT	-	Core Planning Team
CT	-	Consultants Team
CWMC	-	Compartment Water Management Committee
CWM forum	-	Compartment Forum
DAE	-	Department of Agricultural Extension
DC	-	Deputy Commissioner
DEM	-	Digital Elevation Model
DFO	-	District Fishery Officer
DGIS	-	Directoraat Generaal Internationale Samenwerking
DFL	-	Dutch Guilders
DHI	-	Danish Hydraulic Institute
DLAC	-	District Land Acquisition Committee
DoF	-	Department of Fisheries
DPHE	-	Department of Public Health Engineering
DS (WL)	-	Downstream Water Level
DSS	-	Departmental Social Services
DTC	-	District Technical Committee (Agriculture)
DTW	-	Deep Tube Well
DWA	-	Deep Water Aman
DWTA	-	Deep Water Transplanted Aman
EAD	-	Expected Annual Damage
EC	-	Executive Committee
EIA	-	Environmental Impact Assessment
EIRR	-	Economic Internal Rate of Return
EMG	-	Embankment Maintenance Group
EMP	-	Environmental Management Planning
EPT	-	Extended Project Team (CPP)
FA	-	Financial Assistance
FAP	-	Flood Action Plan
FAP 19	-	Geographic Information System FAP
FAP 20	-	Compartmentalization Pilot Project FAP
FAP 25	-	Flood Modeling and Management FAP
FAO	-	Food and Agricultural Organization
FCD	-	Flood Control and Drainage
FCD/I	-	Flood Control, Drainage and Irrigation
FDAM	-	Flood Damage Assessment Modeling
FFW	-	Food for Works
FMM	-	Flood Management Model
FPCO	-	Flood Plan Co-ordination Organization (merged with WARPO)
FRG	-	Federal Republic of Germany
FRI	-	Fisheries Research Institute
FTG	-	Farmers Testing Group
FWMM	-	Flood and Water Management Model

FY	-	Financial year
GB	-	Grameen Bank
GDI	-	Gender related Development Index
GIS	-	Geographical Information System
GHK	-	Consultants Group
GoB	-	Government of Bangladesh
GoN	-	Government of Netherlands
GPA	-	Guidelines for Project Assessment (FPCO 1992)
GPC	-	Gated Pipe Culvert
GPI	-	Gated Pipe Inlet
GPS	-	Global Positioning System
GPV	-	Gross Product Value
GO	-	Government Organization
ha	-	Hectares
HD model	-	Hydrodynamic Model
HDI	-	Human Development Index
hh	-	Household
HTW	-	Hand Tube well
HYV	-	High Yielding Variety
ICDDR'B	-	International Center for Diarrhoeal Disease Research, Bangladesh
ICID	-	International Commission on Irrigation and Drainage
ICWMC	-	Initial Compartmental Water Management Committee
ID	-	Institutional Development
IDC	-	Information Dissemination Center
IDP	-	Institutional Development. Promoter
IOV	-	Inspectie Onderzoek Ter Velde (DGIS- M&E unit)/ Operations Review Unit (Ministry of Foreign Affairs GoN)
IPM	-	Integrated Pest Management
ISPAN	-	Irrigation Support Project for Asia and the Near East
IWRM	-	Integrated Water Resources Management
JrE	-	Junior Engineer
JMBA	-	Jamuna Multipurpose Bridge Authority
JWME	-	Junior Water Management Engineer
KfW	-	Kreditanstalt für Wiederaufbau
KJDRP	-	Khulna Jessore Drainage Rehabilitation Project
KSS	-	Krishak Samabaya Samity
LCS	-	Landless Contracting Society
LGED	-	Local Government Engineering Department
LFP	-	Lohajang Flood Plain
LLP	-	Low Lift Pump
Lps	-	Liters per second
LUS	-	Land Use Survey
LV	-	Local Variety
MAEP	-	Mymensingh Aquaculture Agriculture Extension Programme (GoB)
MARC	-	Multi - Action Research Center
MBSS	-	Mohila Bittahin Samabay Samity (Women's Landless Cooperative Society)



ME	-	Mechanical Engineering Department, BWDB
M&E	-	Monitoring & Evaluation
MDF	-	Management Development Foundation, Netherlands
MDSCS	-	Multi- disciplinary Sub- compartmental Survey (CPP)
meq	-	Milliequivalent
MIKE II	-	Name of Modeling Program
MIWDFC	-	Ministry of Irrigation, Water Development and Flood Control
MoU	-	Memorandum of Understanding
MOT	-	Manually Operated Tubewell
MP	-	Muriate of Potash
MPO	-	Master Plan Organization (now WARPO)
m+ PWD	-	Meter plus Public Works Department
MT	-	Metric Tons
MV	-	Modern Variety
MoWR	-	Ministry of Water Resources (formerly MIWDFGC)
NAA	-	Northern Adjacent Area
NACOM	-	NGO
NAM	-	Rainfall -runoff module of MIKE II
NAS	-	Needs Assessment Survey
NAI	-	Needs Assessment Intervention
NCA	-	Net Cultivable Area
NCRS	-	North Central Regional Study
NGO	-	Non-Government Organization
NPV	-	Net Present Value
NWMP	-	National Water Management Plan
NWP	-	National Water Policy
NWRS	-	North West Regional Study
ODA	-	Overseas Development Agency
O&M	-	Operation and Maintenance
OFR	-	On- Farm Research
OFRD	-	On-Farm Research and Demonstration
OFTD	-	On-Farm, Testing and Demonstration
OFTR	-	On- Farm Testing and Research
OM	-	Organic Matter
P	-	Phosphorus
PAP	-	Project Affected Person
PC	-	Project Council
PD	-	Project Director
pH	-	Hydrogen-ion concentration
PoE	-	Panel of Experts (FPCO)
PPG	-	Peoples Participation Guidelines
PPM	-	Parts per Million
pm	-	Person month
PRA	-	Participatory Rural Appraisal
PSA	-	Production System Analysis

PT	-	Project Team
PWD	-	Public Works Department
RASDO	-	Rural Agricultural Social Development Organization
R&H	-	Roads and Highways
RF	-	Resident Facilitator
RNE	-	Royal Netherlands Embassy
RRA	-	Rapid Rural Appraisal
SATU	-	Social Advancement through Unity
SC	-	Sub-Compartment
SCF	-	Standard Conversion Factor
SCWMC	-	Sub-Compartment Water Management Committee
SDE	-	Sub-Divisional Engineer
SFS	-	Social Forestry System
SIDO	-	Sr. Institutional Development Officer
SIR	-	Sirajganj Interim Report
SIRDP	-	Sirajganj Integrated Rural Development Project
SMG	-	Structure Maintenance Group (CPP/PAP)
SO	-	Section Officer
SRDI	-	Soil Resources Development Institute
SSS	-	Senior Scientific Officer/ Society for Social Services
SRP	-	Systems Rehabilitation Project
SUS	-	Samaj Unnayan Sangstha
STW	-	Shallow Tube Well
SWMC	-	Surface Water Modeling Center
TAPP	-	Technical Assistance Project Proforma
TA	-	Technical Assistance
T- Aman	-	Transplanted Aman
TARD	-	Technical Assistance for Rural Development (NGO)
TC	-	Technical Committee (MWR, GoB)
TCM	-	Tangail Compartmental Model
TIR	-	Tangail Interim Report
Tk	-	Taka
TL	-	Team Leader
TN	-	Technical Note
TNO	-	Thana Nirbahi Officer
ToR	-	Terms of Reference
TSP	-	Triple Super Phosphate
UNDP	-	United Nations Development Program
UNICEF	-	United Nations International Children's Emergency Fund
UP	-	Union Parishad
UPOMA	-	NGO
UST	-	Unnayan Shahajogi Team
WARPO	-	Water Resources Planning Organization
WB	-	World Bank
WCS	-	Water Control Structure

WFP	-	World Food Program
WID	-	Women in Development
WME	-	Water Management Engineer
WMC	-	Water Management Committee
WP	-	Working Paper
WUG	-	Water Users Group
XEN	-	Executive Engineer (CPP)
XO	-	Extension Overseer
Zn	-	Zinc

Glossary

<i>Aman</i>	A group of photoperiod-sensitive rice planted in May-August and harvested in November-December.
<i>Aus</i>	Photoperiod-insensitive paddy varieties grown with irrigation from December -February
<i>Baor</i>	Oxbow lake, natural depression usually formed by the change of course of rivers
<i>Bazar</i>	Market place
<i>Beel</i>	Small lake, low-lying depression, a permanent body of water in a floodplain or a body of water created by rains or floods.
<i>Bidi</i>	Local Cigarette
<i>Bigha</i>	Unit of land (1/3 of an Acre)
<i>Boro</i>	A group of photoperiod-insensitive and fairly cold tolerant rice varieties transplanted in December-February and harvested in April-May.
<i>Borrowpit</i>	Excavated small and seasonal water bodies present mainly along the public roads.
<i>Catch Assessment</i>	Determining the daily catch of the fishermen
<i>Catch per unit</i>	Quantity of fish caught by the fishermen in unit time and effort (Fishing equipment)
<i>Chamara</i>	Important deep water <i>Aman</i> variety
<i>Chari in the Bari</i>	A ditch on the homestead
<i>Chawk</i>	A readily recognizable manageable field unit bounded by village roads and settlement areas. These are physical entities and are easily recognized by village people. Each chawk has water inlet or outlet through bridges, culverts, road breaches etc.
<i>Chula</i>	Home made furnace
<i>Cluster</i>	A group of sub-compartments, which are merged together for management reasons. Their hydrological features resemble an independent status.
<i>Compartment</i>	A (semi) protected area or part thereof in which effective water management particularly through controlled flooding and controlled drainage, is made possible through structural and institutional arrangements. A compartment will be sub-divided into Sub-Compartments and operational Water Management Unit.
<i>Crore</i>	100 lakh
<i>Cusec</i>	Discharge unit: 1 cusec equals 28 liters per second
<i>Decimal</i>	Unit of area measurement, 40 m ²
<i>Deshi Jute</i>	White jute (<i>Corchorus capsularis</i>) varieties, tolerant to standing water.
<i>Dhaincha</i>	An erect leguminous species (<i>Sesbania sesban</i>), used for green manure and fencing
<i>Doon</i>	Traditional water lifting device
<i>Dopa</i>	Lowest land type according to farmers' classification
<i>DW Aman</i>	Deep water <i>Aman</i> , a rice variety
<i>Frame Survey</i>	A survey for estimating the number of fishermen or gears.
<i>Hat</i>	Weekly market
<i>Hijoldigha</i>	Important deep water <i>Aman</i> variety
<i>IPM</i>	Integrated Pest Management, a balanced combination of pest control measures, including biological, mechanical and chemical methods, based on observations of population levels of pests and predators, economic thresholds and scoring.

<i>Jalmahal</i>	A leased water body or river stretch.
<i>Khal</i>	A natural channels.
<i>Kharif</i>	Crop season from March-October (Kharif-I: March-June, Kharif-II: July-October)
<i>Khash land</i>	Land owned by the government
<i>Kutcha</i>	Unlined earthen channel
<i>Lakh</i>	100.000
<i>Madrasha</i>	Islamic School
<i>Mastan</i>	Muscle man/thug
<i>Mohalla</i>	Urban village
<i>Multi-criteria analysis</i>	An analysis and display of the impacts of proposed structural and non-structural works in which a wide range of criteria is used, such as social, environmental and economic. Impacts can be quantified in financial terms or may be evaluated using a scale from -5 to +5. Those items that cannot even be rated on such a scale are dealt with in a descriptive way.
<i>Pagar</i>	Small water body
<i>Palam</i>	Homestead land
<i>Patchot</i>	Intermediate land type according to farmers' classification
<i>PA-Matrix</i>	A relational matrix, depicting links between participants and activities in a certain process.
<i>Parishad</i>	Council
<i>Perching</i>	Placement of branched sticks (perches) in crop land as resting place for insect-eating birds.
<i>Pourshava</i>	Town council
<i>Pucca</i>	Lined earthen channel
<i>Rabi</i>	Crop season (November-February)
<i>Rapid Rural Appraisal</i>	A systematic, but semi-structured activity carried out in the field by a multi-disciplinary team and designed to quickly acquire information. Bacterial processes of separating jute fiber in standing or slows running water.
<i>Retting</i>	Bacterial processes of separating jute fiber in standing or slows running water.
<i>Salish</i>	Traditional informal village court which mitigate the disputes of the vilagers. The traditional village Matabbars (Chieftains) are the judges.
<i>Sub-Compartment</i>	A sub-unit of a compartment, in which to a certain extent the water management can be controlled by the people living in the area represented in a Water Committee. The sub-compartment is mostly separated from the adjoining ones by embankments or roads and provided with (semi) cotrolled structures.
<i>T. Aman</i>	Transplanted Aman, a rice variety.
<i>Tan</i>	Highest land type according to farmers' classification.
<i>Thana (previously Upazila)</i>	Local administrative unit. Each Thana is composed of 10-15 Unions.
<i>Tossa Jute</i>	Jute (<i>Corchorus olitorius</i>) varities, grown in the highest land types, not tolerant to standing water.
<i>Union</i>	Smallest electoral unit of areas outside municipalities comprising several mouzas (or villages), and generally divided into three wards. It has a Union Parishad (Council). Local administrative unit. Each Thana is composed of 10-15 Unions.

Annex G
Flood Mitigation Benefits



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Introduction

The Compartmentalization Pilot Project (CPP), Tangail, is primarily aimed at developing water management systems for agricultural production through the control of floodwater. Since its inception in 1992, there has been substantial investment in CPP. As of mid 1998, re-excavation of 129 kilometers of khals and resectioning of 68 kilometers of embankments have been undertaken. Besides, regulators, bridges/culverts and drainage system have been constructed. Over and above, there were about 50 kilometers of peripheral embankments constructed during early 1970s. All these are aimed at reduction of crop losses. Nevertheless, the CPP interventions have potentially generated benefits to non-agricultural sectors such as residential houses, business, industries, offices and roads sector.

There has been little research on methods of flood loss assessment to urban and nonagricultural sectors in Bangladesh. Constructed within the framework of the Flood Action Plan, FPCO Guidelines (FPCO 1992) have concentrated on the evaluation methods of agricultural protection schemes that are principally aimed at reducing potential crop losses. The guidelines, however, recommended that non-agricultural benefits be included in economic analysis, without spelling out any assessment methods/principles whatsoever of how to assess the non-agricultural damages (e.g. to residential and commercial sectors). It is suggested that direct loss data (e.g., to embankments and roads) be collected from secondary sources such as relevant Ministries/Agencies (e.g., MRR, BWDB) prepared in the form of reports. A careful scrutiny has been stressed to reconcile inconsistencies and inaccuracies in such data.

Following fast urbanization within the CPP area, especially the expansion of Tangail Town, potential non-agricultural and urban flood losses in general are becoming increasingly important. It is of importance for this pilot study, therefore, that the non-agricultural benefits generated by the CPP interventions be assessed in order to facilitate the evaluation of the project more comprehensively.

Against this background, the major objective of the flood loss study is to obtain an estimate of the total non-agricultural benefits of protection derived from CPP.

More specifically, the objectives are the following:

- Determine flood frequencies (return periods) applying to CPP compartments through linking those directly to the water levels in the Lohajang river (i.e., readings at Jugini and other measuring stations) based on past flood experience,
- Assess potential damage for CPP compartments (including the core town) for floods of different magnitudes, assuming a "without project" situation by concentrating on non-agricultural damages,



- Assess benefit assessments (or Expected Annual Damage - EAD), due to the project, for the CPP area, as a whole and Tangail town, in particular, and
- Construct stage-damage (benefit) curves for various economic sectors for the CPP area,

The study deals with tangible damage, direct and indirect. The following five broad sectors, which are viewed as comprising the main economic loss sectors in the nonagricultural economy of CPP, have been considered for the investigation:

- Residential houses
- Business (Trading)
- Industries
- Office & Public buildings
- Roads

Since there are often overlaps between office and public buildings, the two subsectors have been grouped under one category.

Besides accumulating a knowledge base of the magnitude of property damage in the CPP area, the study also aims to reveal and categorize various non-agricultural impacts of flooding. This may be used as a guide for evaluation purposes in future through taking into consideration the non-agricultural losses that can be averted in even agricultural protections - the aspect of which has often largely been ignored.

The Tangail urban and the CPP localities are considerably flood prone areas. Therefore, the knowledge base of the vulnerability of various non-agricultural sectors may eventually be used in policy formulation in land use and other regulations, which is expected to contribute towards a better policies in relation to floodplain management in the Tangail CPP and similar other interventions. The knowledge base is also expected to help explore possibilities of proposals similar to CPP interventions elsewhere in the country.

Flood Damage Modeling to Non-Agricultural Sectors

Types of Flood Impact

Flood research is principally centered on flood damages. Flood damages are direct and indirect. Direct damages are physical and usually visible losses arising out of direct contact with water (e.g., damages to house structure). Indirect impacts are the consequences of direct contact of property with water and are revealed through interruption and disruption of economic and social activities (e.g., production losses due to e.g., direct losses to machinery). Indirect effects can involve effects in the both short and long run. Indirect impacts, together with the direct ones, may result in a further chain of effects over time, called linkage effects.

In yet another perspective - from the viewpoint of economic values - flood impacts are recognized as belonging broadly to two further categories: tangible and intangible. The tangible impacts are those to which a monetary value can be assigned in order to estimate them. Intangible impacts are defined as those that cannot directly be evaluated in terms of money.

Existing Assessment Methods - Advanced Countries Perspectives

Research on flood impacts and their modeling has been carried out in a few advanced countries. The major contributing countries are the USA, UK and Australia. In the USA, the collection of flood damage information has been in practice as far back as 1902. In the UK, the practice started only in the late 1960s. Nevertheless, these countries started using these data for appraisal of flood alleviation schemes comparatively recently.

Residential Sector

Broadly, two approaches are adopted in flood loss assessments and construction of standard damage data sets: surveys of actual floods and the synthetic approach. While the first approach involves damage assessments during or after the actual events, the second approach involves synthesizing damage information from multiple secondary sources, through constructing susceptibility matrices for different damage components on various hypothetical flood scenarios.

In the USA, various federal agencies carry out rapid assessments of flood loss potential (so called windshield surveys) from an examination of the external appearance of the affected residential buildings. Flood loss potentials for future floods are assessed, or rather projected based on actual events, which are used mainly for appraisals of flood control projects at regional levels.



The synthetic method of flood damage assessment is now being adopted in the USA. The method involved generation of synthetic damage data in response to specific requirements of the federal flood insurance administration, through developing depth-damage curves based on direct damages to residences, grouped according to aspects such as number of rooms, stories and construction materials. The susceptibilities at each hypothetical depth for each house type are estimated from different sources, such as relevant builders and manufacturers. These curves formed the basis of estimating potential damages to different groups of residences, which are then generalized to similar residences in other areas of USA.

In the UK, the assessment of potential flood damages based directly upon actual events was found impracticable for many reasons. The major reasons related to the scarcity of observable floods over various depths or duration and a large number of house types occupied by a large number of socio-economic groups. Consequently, the synthetic approach was adopted for the assessment of residential flood loss potential. They adopted the synthetic approach in constructing nationally applicable standard data sets at various depths and duration.

Commercial Sectors

Research on flood losses in commercial sectors is centered on indirect losses, as assessment methods for direct losses are relatively straightforward. Hitherto, only a limited number of studies have been carried out on commercial flood losses in advanced countries, let alone elsewhere. Research on indirect losses is particularly meager. The approach of predicting industrial flood loss potentials for future floods on the basis of actual events used to suffer from many estimation biases, such as those arising out of the tendency to use replacement cost rather than depreciated costs. The use of crude ratios between direct losses and production disruptions were also highly rudimentary.

Later, some studies in Australia and USA found it methodologically difficult to obtain the relationship of production losses (indirect loss) with depths of flooding of past events. The studies also recognized that firms' financial losses should be distinguished from national economic losses. It was also recognized that the best measure of indirect loss is value added on production lost. Additionally, production transfers within the economy need to be incorporated to obtain true estimate of indirect loss.

Thus, given that indirect losses are highly variable due to different flood conditions and diversity in commercial activities, it was almost impossible to appropriately standardize commercial losses, both direct and indirect. Hence, the British researchers developed interview techniques in the loss assessment of commercial sectors. The fundamental method involved deriving damage estimates in hypothetical floods, based upon expert judgements through interviewing industrial managers. It was thus possible to overcome many problems associated with the approaches used in past research. The methodology distinguished national economic losses from firms' financial losses, through incorporating production transfers within economy. It also addressed the problem of over-estimation of direct loss potential through incorporating average remaining values.

As for linkage effects of flooding or multiplier effects, research has been far more limited. Conventionally, benefit-cost analysis takes account of national economic losses, and it is argued that multiplier effects are likely to be counterbalancing in many economies. The assessment of flood damages, which is *sine qua non* to flood protection appraisal methods, has long been a formidable task. For the economic analysis of any floodplain management, the single most essential figure is the estimate of Expected Annual Damage (EAD).

Flood damage assessments involve two principal techniques: synthetic techniques and stage-damage curves through surveys of actual floods. The generation of data sets at disaggregated levels of depths and duration is often not feasible mainly because of the lack of adequate variations of depth and duration in a specific flood in a given area. Stable depth-damage curves are difficult to establish in these circumstances. The most serious problem is that actual damages do not reflect potential damage because of the varied extent of damage-reducing measures undertaken by flood plain users.

With regard to standard data set construction, the damage data arithmetically averaged from actual flood damages can rarely be consistent with various depths and duration. The actual damages do not reflect the potential damage in that there are varied extent of damage-reducing measures among floodplain users. Hence, actual damages are not expected to portray close relationships with flood variables such as depths and duration. Besides, the damage data sets are inconsistent because of the large variations in damages and a highly skewed distribution over depths and duration.

This dictates the need to adopt a different approach that involves predicting damages through establishing functional relationships with flood variables. The approach, which has been termed as regression approach appears to be particularly useful for the refinement of data at disaggregated levels of depths and duration.

Flood Loss Research in Bangladesh

In Bangladesh, especially in non-agricultural sectors, there has been no attempt to systematically collect flood damage data. There exists little basic research on flood losses and their assessment methods, in either urban or non-agricultural losses. Flood research has almost been limited to only appraisals or evaluation studies in the form of reports, which focus largely on agricultural losses.

FAP-Project Assessment Guidelines

There exist a number of documents in the form of guidelines on appraisal methods and economic analyses for FCD/I projects in Bangladesh. These are, among others, FPCO Guidelines for Project Assessment (1991a; 1992e); Shahabuddin and Rahman (1992); MPO Investment Analysis Model (1991); and GoB-Republic of France's Pre-feasibility Study for Flood Control in Bangladesh (1989).

FPCO Guidelines (1991a; 1992e) are designed for the principles to be used in economic and financial analysis of investment projects under the Flood Action Plan. The guidelines are largely concerned with appraisal methods of agricultural protection, but concentrating on various costs, such as economic prices of commodities and conversion factors. Although non-agricultural damages are recommended for inclusion in the economic analysis, almost no guidelines on methods of loss assessments, let alone on non-agricultural losses, are covered in any of the guidelines. On the other hand, flood loss potentials (direct and indirect, on various non-agricultural sectors) are enormous, which are expected to further increase with the growth of the economy in the years to come in Bangladesh. Without spelling out any assessment methods/principles whatsoever of how to assess the non-agricultural damages the guidelines recommended that the direct damage (e.g. to embankments and roads) be included in the economic analysis. It has been suggested that direct loss data be collected available from secondary sources such as relevant Ministries/Agencies, in the form of reports. A careful scrutiny, however, is stressed to reconcile inconsistencies and inaccuracies in such data. It has also been suggested that the damages caused due to economic and social interruptions of activities are difficult to assess and should not be included in the analysis.

The document, GoB-Republic of France (1989) (Pre-feasibility Study for Flood Control in Bangladesh) suggests that although Bangladesh is generally well furnished with statistical information and documentation, the information with regard to flood damages (on particularly non-agricultural sectors) are incomplete, inconsistent, and partially incorrect. Hence, the study suggests that flood damages are collected from various reports prepared by various agencies, who generally maintain the damage records in physical, but not in monetary terms (e.g. number of people affected, houses damaged). It has been recommended to use best possible guesses from damage records of past floods, in appraising flood protection projects.

Hence, few guidelines on methods of loss assessments, let alone for urban and non-agricultural losses, are covered in any of the guidelines.

FAP-Urban Protection Studies

In the recent past, a number of feasibility studies for town protection has been carried out (FPCO, FAP-8A 1991b; FPCO, FAP-8B 1991c; FPCO, FAP-9A 1992f; BWDB, FAP9B 1992; GOB-UNDP, 1992). Because of different primary objectives, the studies adopted varied methodologies in the assessment of protection benefits.

In general, the methodologies on loss assessments (i.e., benefits of protection) adopted by the studies appear to have suffered from serious weaknesses.

Most studies have sought damage information from records of past floods. An important limitation is that, in none of the studies, potential loss data sets by depths or duration, by sectors or sub-sectors are constructed. No land use survey by subsectors (commercial activities) or by house types (residential sector), or any hydrological survey to determine vulnerability of individual properties is carried out. The studies use only limited land use information, collected largely from secondary sources. On the other hand, the information on land levels and heights of properties are crucial to the precision of flood protection benefits. In addition, flood loss estimates are very sensitive to small changes in flood levels of properties. The benefit assessment without any knowledge of the extent of inundation (in terms of depths or duration) caused to various types of properties by a range of floods has certainly led to gross errors.

Following the lack of standard potential loss data sets in Bangladesh, the study FAP-8A has sought linear relationships of damage ratios (to values) with depths and duration for 1987 and 1988 flood, which appears not to be logical. However, a linear function is likely to be unsuitable in that it yields damages even for a zero depth or duration of flooding. Additionally, in such a function the possibility of satiation of damages in varying depths or duration is ignored. More importantly, unless any groupings to properties under investigation by homogeneity are carried out, no stable relationships are likely to exist, as there exists a great diversity in their type, stock, capital and thus damage dimension across various properties. In the commercial plants, for example, enormous variations are manifested, at times a few hundred times, across various types of enterprises.

Almost all the studies use flat rates (fixed ratios) to assess damages to properties regardless of type and size of properties in each of the sectors. One of the most serious limitations relates to that the studies have not distinguished actual event damages from potential damages. The actual damages (which is indeed a part of the

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full potential damage), either in absolute or proportional terms, are not suitable to exhibit functional relationships with depths and duration, as there exists varied extent of damage reduction measures adopted by various flood plain occupants. The studies generally have not properly distinguished, if at all, between financial and economic losses to properties. Another limitation is that the studies generally have not incorporated average remaining values while estimating flood damages. This is associated with substantial over-estimation of damages.

The income loss in households and profit loss in commercial enterprises is not the true reflection of indirect flood damages. The production loss in industries amounts to the loss to value added, and the turnover loss in business amounts to the loss to gross margin. Additionally, the income losses in households and profit loss in commercial enterprises have every potentials of being double counted.

In estimating indirect losses, no consistent methodology is followed. A serious limitation is that output recoveries, trade adjustments and the transfer of losses have not been accounted for in the studies. In industrial/business enterprises, damage to machinery/equipment and inventories are pooled together, and flat rates for the sectors as a whole are used, which is subject to significant errors as machinery and stock have completely different susceptibility to inundation.

The FAP 9-A study considers mainly structural damage, represented by fixed ratios, irrespective of any size and type of properties. Nevertheless, the variations of susceptibilities and damages, both within and among groups of properties are enormous. Similarly, flood damages are significantly different (at times many-fold) among different socio-economic class of households and size and scale of commercial enterprises. The use of flat rates across all properties (commercial - across business and industries, households - across all socio-economic groups) inevitably leads to a considerable over-estimate of benefits. For example, damage ratio for a low-cost house type is many-fold compared to that for a high-cost house. The most serious limitation of the methodology adopted in the studies relates to the use of average depths or duration of inundation by zone/area, which inevitably leads to serious errors in the benefit assessment.

In the absence of any information on land levels and property heights, and hence any knowledge of the extent of inundation caused to various types of properties by a range of floods, the benefit assessment is certainly associated with gross estimation errors. This is more so following that in Bangladesh small differences in flood levels

can be significant in terms of area and properties affected and damages caused.

What this implies is that the FAP studies have not adequately dealt with benefits of protection due to non-agricultural sectors. The studies appear to have not been based on sound and consistent methodologies and damage data, in consequence of which the benefit assessment appears to have been subject to considerable errors.

The current study has taken into account of the points discussed above while estimating the benefits of protection due to the CPP. Thus, the study can be used as a guide to facilitate appraising both agricultural and urban protection in Bangladesh more comprehensively in future.

Methodology

Existing Flood Loss Models

Three basic loss models have been in use for regional loss modeling having potential uses in project appraisals:

- Regional econometric model,
- Unit-loss models,
- Input-output (I-O) models.

All of these models have generally found applications in earthquake and flood loss modeling. However, the regional econometric models and the input-output models are largely used in earthquake impact modeling, whereas the unit-loss model is used mainly in flood loss modeling.

Regional Econometric Model

The regional econometric model, developed by Ellson et al (1983), uses housing stock damages estimated in terms of housing units destroyed, and then assesses losses by comparing regional econometric activities with, and without, an event through multivariate analysis. Almost invariably, the model uses I-O tables to determine the effects on the total economy by adjusting the outputs of the affected sectors. The most important limitation of the econometric model is that it can not easily model losses caused by floods of various magnitudes, so that frequency analysis is difficult to be performed in assessing expected annual benefits of protection.

Input-output models, in combination with econometric models, are used for modeling impacts through inter-relationships among industrial sectors in an economy. The impact of a primary fall in output in industries upon the economy is assessed through this model. The model is based on input-output tables, national or regional. In essence, the model is not used to assess primary impacts, but used to assess the knock-on effects (multiplier effects) of primary impacts.

Unit Loss Models

Initially developed by the American researchers, the unit loss model was later adopted by researchers in the UK and Australia. The model involves, first, identifying flood prone properties according to their land uses, and estimating individual property levels and floor heights. Through an interactive computational model, the model then employs standard potential depth-damage data and frequency analysis of flood levels, to estimate the total flood damage potentials in the area under study for floods of various magnitudes. The model has recently received widespread use in appraising flood alleviation schemes both within and outside UK.



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Islam (1997) has recently introduced the model (with some modifications) in Bangladesh and the current study is centered on this model.

The principal advantage of the unit-loss model over the regional econometric model is that it can provide fine-level estimates for damages, disaggregated over spatial and sectoral properties unit by unit. More importantly, the model is capable of separating impacts by types, flood levels and frequencies - even when flood level and frequency differences are small. The model is thus capable of appraising benefits for a range of flood protection standards, a feature, which is inconceivable by any other models. The model has limitations. The most important limitation is that the model is inappropriate to be applied to large-scale floods or wider regions. The model is demanding in terms of resources, time and data, particularly in respect of high quality hydraulic and hydrological information, the information that most regions often lack.

Appraisal Process for the CPP Area

The unit-loss appraisal model aims at assessing expected annual damage (or the benefits of protection) involves four basic components:

- Potential depth-damage data sets,
- Land use of properties,
- Level and floor heights of properties,
- Damage-frequency analysis.

Principles of Flood Damage Assessment

This CPP study has adopted some methods that exists in the developed countries, modified some of them and developed some new methods, suiting flood and socioeconomic conditions in Bangladesh. The study has generated some standard potential depth-damage and duration-damage data sets for business, houses, industries, roads and institutions.

Assessment of Physical Damage

Depending upon varied extent of susceptibilities, the physical damage (or direct damage) components may be grouped into

- Building structure,
- Machinery/equipment (including furniture and fittings),
- Stock of inventory (for households) or stock of input and output (for commercial units).

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Following the assumption that the direct damage to building involves floors and walls the components that are exposed to direct contact of floodwater, the study considers structural damages to include those to floors and walls. It is assumed that flood damage is the cost of returning the relevant property to pre-flood conditions, through either repair or replacement of damaged items. While using replacement values, care is taken so that average remaining values are accounted for. The value of damages to buildings or inventories thus amounts to total involvement comprising:

- Repair works if already undertaken
- Replacement works if already undertaken
- The remaining damage

Direct damages are defined to be the physical and visible - losses arising out of direct contact with water. Indirect impacts are the consequences of this direct contact of properties with water. Indirect impacts, together with the direct ones, may result in a further chain of effects over time, called linkage effects.

In this study, five broad damage components in the commercial sector are distinguished:

- Structural damage
- Machinery and Equipment damage
- Stock damage
- Production/turnover (primary indirect) loss
- Linkage effects

Assessment of Production Loss

In this study, the production loss in industries amounts to the loss to value added, and the turnover loss in trade amounts to the loss to gross margin. Value added is defined to be the gross output minus industrial costs while gross margin is defined to be the gross sales minus purchase costs. Enterprises both within and beyond the compartment may be disrupted by flooding. For industries, the principles set out here are for the assessment of losses to flooded enterprises. For industrial and business enterprises, apart from the flooded units, the losses due to business disruption of nonflooded units through economic linkages are also assessed. Total output/turnover losses are estimated as the sum of losses caused during complete closure and that caused during partial closure. The losses caused during complete and partial closures amount to that of the normal output/turnover had there been no floods. Ideally, the losses are to be estimated, net of recoveries, if any, during the period. The additional

costs of working less efficiently, if any, are also to be added to estimate the firms total output/turnover loss.

Based on these principles, the following flood loss estimation formulae are used to assess production loss. The formulae are used to estimate net losses in output/turnover, but the ultimate loss to a firm, as already mentioned, is the loss to value added/gross margin.

Formulae

1. PRODUCTION LOSS DURING COMPLETE CLOSURE (TK):

$$PDCCLOSE = (CCLOSE * OUT/30).$$
2. PRODUCTION DURING PARTIAL CLOSURE (TK):

$$PDPCLOSE = (PCLOSE * OUT/30) * AVPROD/100.$$
3. PRODUCTION LOSS DURING PARTIAL CLOSURE (TK):

$$PDPCLOSS = (PCLOSE * OUT/30) * (1 - AVPROD/100).$$
4. TOTAL PROD LOSS DURING COMPLETE & PARTIAL CLOSURE(TK):

$$TOPDLOSS = (PDCCLOSE + PDPCLOSS).$$
5. PRODUCTION LOSS MADE UP (TK):

$$PDMAKUP = (TOPDLOSS * MADEUP/100).$$
6. TOTAL NET PRODUCTION LOSS (TK):

$$NTPDLOSS = TOPDLOSS - (PDMAKUP - ADCOST).$$

Where,

CCLOSE	= COMPLETELY CLOSED DUE TO FLOOD (DAYS)
OUT	= MONTHLY OUTPUT (TK)
PCLOSE	= PARTIALLY CLOSED DUE TO FLOOD (DAYS)
AVPROD	= AVERAGE PRODUCTION DURING PARTIAL CLOSURE (%)
MADEUP	= % OF LOST PRODUCTION RECOVERED
ADCOST	= ADDITIONAL COST INCURRED FOR RECOVERY

Principles of Modeling Multiplier Effects

For flood-affected industrial units, linkage effects are estimated through use of standard data on multipliers. Briefly, the input-output models are used to assess linkage effects of flooding. Given that the national input-output table is now updated for 1993/94 (BIDS, 1998), multipliers are updated for the assessment of linkage effects

of flooding. The national table updated for 1993/94 partitioned the national economy into 79 production sectors. The 79 sectors of the economy are rearranged and consolidated by incorporating 101 sample industrial units (in 5 broad activity groups) under investigation. Having performed the rearrangement, thus, the input-output table has been condensed into 55 economic sectors and the output multipliers for the five industry groups are estimated. In this study, linkage effects refer to backward linkages.

The linkage effects are defined to be $L = (MLT - 1)$, where L = Linkage effects and MLT = Multipliers. The new multipliers for backward linkages constructed are as follows:

Industry type	Output multipliers
1: Food and Agro-based	2.64723
2: Cotton and textiles	3.17292
3: Timber & furniture	3.01505
4: Engineering & electrical	2.84874
5: Miscellaneous & service	2.48899

Conventionally, benefit-cost analysis takes into account of national economic losses, and it has been argued by many researchers that multiplier effects are likely to be counterbalancing in many economies. Hence, the study has not ultimately estimated and included the linkage effects in the estimate of total benefit assessment in the CPP. However, one can add up, if desired, the linkage effects in the total benefits using the above estimates of multipliers.

House Structure and Type in the CPP Area

The major sector either in urban or rural areas of CPP is the residential sector. Houses in Bangladesh and construction materials used are significantly different from those in advanced countries, where most flood loss research has taken place. An important characteristic of houses in advanced economies is that houses have basement floors or cellars. In contrast, the Bangladesh houses have no such basement floors. Overwhelmingly large proportions of houses in the country, as a whole, are kutcha,¹ vast majorities of which are squatters and illegal settlers. Small proportions of houses in the country are pucca². Unlike elsewhere or in advanced countries, floor materials used in Bangladesh are almost invariably made of cements and bricks (in case of pucca houses) or mud (in case of kutcha ones). There are very few, if any houses which use wood or similar items in building their floors.

¹ Kutcha refers to a house type, having both wall and roof materials made of simply straw and bamboo; according to BBS (1991), about 45 per cent of the houses in the country represent this type (as of 1990).

² Pucca refers to a house type, made of rod, cement and concrete (RCC). This type of house constitutes 16 per cent of the total houses in urban areas (BBS 1991).

Houses having planned layouts are rare; other than for pucca and raised buildings, houses hardly require any formal layouts to undergo construction. In fact, there are barely any building regulations controlling the constructions of kutchha and semi-pucca houses. Houses in Bangladesh are not located in a systematic manner, which as will be seen later, poses difficulties in conducting land use, land level and height survey. As no house has any basements, potentially there are hardly any damaging effects below floor levels. One other basic difference is that the houses in Bangladesh are plastered both outside and inside. The use of wallpapers is rare; instead, they are coated with lime or paint.

Four main materials used in the house construction in Bangladesh are bamboo, corrugated iron (CI) sheet, mud and brick. Timbers are used in all the types of houses, but mainly in doors, windows and wall/roof frames. Following the assumption that the direct damage to houses involves mainly floors and walls - the components which are exposed to direct contact of flood water - houses in Bangladesh can conveniently be distinguished according to type of walls and floors (irrespective of roof materials used). Theoretically, there can at least be eight major material combinations, with brick, CI sheet, mud and straw (thatched), which are as follows:

Type	Floor	Wall
B-B*	Brick	Brick
B-C*	Brick	C I sheet
B-M	Brick	Mud
B-T	Brick	Thatched
M-B	Mud	Brick
M-C*	Mud	C I sheet
M-M	Mud	Mud
M-T*	Mud	Thatched

The field survey indicates that four types (under asterisk *) of houses exist in the CPP. This is also largely true for Bangladesh, as a whole. The house type M-M (mud floor and mud wall) is rare in the study area. In fact, the categorization of houses into only four types has turned out as one major advantage in the construction of average damage data sets in the residential sector. This also suggests the feasibility of the damage data construction from surveys of actual floods.

Since house roofs are not usually directly exposed to flood water, these are not taken into account while classifying the houses. The study, thus, contemplated the above mentioned four types of houses in the CPP area.

Urban and Rural Characteristics of the CPP Area and Use of Standard Damage Data Sets

The area under CPP can broadly be divided into two categories. One is that associated with urban characteristics, which consists of the sub-compartment 16 (SC 16), comprising the Tangail core town. The other, which is located in the periphery having relatively rural characteristics, consists of the sub-compartments 1 through 15. In this study, analysis is carried out separately for these two broad locations, Area 1 and Area 2. Information for sub-compartments 1 through 15 is amalgamated. Thus, hereafter Area 1 refers to SC 16 and Area 2 refers to SC 1 through 15.

Table 1 presents information on aspects such as income, floor space and value of properties in urban areas (Area 1: SC 16) and in rural areas (Area 2: SC 1 through 15). It is evident that the properties in two locations are significantly different in terms of, say, household income, contents and value of properties.

Values shown in 1998-99 prices (000 Taka)				
Area/Value	Brick (floor) brick (wall) -BB	Brick (floor) CI sheet (wall) BC	Mud (floor) CI sheet (wall) -MC	Mud (floor) thatched (wall) -MT
Area 1: SC 16				
Value of building	203	136	81	19
Floor height (cm)	33	27	25	24
G floor space (sq m)	59	56	46	25
Value inventories	202	140	99	31
Annual income	152	103	95	52
Area 2: SC 1-15				
Value of building	150	120	65	7
Floor height (cm)	51	51	50	46
G floor space (sq m)	-	-	-	-
Value inventories	70	40	20	12
Annual income	120	100	80	40
Table 1: Characteristics and categorization of house types in CPP Areas				

The classification of house types with property values and occupants income shows that the four broad types of houses are occupied by four distinctly different socioeconomic classes of occupants, in terms of value of structures and inventories, household income and even floor space.

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The standard flood loss data sets produced in Islam (1997) concern properties largely in Tangail town. Thus, the data sets are not truly applicable for the benefit assessment in rural areas. It is founded that flood losses are positively and closely related to value of properties. In other words, flood losses, other things remaining the same, will be less in case of less valuable properties, either to structure or inventories or machinery. Hence, the residential standard damage data sets for urban areas have been appropriately adjusted according to ratios to urban to rural value of properties (by components of structure and inventories, for example) for its application in Area 2 (SC 1 through 15).

For use in rural locations, an attempt was made to construct standard loss data sets for units such as handlooms, the type of units which exist in large numbers in such locations as, as already indicated, there are considerable variations in capital, stock and output among various units across urban and rural areas. In a bid to increase precision, the handloom units for even urban areas have been segregated from the sub-sector 2 (Cotton and textiles) as a separate category; thus separate loss data sets for handlooms have been constructed for use in the loss assessment of industrial sector in Area 1 and Area 2.

Populations and Households in the CPP Area

The CPP areas are situated in four Thanas, Tangail Sadar, Delduar, Basail and Kalihati. The number of villages, households and populations under the CPP area by its 16 compartments are presented in Table 2.

According to the 1991 census, the total number of households in the CPP is estimated to be more than 48 thousands with a total population of more than 263 thousand. The number of villages/mouzas is 269 in 12 unions (including one Pourashava), with a considerable number of overlaps of villages in more than one compartment. The current number of properties in Area 1 and Area 2 added together are estimated as 62,485, including residential houses of 52,743 and commercial premises of 9,742. Although it is difficult to estimate the exact number of residential households because of overlaps due to the dual use of premises for both commercial and residential purpose. The growth rate of households in the CPP area based on the above figure estimates as 1 per cent per annum during a period between the 1991 census and the current survey (in late 1999).

Meaning of Potential Loss

Inevitably, the hazard prone occupants often take some measures or actions to

protect their properties before, during or after the event. The term potential damage is often used to denote the total likely damage. In the UK or USA, for example, potential damages usually include the total likely damages, which could have occurred had the victims not adopted any measures to avoid this.

Sub-compartment	No of villages (including Mouzas & Mohallas)*			No. of Households			No. of Population			Area (ha)	
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Gross	Cultivable
01	5	-	5	941	-	941	6060	-	6060	247	191
02	9	-	9	2988	-	2988	1686	-	16867	544	438
03	11	-	11	2269	-	2269	14136	-	14136	1116	931
04	15	4	19	1668	1697	3365	8364	8967	17331	805	579
05	10	2	12	1069	1159	2228	5855	6868	12723	369	262
06	16	1	17	2002	332	2334	10934	1987	12921	669	523
07	14	2	16	1606	246	1852	8740	1408	10148	796	670
08	9	4	13	930	1159	2089	4971	6538	11509	779	642
09	10	-	10	1002	-	1002	5440	-	5440	403	289
10	24	-	24	2306	-	2306	12146	-	12146	876	682
11	16	9	25	2317	1968	4285	12247	11361	23608	1168	831
12	10	4	14	2191	1019	3210	12027	5319	17346	1037	815
13	7	-	7	989	-	989	6031	-	6031	457	332
14	16	6	22	2491	1150	3641	13208	5879	19087	1186	863
15	17	-	17	2920	-	2920	15570	-	15570	767	550
16	-	23	23	-	8105	8105	-	42744	42744	619	156
LFP	12	13	25	1142	2366	3508	6396	12985	19381	1362	1009
Grand total	201	68	269	28831	19201	48032	143811	104056	263048	13200	9763

Table 2: Population and household by sub-compartments

In this analysis, however, the term "potential" is used in a different way. In Bangladesh, much of inventories or stock or even machinery are saved from flood losses through some measures without incurring considerable costs, if any at all. Hence, in this analysis, damages avoided through such measures/activities have been taken into account to estimate the ultimate flood loss. In commercial sectors, recovery has already been incorporated while assessing production losses (indirect damage) in the construction of standard loss data sets.

Assumptions Related to Damages Avoided through Loss-Saving Measures

The following assumptions in relation to damages avoided through loss saving

measures have been adopted in the adjustment of the loss data sets³ :

Damages avoided to	Percentage saved
(a) Structure for residential house	10
(b) Inventories for households	54
(c) Structure for business/industries	10
(d) Inventories/stock for business/industries	80
(e) Machinery for business/industries	80
(f) Production loss for business/industries (to region)	36
(g) Production loss for business/industries (to region)	25

Updating Standard Flood Loss Data Sets

As already mentioned, the study uses the average damage data sets for various sectors of the economy constructed by Islam (1997), as an input into the unit-loss model to subsequently estimate the expected benefits of flood protection in the CPP area. The data sets are available separately for sectors and various damage components, for eight depths and two durations. The damage data sets available for 1992/93 price were updated for 1998/99 prices through use of appropriate deflators. The deflators for 1998/99 have been estimated by semi-logarithmic trend analysis from historical price index data. The price index of building materials is used for damage to structure; national income deflator is used for other damages, including stock and machinery damage.

Land Use and Level Survey

A detailed land use, land level and height survey was undertaken for existing individual properties in each of the 16 compartments within the Tangail CPP area. The survey was carried out in accordance with a pre-designed checklist.

Survey Methodology

The CPP areas are situated in four Thanas, Tangail Sadar, Delduar, Basail and Kalihati. The highest proportion of the CPP lies under the Tangail Sadar (82.5%), followed by Delduar (14%), Basail (3%) and Kalihati (0.5%). The CPP area with its 16 compartments has a total gross area of approximately 132 square kilometers. The number of villages under the CPP area is 269, including overlaps of some villages in more than one compartments. As already mentioned, the total number of households in the CPP is estimated to be more than 48 thousands with a total population of more than 263 thousands (Table 2). In other words, there are about 100 thousand

³The assumptions are taken on the experiences of 1998 flood (See Islam 1997).

residential houses, assuming an average of two houses per household. Over and above, there are industries, business, offices and public buildings situated in 16 compartments in four Thanas.

Tangail is a secondary town. There are no large industries. Most industries are small or medium units, at best. Industries in Area 2 are largely traditional handloom units with other types of industries rare. Business units in Area 2 are also largely petty traders mostly located in village markets. Office and public buildings in Area 1 include government and non-governmental offices, clinics and educational institutions while those in Area 2 mostly include religious institutions (such as mosques having few inventories) and a few educational institutions.

Given time and resource constraints, it was not possible to carry out a complete census of all the properties with regard to land use and level. Therefore, approximately one-fourth of the households in each of the villages in each compartment, SC 1 through SC 15, was covered in the field survey. The number of households in each compartment was determined with probability proportional to size. The investigation covered houses, industries, business, office and public buildings and roads.

The survey was conducted on properties in 269 villages/mouzas/wards across compartments in accordance with a pre-designed check list, incorporating basic information, such as location, road name (by which properties were situated), land use type, construction type, ground level and floor heights of properties. Only the ground floor properties were recorded. Separate record sheets were used for the individual compartments.

Broadly, two different methodologies have been adopted for the land use, level and height survey for the two types of areas, Area 1 and Area 2.

Methodology for Area 1 (SC 16)

Since the area of SC 16 is relatively small and area wise concentration of properties in urban areas of SC 16 is high, all the properties in various sectors have been surveyed. First, the main roads were identified, by which the sub-roads and the properties were situated. The levels of the main roads were estimated through actual measurements. Because of the lack of appropriate maps, no grid references as to the location of the properties is possible. Instead, each of the main roads by which the properties were located has been identified as the references for the location of the

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individual properties. All the main roads (all of pucca type) have been coded separately. The sub-roads of the main roads, however, have not been coded.

The measurements relating to levels of sub-roads (in relation to main roads) and the ground levels of the properties (in relation to sub-roads) were made through mainly eye estimation. The floor heights of the properties (in relation to the ground levels) were also estimated mostly through eye estimation, although a few cases selected at random were crosschecked through actual measurements to give accuracy improvements.

The main roads and sub-roads (under each of the main roads) and subsequently the floor heights, having been related to the PWD Bench Mark, each of the properties were thus linked with the flood records of the Jugini gauging station.

Slope Factors - Water Surface Gradient for SC 16

Tangail town, situated in the young Jamuna floodplain, is in the north central region of Bangladesh. The Dhaleswari river (which originates from the Jamuna river), and its distributary, Lohajang (which passes through the town) is the main source of flooding in the compartment.

The flood level records are based on a single gauging station, which is not situated in the community, but about 13-Km upstream of the main town. The river surface normally has a significant downstream gradient. The properties located in the downstream are thus likely to have lower flood levels than those around the gauging station in the upstream. The level differences are likely to be lower if the flood gradient is steep (e.g. in the larger floods with higher intensities), and when the properties are irregularly spaced along the river valley. The interventions by depressions, canals, culverts, roads and embankments are also likely to contribute to the variations in water levels in the urban areas. This is likely to be prominent more in case of urban built-up areas like SC 16.

The Compartmentalization Pilot Project (CPP-Flood Action Plan 20) has estimated a mean difference in level, -33 cm, linking the water level (of monsoon 1991) of Jugini gauging station with one of the compartments (SC-16). The mean level difference, -75 cm, between Jugini gauging station with all the 15 compartments (excluding SC 16) estimated by CPP also appears to be inappropriate for the present purpose. The use of mean level difference for the purpose of damage assessment can be misleading in that it is quite likely that the 47 different roads will have completely different flood levels.

Sub-Compartment	Area (hectare)	% of area inundated by depths (meter)							
		Dry	-.30	-.60	-.90	-1.20	-1.5	-1.8	1.8+
SC 1	247	61.1	10.9	12.2	9.3	5.3	0.0	0.0	1.2
SC 2	544	21.3	18.9	24.5	20.2	15.1	0.0	0.0	0.0
SC 3	1120	11.5	8.3	20.8	31.8	22.6	3.5	1.5	0.0
SC 4	817	25.4	10.5	13.5	24.2	13.8	7.6	1.6	3.4
SC 5	375	1.0	12.0	25.3	28.3	20.8	9.6	1.9	1.1
SC 6	638	1.4	3.3	24.1	26.8	19.1	14.3	6.4	4.6
SC 7	798	19.0	3.9	12.8	22.3	18.1	11.3	5.6	7.0
SC 8	784	46.1	13.4	12.1	10.1	8.0	8.4	1.8	0.1
SC 9	403	34.3	8.9	14.9	18.6	8.2	4.2	2.5	8.4
SC 10	873	7.4	3.3	9.9	13.9	15.0	12.7	18.0	19.8
SC 11	1171	4.0	5.3	17.8	26.3	20.8	13.8	7.0	5.0
SC 12	1053	32.7	5.6	10.2	13.8	15.0	14.7	4.8	3.2
SC 13	475	35.4	14.1	19.4	13.3	10.1	6.5	0.6	0.6
SC 14	1195	17.2	10.5	23.3	20.3	10.4	8.7	2.8	6.8
SC 15	771	56.2	12.7	13.2	14.5	2.2	0.4	0.0	0.8
Sub-total	751	25.1	9.4	16.9	19.6	13.6	7.7	3.6	4.1
SC 16	670	13.4	19.0	56.4	9.4	0.8	0.5	0.2	0.5

Table 3: Inundation depth by sub-compartments (Pre-project situation): 2 year flood

Sub-Compartment	Area (hectare)	% of area inundated by depths (meter)							
		Dry	-.30	-.60	-.90	-1.20	-1.5	-1.8	1.8+
SC 1	248	50.4	17.7	12.9	10.5	6.5	0.8	0.0	1.2
SC 2	543	7.4	7.2	28.6	27.3	22.5	7.0	0.0	0.0
SC 3	1120	3.6	7.3	17.1	28.0	28.7	12.2	2.4	0.7
SC 4	818	22.0	9.8	14.8	20.4	16.1	9.9	3.1	3.9
SC 5	376	0.0	6.1	21.8	28.7	22.6	15.7	3.5	1.6
SC 6	637	0.0	1.6	10.8	31.7	22.3	15.4	12.4	5.8
SC 7	798	15.9	3.4	6.1	23.6	17.8	15.8	8.0	9.4
SC 8	783	41.3	14.7	12.4	11.8	6.8	10.5	2.2	0.3
SC 9	402	30.6	7.7	14.9	20.7	7.7	6.7	3.0	8.7
SC 10	873	6.8	2.6	11.6	14.9	14.1	14.9	14.6	20.5
SC 11	1171	2.1	4.2	20.6	27.4	20.6	13.1	6.7	5.3
SC 12	1052	32.2	4.5	9.4	12.6	14.2	15.5	5.4	6.2
SC 13	475	34.9	12.2	19.0	16.2	9.3	7.8	0.0	0.6
SC 14	1194	16.6	10.7	20.4	22.2	11.2	9.13	2.8	7.0
SC 15	771	42.2	16.6	14.9	19.5	4.8	1.2	0.0	0.8
Sub-total	751	20.4	8.4	15.7	21.0	15.0	10.4	4.3	4.8
SC 16	670	10.7	12.5	57.3	17.2	1.0	0.6	0.2	0.5

Table 4: Inundation depth by sub-compartments (Pre-project situation): 5 year flood

of inundation in the 1988 flood for each of the main roads are estimated from several observations at various points⁴. The flood marks (which were, at the time of survey, distinct on the house external walls) and discussions with the residents helped accomplish this. Having known the RLs of the individual roads from the physical measurements, the difference for each of the roads could be estimated through linking these with the 1988 flood level at the gauging station. Hence, let D_r be the mean 1988 flood depth of r -th road and R_r is its RL. Then gradient or the slope factor, S_r , of the r -th road is given by $S_r = L_j - (D_r + R_r)$, where L_j is the 1988 flood level at the Jugini gauging station. The average slope factor for the main roads in Tangail estimates as 1.02 meter, with a standard deviation of 0.38 meter and range 1.82-meter. The mean RL of the roads is estimated to be 11.35 m + PWD and the mean depth of flooding across all the roads is estimated to be 0.88 meter.

Methodology for Area 2 (SC 1 through 15)

In the Area 2 (SC 1 through 15) the survey was carried out on sampling basis, largely on proportionate (to households) basis, in the range of up to 50%, depending on locations. The overall percentage of properties surveyed is about 28%.

The area elevation data were supplied by the Flood Management Model of CPP. The inundation depth data (in percentage form, of area by sub-compartments) for various selected depths and selected floods of five return periods in pre-project situation were also supplied by the flood model. The inundation depth data (in percentage form) for five selected floods are shown in Tables 3 through 7.

The inundation depth data supplied by Flood Management Model (GIS Section) of CPP are based on some assumptions:

- Annual peak levels are considered for the frequency analysis
- 10-day average and duration are considered in the frequency analysis
- Full river and hydrological system has been taken into consideration.

The Flood Management Model of CPP has been calibrated and validated with recent years data. The model has been used to produce relevant inundation depth data for damage assessment. The model was adjusted to represent the pre-project condition. In the pre-project condition, there was peripheral embankment except few breaches. In the model, those breaches have been incorporated artificially.

One of the major flaws of the application of GIS data in the current study appears to be in that the individual property locations (grid reference) were not available so that

⁴It could be ideal, however, if for more than one flood, rather than only 1988 flood, could be included.

Sub-Compartment	Area (hectare)	% of area inundated by depths (meter)							
		Dry	-.30	-.60	-.90	-1.20	-1.5	-1.8	1.8+
SC 1	248	2.1	7.3	16.1	30.2	19.8	8.9	7.3	7.7
SC 2	544	0.0	0.0	0.4	7.7	26.1	28.5	21.7	15.6
SC 3	1120	0.1	0.5	2.1	6.4	21.4	20.9	18.9	29.7
SC 4	818	0.0	0.0	12.5	16.0	18.2	20.9	15.9	16.5
SC 5	376	0.1	0.0	10.6	26.6	25.5	22.6	11.4	3.2
SC 6	637	0.0	0.9	4.9	22.1	28.4	19.0	13.7	11.0
SC 7	799	7.5	3.8	5.9	16.4	26.0	16.5	12.0	11.9
SC 8	784	12.1	7.4	23.6	18.9	17.2	7.7	10.2	2.9
SC 9	403	26.3	8.2	12.4	15.4	15.4	9.4	2.2	10.7
SC 10	873	1.0	5.5	6.5	10.3	17.3	12.0	11.7	35.7
SC 11	1171	0.6	0.8	7.0	22.6	22.9	19.4	14.9	11.8
SC 12	1053	21.8	6.1	7.7	9.0	13.3	13.1	17.6	11.4
SC 13	476	16.9	8.0	10.3	24.2	18.9	11.6	7.4	2.7
SC 14	1193	7.6	3.6	7.6	19.7	23.1	16.3	8.4	13.7
SC 15	772	2.6	2.9	11.7	25.5	29.8	15.7	9.1	2.7
Sub-total	751	6.4	3.7	9.3	18.1	21.6	16.2	12.2	12.5
SC 16	669	0.0	1.8	15.8	58.6	20.5	2.1	0.5	0.7

Table 5: Inundation depth by sub-compartments (Pre-project situation): 10 year flood

Sub-Compartment	Area (hectare)	% of area inundated by depths (meter)							
		Dry	-.30	-.60	-.90	-1.20	-1.5	-1.8	1.8+
SC 1	247	0.1	0.0	0.8	2.0	13.8	15.0	37.3	31.2
SC 2	544	0.0	0.0	0.0	0.0	0.0	2.2	7.5	90.3
SC 3	1120	0.1	0.0	0.0	0.0	1.9	2.0	14.5	81.7
SC 4	817	0.0	0.0	0.0	0.0	4.9	17.1	14.8	63.2
SC 5	375	0.1	0.0	0.0	0.0	9.3	26.1	28.5	36.0
SC 6	636	0.0	0.0	0.0	1.6	6.1	23.0	28.0	41.4
SC 7	798	2.0	2.0	2.6	5.1	5.3	15.9	27.6	39.5
SC 8	783	1.9	3.6	6.6	12.8	21.6	18.3	16.0	19.2
SC 9	402	0.1	3.5	18.4	14.2	12.4	15.4	14.4	21.6
SC 10	873	0.0	0.0	0.1	5.5	5.8	9.6	16.2	62.8
SC 11	1171	2.0	0.2	0.6	1.1	10.0	22.5	22.1	43.5
SC 12	1053	2.1	5.3	16.0	8.3	8.1	9.2	12.5	38.5
SC 13	475	0.4	3.0	11.8	15.0	14.1	23.0	17.5	15.2
SC 14	1194	0.0	0.0	6.6	5.9	11.7	21.3	21.4	33.2
SC 15	771	0.0	0.0	1.7	1.3	4.7	15.3	35.7	41.4
Sub-total	751	0.6	1.2	4.3	4.8	8.6	15.7	20.9	43.9
SC 16	669	0.0	0.0	0.0	3.3	14.7	59.3	19.6	3.1

Table 6: Inundation depth by sub-compartments (Pre-project situation): 20 year flood

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Sub-Compartment ments	Area (hectare)	% of area inundated by depths (meter)							
		Dry	-.30	-.60	-.90	-1.20	-1.5	-1.8	1.8+
SC 1	247	0.0	0.0	0.0	0.4	2.0	13.0	15.4	69.2
SC 2	544	0.0	0.0	0.0	0.0	0.0	0.0	0.7	99.3
SC 3	1120	0.0	0.0	0.0	0.0	0.0	1.5	1.9	96.6
SC 4	817	0.0	0.0	0.0	0.0	0.0	1.0	17.5	81.5
SC 5	376	0.0	0.0	0.0	0.0	0.2	14.1	26.9	58.9
SC 6	537	0.0	0.0	0.0	3.5	9.7	13.8	30.8	42.2
SC 7	798	0.0	1.9	3.3	4.8	7.0	13.7	29.3	40.1
SC 8	783	0.4	2.7	6.5	9.8	22.9	19.4	16.5	21.8
SC 9	401	0.1	2.7	17.7	11.0	12.7	18.7	11.7	25.4
SC 10	873	0.0	0.0	0.4	6.4	4.7	14.9	13.9	59.7
SC 11	1172	0.1	0.2	0.3	1.0	13.8	21.1	18.0	45.7
SC 12	1053	0.0	0.5	6.2	16.9	7.7	7.3	10.9	50.5
SC 13	476	0.1	0.4	9.5	12.8	9.1	12.8	25.9	29.4
SC 14	1194	0.0	0.0	0.0	6.3	6.1	10.1	21.4	56.1
SC 15	772	0.0	0.0	0.0	1.8	1.3	5.8	16.0	75.1
Sub-total	751	0.1	0.6	2.9	5.0	6.5	11.2	16.9	56.8
SC 16	669	0.0	0.0	0.0	0.6	10.3	24.9	53.3	10.9

Table 7: Inundation depth by sub-compartments (Pre-project situation): 30 year flood

some broad assumptions had to be adopted. For example, it had to be assumed that the percentages of area inundation were the same as the percentages of spatial properties at risks in various compartments.

Land Use Code

One of the main aims of the land use survey is to classify the properties into classes for which depth-damage curves (depth-damage data sets) are available. Hence, a detailed coding system for various sectors under investigation has been devised. The land use survey has classified properties into the five major sectors:

- Residential
- Business
- Industry
- Office and public buildings
- Roads.

For the SC 16, each of the main roads by which the properties were located has been

identified as the references for the location of the individual properties. The main roads were coded separately.

The properties have been grouped according to types, as homogeneous as possible in terms of, among others, type and susceptibility of output and size of capital. Following the assumption that the direct damage to building involves floors and walls -the components which are exposed to direct contact of flood water, the residential properties (Sector 1), has been grouped into four broad categories according to major construction materials used: BB, BC, MC and MT (as explained in above). The business premises (Sector 2) have been coded according to seven broad groups. The industrial units (Sector 3) coded into five broad groups. Likewise, the office and public building sector (Sector 4) was coded in accordance with five broad groups.

Ground Level and Height Survey

Information on land level and height of properties is of key importance to the precision of flood damage assessments. However, the level and height information of properties are not available from any previous study of CPP (GIS). Following that detailed and recent contour maps showing contours of roads (by which properties are located) were lacking, a ground level and height survey was carried out, for both Area 1 and Area 2, which aimed at estimating the floor and ground heights of each property.

For the Area 1, the datum line for each of the roads (for connecting those with the flood levels at Jugini station) was estimated, from which the level of the individual properties at floor level were estimated and hence connected with flood records. Thus, the extent of inundation of each property was determined.

For the Area 2, as already explained, the inundation data (in percentage form, of compartments area) for various selected depths and floods were supplied by the CPP (GIS). From this, the level of inundation for the individual properties at floor level were estimated from ground level and floor height data generated from the survey.

Application of Standard Loss Data Sets

The study uses the average damage data sets for various sectors of the economy in CPP, as input into the unit-loss model to subsequently estimate the expected benefits of flood protection in the CPP area. Aspects relating to assumptions and conditions have been presented in Table 8.



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Sector/land use	Damage data used	Broad methods/assumptions
ALL SECTORS	Depth-damage data, except for roads sector, and for 'other' damage component in residential sector	Average group depth damage data are constructed for all sectors at 98/99 price, through regression methods; 2 & 5 yr flood use short duration data; 10, 20 & 30 yr flood use both short & long duration data, based on corresponding sample proportions in each category. Sample floor space used to estimate total floor space, except for office sector. Structural damages, for all sectors, assumed 10% damage avoided through reduction measures. Inventories/stock/machinery/equipment adjusted for damage-reduction activities.
1 Residential	Proportional depth-damage data : direct damage Per household damage data : 'other' direct damage	Average group proportional (to value) depth damage data (by individual damage components). Structural damage considers 'main structures', clean-up costs incorporated into structural damages. Other' damages (eg livestock, trees etc) not considered.
2 Business	Per sq metre depth-damage data : direct & indirect damage	Business group loss average data (by individual damage components) used. For indirect damage, regional damage incorporated. Linkage effects not contemplated, but multipliers constructed through use of national Input-Output Table.
3 Industries	Per sq metre depth-damage data : direct & indirect damage	Manufacturing group loss average data used by individual damage components. Industries-related services included in manufacturing; for indirect damage, damage to region incorporated. Linkage effects not estimated but multipliers constructed through use of national Input-Output Table.
4 Office	Per sq metre depth-damage data : direct damage	Office group loss average data (by individual damage component) used. Educational institutions, health and utility services included. In SC 1-15, public buildings include mostly religious institutions. Population floor space used.
5 Roads	Per km event-loss data : direct damage	Trend analysis method used; only pucca roads, under R & H Div and Pourasava authority contemplated. No assessment made for herring-bone and kutcha roads
Table 8: Flood loss data and assessment methods used in the estimation of non-agricultural flood damage in CPP Area		

Average group depth damage and duration-damage data for damage components for the sectors were constructed for 92/93 through regression methods (later converted to 98/99 price). The 2 & 5-yr. flood used short duration data; 10, 20 & 30 yr. flood used both short & long duration data.

The major sector either in urban or rural areas is the residential sector. For the residential sector, thus, in order to enhance precision the standard data for group loss average proportions (to values) have been used as there is large variations among

various properties across types and sizes, which is expected to minimize overestimation. For inventory damage in the residential sector or stock damage in the commercial (business/industries/office) no damage potentials were considered when these could be saved through measures such as raising, presumably without costs.

While inevitably sector loss data or per establishment loss data would be suitable for a desk-level appraisal, in order to increase precision, the present assessment has used per square meter group loss average data for business, industries, office and public building sectors. For the business and industries land use, total floor spaces have been estimated using the group sample means, while for the office and public buildings, population floor spaces obtained from the land use survey were used in the group and total damage assessment.

Structural damages, for all sectors, assumed a 10% damage avoided through reduction measures. Structural damage considered that for main structures. Clean-up costs were incorporated into structural damages. Other damages (e.g. livestock, trees etc) were not considered.

Inventories/stock/machinery/equipment damages were adjusted for damage-reduction activities. For indirect damage, regional damage incorporated. Tangail greater district has been considered as the region. Linkage effects were not contemplated, but multipliers constructed through use of recently updated national Input-Output Table. One can add up linkage effects to total benefits, through use of multipliers, if considered appropriate.

For roads, per km event-loss direct damage data generated from trend analysis method were used; only pucca roads, under R&H Div and Pourashava authority were contemplated. No assessment made for herringbone and kutchra roads. The study has dealt with tangible damage, direct and indirect.

Hydrological Survey, Frequency Analysis and Extent of Inundation in Pre-Project Situation

The fourth essential component of the benefit assessment is hydraulic and hydrological data. However, detailed level hydraulic and hydrological survey have not been contemplated; instead, the research concentrates on collecting information on flood levels.

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Because flood discharge data were not available, as already mentioned, flood level information was used in carrying out the frequency analysis. The information on flood levels was available from the Water Development Board (Tangail) and CPP for more than a 4-decade period up to 1998 (from 1949). The flood levels were available for the gauging station, Jugini, which is located at the mouth of the Lohajang river and connected with a fixed reference level (PWD Bench Mark).

Water levels at Jugini station (during 1949-1998) are presented in Table 9. Useful simulations were made by CPP (GIS) for different magnitude of floods and frequencies. Frequency analysis was carried out for the water levels of Lohajang river at Jugini station (Tables 10 and 11). As the inundation of the project area is influenced by not only the peak level but also the duration, two different frequency analyses using Gumble distribution were carried out, considering the peak level and 10-day average (maximum) level.

From the frequency analysis for the peak level, It is found that 1988 flood has a return period of 30 year (13.43 m+PWD) and 1998 flood has a return period of 27 year (13.39 m+PWD⁵). On the other hand, the analysis considering 10-day average maximum shows that 1988 has a frequency of 25 year and 1998 has a frequency of 18 year. It is interesting to note that from the peak level analysis, the 1995 flood and the 1966 flood has a frequency of 10 and 5 year respectively. From a 10-day average maximum level analysis the two floods has a frequency of nearly five and 7-year respectively. The simulation of the model shows more inundated area in 1966 than 1995. This is clearly because of the duration of the two floods.

Simulations were made for the flood frequencies 2, 5, 10, 20, 25 and 30 years. The 1988 flood was considered as a 30-year flood and 1998 was considered as a 25-year flood; the 1995 flood was considered as a 5-year flood.

The model simulations worked out the extent of inundated areas for various depths for different sub-compartments, which were subsequently used in the flood loss assessment for SC 1 through 15 (Table 3 through 7).

As evident from inundation data presented in these tables, the sub-compartments under CPP, largely, are flood prone areas. However, among the compartments SC 16 appears to be more vulnerable to flooding. In a 2 year flood, for example, about 75 per cent of the area under SC 1 through 15 are subject to flooding to varied depths while about 87 per cent of the area under SC 16 are at risk in a flood of the same return

⁵The return period for the 1988 flood in other parts of the country ranges up to 60 years.

Year	Water level (m+PWD)	Year	Water level (m+PWD)
1988	13.43	1991	12.40
1998	13.39	1956	12.32
1955	13.01	1996	12.40
1995	12.98	1973	12.30
1987	12.95	1993	12.26
1954	12.91	1969	12.24
1958	12.88	1953	12.23
1964	12.87	1977	12.22
1984	12.83	1952	12.20
1949	12.81	1971	12.13
1957	12.78	1972	12.04
1966	12.77	1946	12.01
1968	12.62	1990	11.96
1983	12.55	1997	11.96
1950	12.54	1975	11.83
1965	12.54	1992	11.80
1970	12.50	1981	11.78
1948	12.47	1986	11.75
1974	12.47	1989	11.62
1967	12.46	1976	11.61
1985	12.43	1978	11.45
1951	12.42	1994	11.22
1945	12.40		

Table 9: Water level at Jugini station during 1949-1998

Return period	Value in PWD	Representative year	Recorded water level (m+PWD)
2	12.29	1996	12.30
4	12.62	1968	12.62
6	12.80	1949	12.81
10	13.00	1955	13.01
27	13.28	1998	13.39
30	13.44	1988	13.43

Table 10: Frequency analysis of the water level at Jugini station (peak level)

Return period	Expected water level (m + PWD)
2.33	12.37
5	12.72
10	13.00
12	13.08
20	13.28
50	13.63
100	13.90

Table 11: Frequency analysis of annual maximum water level data at Jugini (using Gumbel distribution) 1945-1998

period. In a 10 year flood, about 95 per cent of the area under SC 1 through 15 are inundated while in the same flood type the whole of SC 16 are at the risk of inundation.

Benefit Assessment to Non-Agricultural Sector

The major theme of the study is the assessment of potential damage for CPP compartments (including the core town) for floods of different magnitudes, assuming a "without project" situation, vis-a-vis the benefit assessment derived from the CPP.

Results of the Land Use Survey

Number of Properties

As is evident from Table 12, residential properties account for about 84.4% of the total, followed by business units constituting about 7.4%, industries about 6.6% and office constituting 1.6% of the total properties.

Sub-Compartments	Number of properties Sectors				
	Residential	Business	Industry	Office	Total
SC 1	1258	15	69	25	1367
SC 2	4266	256	163	68	4753
SC 3	3756	56	106	35	3953
SC 4	4348	68	70	82	4568
SC 5	2975	80	124	64	3243
SC 6	2805	90	186	110	3191
SC 7	2565	126	120	31	2842
SC 8	1170	102	48	32	1352
SC 9	1175	117	142	26	1460
SC 10	3290	146	160	52	3648
SC 11	2840	122	228	56	3246
SC 12	3080	174	133	27	3414
SC 13	1268	64	100	12	1444
SC 14	3705	44	256	39	4044
SC 15	4715	201	626	57	5599
Sub-total	43216	1661	2531	716	48124
%	89.80	3.45	5.26	1.49	100.00
SC 16	9527	2980	1564	290	14361
Total	52743	4641	4095	1006	62485
%	84.41	7.43	6.55	1.61	100.00

Table 12: Total number of properties by major sectors by sub-compartments

Of this, Area 1, comprising the sub-compartment SC 16 and the Tangail town, has the highest number of properties, more than 14 thousands. In Area 1, residential properties account for about 66% of the total, followed by business units constituting about 21%, industries about 11% and office constituting 2% of the total properties.

Area 2, comprising rural areas of SC 1 through 15, has 48,124 properties. Residential properties in Area 2 account for about 90% of the total, followed by business units constituting about 3.5%, industries about 5.3% and office constituting 1.5% of the total properties. Of the 15 compartments in Area 2, SC 15 has the highest number of properties, 5,599 and the SC 8 has the lowest number of properties, 1,352. The other larger compartments, in terms of number of properties, are SC 2, SC 4 and SC 14 each having more than four thousand properties. The other relatively smaller compartments are SC 1, SC 13 and SC 9 each having less than two thousand properties.

Sub-Compartments	Number of units (household) House type				Total
	1	2	3	4	
SC 1	54	10	684	510	1258
SC 2	182	190	2372	1522	4266
SC 3	60	75	2139	1482	3756
SC 4	64	68	2324	1892	4348
SC 5	70	42	1596	1267	2975
SC 6	84	69	1491	1161	2805
SC 7	60	25	1305	1175	2565
SC 8	-	15	715	440	1170
SC 9	-	10	735	430	1175
SC 10	-	20	2180	1090	3290
SC 11	75	45	1465	1255	2840
SC 12	25	65	2230	760	3080
SC 13	12	20	844	392	1268
SC 14	20	45	2445	1195	3705
SC 15	100	55	2890	1670	4715
Sub-total	806	754	25415	16241	43216
%	1.87	1.74	58.81	37.58	100.00
SC 16	3423	2795	1455	1854	9527
%	35.93	29.33	15.27	19.47	100.00

Table 13: Total residential properties by house type by sub-compartments

Table 13 shows the distribution of residential houses by construction type. It is evident that in the urban location of Area 1, the houses of higher socio-economic classes, that is, BB (brick floor with brick wall) and BC (brick floor with CT sheet wall) categories constitute 36 and 29 per cent of the total residential properties respectively. The poorer construction type, MT (mud floor with thatched wall) and MC (mud floor with CI sheet wall) type are less common, 15 and 19 per cent respectively.

The distribution of properties over wards in Area 1 shows that Ward 2 has the highest properties, 38 per cent, followed by Ward 1 having 33 per cent of the properties. Ward 6 and Ward 5 have the least number of properties, seven and 2 per cent of the total properties respectively (Table 14).

Wards	Number of properties Sectors				
	Residential	Business	Industry	Office	Total
Ward 1	2352	1703	610	31	4696
(Central)					(32.7)
Ward 2	4329	635	379	117	5460
(Betka)					(38.0)
Ward 3	1270	84	41	80	1475
(Zila Sadar)					(10.3)
Ward 4	806	395	248	31	1480
(Dighalia)					(10.3)
Ward 5	230	4	37	3	274
(Santush)					(1.9)
Ward 6	540	159	249	28	976
(Kazipur)					(6.8)
Total	9527	2980	1564	290	14361
	(66.3)	(20.8)	(10.9)	(2.0)	(100.0)

Table 14: Number of properties by major sectors by ward : SC 16 Area

In Area 2, the poorer construction type, MT (mud floor with thatched wall) and MC (mud floor with CI sheet wall) type are the most common, 38 and 59 per cent of the total residential properties respectively. The least common is the BC (brick floor with CI sheet wall) and BB type, accounting for about 1.9 and 1.7 per cent respectively.

Ground Levels of Properties

As regards Ground Level (GL) of properties, the two areas, Area 1 (SC 1) and Area 2 (SC 1 through 15) are not comparable as GL of properties in Area 1 refers to that with respect to the level of main roads while those in Area 2 refers to that with respect to average elevation. Nevertheless, the ground levels of properties in Area 2, largely, appear to be higher as compared with those in Area 1.

In Area 2, the business units are estimated to have the highest GL, 1.94 meters, followed by the industrial units having 1.85 meters, the office units having 1.80 meters and residential units having the lowest GL, about 1.79 meters (Table 15). It appears

that the difference in GL of properties among various sectors is not significant.

Sub-Compartment	Ground level of properties (meters) by sectors			
	Residential	Business	Industry	Office
SC 1	1.40	1.53	1.40	1.48
SC 2	1.66	1.65	1.65	1.59
SC 3	1.53	1.50	1.54	1.49
SC 4	1.58	1.56	1.58	1.59
SC 5	1.59	1.53	1.59	1.58
SC 6	1.90	1.71	1.69	1.72
SC 7	1.84	1.93	1.88	1.71
SC 8	1.85	2.13	1.52	1.78
SC 9	2.95	2.13	2.84	3.05
SC 10	2.06	2.16	1.97	2.04
SC 11	2.26	2.27	2.31	2.46
SC 12	1.52	2.01	1.57	1.70
SC 13	1.79	1.72	1.76	1.66
SC 14	1.86	1.84	1.81	1.64
SC 15	1.75	1.88	1.80	1.77
Sub-total	1.79	1.94	1.85	1.80
SC 16	-0.25	0.02	-0.05	-0.24

Table 15: Ground level of properties with respect to average area elevation by sectors

Floor Heights of Properties

Table 16 presents floor heights of properties by sectors and compartments. It is evident that on average a residential house in urban location of Area 1 has a floor height of 29 centimeters. Within the residential sector, the poorer house types (MT and MC) have the lower floor heights, 26 and 20 centimeters respectively, while the richer house types (BC and BB) have the higher floor heights, 30 and 35 centimeters respectively (Table 17). Of all the sectors, the office and public building sector in Area 1 has the maximum floor height of 34 centimeters, and business units have the minimum, 19 centimeters. It appears that there is a significant association between floor heights and construction type within the residential sector in Area 1. The association between floor heights and the four sectors also appears to be significant.

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Sub-Compartments	Ground level of properties (meters) by sectors			
	Residential	Business	Industry	Office
SC 1	0.49	0.40	0.43	0.48
SC 2	0.46	0.34	0.35	0.51
SC 3	0.48	0.38	0.40	0.43
SC 4	0.49	0.41	0.39	0.46
SC 5	0.47	0.41	0.38	0.47
SC 6	0.47	0.52	0.46	0.50
SC 7	0.49	0.52	0.44	0.55
SC 8	0.56	0.59	0.46	0.53
SC 9	0.49	0.38	0.37	0.42
SC 10	0.58	0.44	0.41	0.52
SC 11	0.48	0.39	0.37	0.48
SC 12	0.59	0.39	0.65	0.56
SC 13	0.46	0.48	0.40	0.42
SC 14	0.45	0.41	0.40	0.41
SC 15	0.43	0.43	0.38	0.42
Sub-total	0.49	0.61	0.41	0.49
SC 16	0.29	0.19	0.20	0.34

Table 16: Floor heights of properties by sub-compartments by major sectors

Sub-Compartments	Floor heights (metres)				
	1	2	3	4	All
SC 1	0.51	0.50	0.51	0.46	0.49
SC 2	0.55	0.51	0.49	0.41	0.46
SC 3	0.51	0.49	0.49	0.46	0.48
SC 4	0.48	0.49	0.51	0.45	0.49
SC 5	0.51	0.52	0.47	0.45	0.47
SC 6	0.48	0.46	0.48	0.45	0.47
SC 7	0.42	0.60	0.49	0.49	0.49
SC 8	0.0	0.60	0.59	0.51	0.56
SC 9	0.0	0.40	0.50	0.47	0.49
SC 10	0.0	0.65	0.62	0.50	0.58
SC 11	0.62	0.55	0.50	0.45	0.48
SC 12	0.64	0.63	0.61	0.39	0.59
SC 13	0.42	0.50	0.47	0.44	0.46
SC 14	0.35	0.51	0.46	0.44	0.45
SC 15	0.42	0.36	0.43	0.43	0.43
Sub-total	0.51	0.51	0.50	0.46	0.49
SC 16	0.35	0.30	0.26	0.20	0.29

Table 17: Floor heights of houses by sub-compartments by house types

As in the case of ground levels, in Area 2 (SC 1 through 15), floor heights of properties in all the sectors are also much higher than those of Area 1 (Table 16). The residential sector in Area 2 has a floor height much higher than that (29 cm) in the Area 1, 49 centimeters. Unlike in the Area 1, there is no significant difference in floor heights between poorer and richer house types (Table 17). Of all the sectors in Area 2, the business units have the maximum floor height of 61 centimeters, and industrial units have the minimum, 41 centimeters. As in the Area 1, the association between floor heights and the four sectors appears to be significant.

Application of the Unit-loss Model and Results

The unit-loss appraisal model aims at assessing expected annual damage (or the benefits of protection). The group loss average potential data sets have been inputted into the unit-loss model to achieve estimates of total event and sector loss. Five hypothetical flood events were considered: 2, 5, 10, 20 and 30-year flood. However, in the assessment of the benefit of protection derived from the CPP, its standard of protection is assumed a 20-year flood.

The computations were performed by SPSS. This software package was used to estimate the number of properties, by type or group in each sector that are flooded by each depth and duration of flooding at each flood frequency. Through incorporating the group average depth-damage data sets for individual group and damage component, total damages for each flood events/sectors were assessed. The Expected Annual Damage (EAD), which is the area under the loss-probability curve, has been estimated separately for the Area 1 (SC 16) and Area 2 (SC 1 through 15) by FORTRAN program.

Vulnerability of Properties and SCs to Flood Events

Tables 18 and 19 show the percentage of properties flooded (at floor heights) by floods of various magnitudes in Area 1 (SC 16) by sectors and wards respectively. It appears that SC 16 (Tangail town) is a considerably flood prone area. It appears that in a 2 year flood, about 2.5% of all properties in SC 16 are inundated, followed by 17% in a 5 year, 49% in a 10 year, 79% in a 20 year and 88% in a 30 year flood. As regards the land uses, the residential properties appear to be relatively more vulnerable and the business sector appears to be relatively less vulnerable to flooding. The information on vulnerability of wards to flooding of various magnitudes in SC 16 is shown in Table 19. It appears that, in Area 1, Ward 6 is the most vulnerable and Ward 4 is the least vulnerable to a flood of frequency 30-year, for example.

Flood frequency	% of houses Type					% of units			
	1	2	3	4	All	Business	Industries	Office	All property
+2 year flood	1.8	2.6	5.4	6.1	3.4	0.1	1.3	2.4	2.5
5 year flood	13.4	11.3	21.6	24.4	18.6	8.6	18.7	18.3	16.5
10 year flood	49.9	54.6	60.9	59.0	54.7	33.2	45.3	35.5	48.8
20 year flood	84.3	86.5	85.4	86.7	85.6	64.3	71.8	67.9	79.3
30 year flood	92.8	93.9	93.9	93.9	93.5	75.8	79.5	76.2	88.0
No of	3423	2795	1455	1854	9527	2980	1564	290	14361
Properties %	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Table 18: Percentage of properties flooded by floods of various magnitudes Area: 1 (SC 16) (Pre-project situation)

All properties (residential / business / industrial / office units)							
Flood type	Ward 1	Ward 2	Ward 3	Ward 4	Ward 5	Ward 6	Total
2 year flood % at risk	0.6	2.1	12.8	0.9	0.0	1.3	2.5
5 year flood % at risk	7.8	15.7	51.7	9.2	10.6	23.4	16.5
10 year flood % at risk	36.5	53.5	75.4	44.6	43.8	49.5	48.8
20 year flood % at risk	76.1	81.8	89.2	64.5	73.7	90.1	79.3
30 year flood % at risk	89.3	89.9	91.3	67.6	88.7	96.7	88.0
Total no of properties	4696	5460	1475	1480	274	976	14361
%	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Table 19: Flood proneness of SC16 Area by wards (flooded above floor of properties) by floods of various magnitudes (Pre-project situation)

Tables 20 and 21 show the percentage of properties, flooded in Area 2 (SC 1 - 15) (at floor heights) by floods of various magnitudes, the former presented by land use and the latter by sub-compartments. It appears that the Area 2 of CPP is relatively less flood prone area, as compared to Area 1. It is evident that in a 2 year flood, about 2.9% of all the properties in Area 2 are subject to flooding, followed by 3.6% in a 5 year, 10.6% in a 10 year, 35.5% in a 20 year and 47.4% in a 30 year flood. As regards the land uses, the residential properties appear to be relatively less vulnerable and the office and public building sector appears to be relatively more vulnerable to flooding.

Flood frequency	% of houses flooded Type					% of units flooded			
	1	2	3	4	All	Business	Industries	Office	All property
2 year flood	2.0	2.4	2.9	2.9	2.9	2.5	3.1	2.9	2.9
5 year flood	2.7	3.4	3.6	9.7	3.6	3.6	3.6	3.8	3.6
10 year flood	9.7	12.5	10.5	28.5	10.7	10.0	9.3	10.3	10.6
20 year flood	38.5	43.4	35.4	36.0	35.8	32.2	32.4	35.9	35.5
30 year flood	55.1	58.2	47.3	48.0	47.9	40.6	43.4	45.8	47.4
No of	806	754	25415	16241	43216	1661	2531	716	48124
Properties	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Table 20: Properties flooded by floods of magnitudes various
requeencia 2: (SC1-15) (Pre-project situation)

% of all properties (residential / business / industrial / office units)						
Flood type	SC 1	SC 2	SC 3	SC 4	SC 5	SC 6
2 year flood						
% at risk	2.6	0.1	1.0	2.6	2.8	2.6
5 year flood						
% at risk	2.6	0.4	4.0	3.2	3.0	4.0
10 year flood						
% at risk	9.9	16.9	29.9	14.2	3.5	6.3
20 year flood						
% at risk	46.9	71.9	76.8	53.9	29.8	22.7
30 year flood						
% at risk	66.2	95.7	93.8	74.7	50.0	22.9
Total no of properties	1367	4753	3953	4568	3243	3191
%	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Flood type	SC 7	SC 8	SC 9	SC 10	SC 11	SC 12
2 year flood						
% at risk	5.1	0.8	1.4	9.5	0.5	4.6
5 year flood						
% at risk	2.6	0.9	2.1	10.4	0.5	6.8
10 year flood						
% at risk	9.1	4.0	2.7	16.8	1.5	6.3
20 year flood						
% at risk	24.8	13.9	6.9	35.9	4.4	22.7
30 year flood						
% at risk	25.3	15.5	14.4	31.2	5.2	22.9
Total no of properties	2842	1352	1460	3648	3246	3191
%	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

(Continued)

% of all properties (residential / business / industrial / office units)					
Flood type	SC 13	SC 14	SC 15	SC 16	Total
2 year flood % at risk	1.9	4.2	2.1	2.5	2.8
5 year flood % at risk	3.5	4.2	2.2	16.5	6.6
10 year flood % at risk	5.2	8.4	3.2	48.8	19.4
20 year flood % at risk	7.9	20.5	26.9	79.3	45.6
30 year flood % at risk	15.8	33.4	48.3	88.0	56.7
Total no of properties	1444	4044	5599	14361	62485
%	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Table 21: Flood proneness of CPP area by compartments (flooded above floor of properties) by floods of various magnitudes (Pre-project situation)

The information on vulnerability of individual sub-compartments to flooding is shown in Table 21. All the sub-compartments combined together, that is in the CPP area, as a whole, a 2 year flood inundates 2.8% of properties, followed by 6.6% in a 5 year, 19.4% in a 10 year, 45.6% in a 20 year and 56.7% in a 30 year flood.

Flood Damage Assessment in Area 1 (SC 16)

The damage assessment of non-agricultural sectors in the CPP area was carried out through use of standard damage data sets. While constructing standard damage data sets based on sample enterprises, complete and partial closure of production has been taken into account. The production loss during the period of complete closure was assessed through segregation of impact due only to flood, which means the production loss due to other factors was excluded in the loss assessments. Similarly, during the period of partial closure, the production loss was assessed through construction of recovery curve at various points of time and thus estimating average production during the recovery period. Any additional costs that were incurred due to, among others, power cuts communication disruption and poor storage capacities have been incorporated.

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The various assumptions in relation to recovery and savings of stock and damage avoided are based on empirical evidence. In the assessment of flood damage to roads sector, only pucca roads have been included, as damage to kutchra roads due to floods is assumed insignificant.

Table 22 shows the damages by sectors and loss components predicted in five selected floods of successive frequencies, ranging from the 2 to the 30 year event in Area 1 (SC 16). The 1988 and 1998 flood, two of the most disastrous events on record in the country has a return period ranging from 40 to 100 year depending on the various locations in the country. In the CPP area, the events have a return period of approximately 30 and 27 years. The available hydrological data do not allow including events beyond the 30-year flood.

It is evident from the Table 22 that the total urban flood loss in Area 1 (SC 16) (Tangail town) predicted in a 2 year flood is about TK 3.0 million, which increases to about TK 31.7 million in a 5 year flood, followed by TK 128.1 million, TK 249.7 million and TK 326.7 million in a 10 year, 20 year and a 30 year flood respectively. The total losses are disaggregated by the five land use sectors and the five damage components.

The residential sector suffers a flood loss amounting to about TK 2.2 million in a 2-year flood. The amount jumps to TK 12.2 million, TK 63.6 million, TK 122.3 million and TK 154.6 million in a 5 year, 10 year, 20 year and 30 year flood respectively.

The business sector incurs a flood loss amounting to TK 0.07 million in a 2 year flood. The amount estimates to as high as TK 8.2 million in a 5 year flood, followed by TK 37.2 million, TK 81.7 million and TK 108.9 million in a 10 year, 20 year and 30 year flood respectively.

The industry sector incurs a flood loss amounting to about TK 0.46 million in a 2 year flood. The amount increases to TK 6.2 million, TK 18.3 million, TK 34.1 million and TK 42.7 million in a 5 year, 10 year, 20 year and 30 year flood respectively.

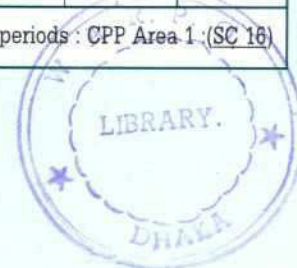
The office and public buildings sector incurs a relatively a minor flood loss, estimating as 0.08 million in a 2 year flood, followed by TK 2.5 million, TK 5.8 million, TK 8.0 million and TK 9.5 million in a 5 year, 10 year, 20 year and 30 year flood respectively.

The damage (direct damage) to roads infrastructure also estimates at a relatively minor amount. The flood damage to this sector is relatively insignificant in a 2 year flood, amounting to TK 0.2 million. However, the amount sharply increases in the

(damage value in 000 Taka :98/99 Price)

Flood	Sector	Direct damage			Indirect damage		Total
		Structure	Inventory /stock	Machinery /equipment	Primary indirect	Linkage effects	
2 year	Residential	833	1340	-	-	-	2173
	Business	3	19	-	44	-	66
	Industries	74	62	35	286	-	457
	Public buildings	56	-	27	-	-	83
	Roads	197	-	-	-	-	197
	Total	1163	1421	62	330	-	2976
5 year	Residential	4474	7684	-	-	-	12158
	Business	494	2287	-	5400	-	8181
	Industries	849	776	456	4091	-	6172
	Public buildings	1960	-	491	-	-	2451
	Roads	2228	-	-	-	-	2228
	Total	10005	10747	947	9491	-	31190
10 year	Residential	24420	39130	-	-	-	63550
	Business	2353	11263	-	23576	-	37192
	Industries	2202	2368	1388	12335	-	18293
	Public buildings	4917	-	865	-	-	5782
	Roads	3329	-	-	-	-	3329
	Total	37221	52761	2253	35911	-	128146
20 year	Residential	46017	76270	-	-	-	122287
	Business	5425	25369	-	50918	-	81712
	Industries	4229	4562	2565	22727	-	34083
	Public buildings	6741	-	1292	-	-	8033
	Roads	3536	-	-	-	-	3536
	Total	65948	106201	3857	73645	-	249651
30 year	Residential	57625	96977	-	-	-	154602
	Business	6926	35053	-	66934	-	108913
	Industries	5338	5813	3185	28398	-	42734
	Public buildings	7957	-	1501	-	-	9458
	Roads	10979	-	-	-	-	10979
	Total	88825	137843	4686	95332	-	326686

Table 22: Estimated potential damage in floods of different return periods : CPP Area 1 : (SC 16)



larger floods, to TK 2.3 million, TK 3.3 million, TK 3.6 million and TK 11.0 million in a 5 year, 10 year, 20 year and a 30 year flood events respectively.

Sector and Damage Analysis of Event Damages for Area 1 (SC 16)

Table 23 demonstrates the sector analysis, while the Table 24 demonstrates the damage analysis in the various selected events for Area 1 (SC 16). As is evident from the Table 23, averaged over all the five flood events, small, medium and large, the residential sector in the SC 16 appears to be the most vulnerable sector in the whole CPPs urban economy, accounting for the major proportion in the total urban loss, e.g. about 48%. The proportion of business damage in the total loss on an average amounts to about 32%, while that for the industries account for about 14%. The sector, office and public buildings, constitutes about 3.5% in the total loss, while the sector, roads infrastructure, accounts for 2.7% in the total urban loss.

As can be seen from the Table 24, averaged across damage components over the 5 flood events, the damage component inventory/stock accounts for the highest proportion e.g. 42% in the total loss in the urban economy. This is followed by the next highest proportion constituting 29% damage caused to primary indirect loss (production loss), structural loss constituting about 28%, and machinery/equipment accounting about 2%.

Flood Damage Assessment in Area 2 (SC 1-15)

Table 25 shows the damages by sectors and loss components predicted in five selected floods of successive frequencies, ranging from the 2 to the 30 year event in Area 2 (SC 1 through 15).

(damage value in 000 Taka :98/99 Price)						
Flood return period	Sector loss (%)					Total events loss (000 Tk.)
	Residential	Business	Industries	Office & public building	Roads	
2 year	73.0	2.2	15.4	2.8	6.6	2976
						(100.0)
5 year	39.0	26.2	19.8	7.9	7.1	31190
						(100.0)
10 year	49.6	29.0	14.3	4.5	2.6	128146
						(100.0)
20 year	49.0	32.7	13.7	3.2	1.4	249651
						(100.0)
30 year	47.3	33.3	13.1	2.9	3.4	326686
						(100.0)
Average	48.0	32.0	13.8	3.5	2.7	147730
						(100.0)
Table 23: Sector analysis of event damages : Area 1: (SC 16)						

(damage value in 000 Taka :98/99 Price)

Flood return period	Component damage (%)					Total events loss (000 Taka)
	Direct damage			Indirect damage		
	Structure	Inventory /stock	Machinery /equipment	Primary indirect	Linkage effects	
2 year	39.1	47.7	2.1	11.1	-	2976
						(100.0)
5 year	32.1	34.4	3.3	30.4	-	31190
						(100.0)
10 year	29.0	41.2	1.8	28.0	-	128146
						(100.0)
20 year	26.4	42.5	1.5	29.5	-	249651
						(100.0)
30 year	27.2	42.2	1.4	29.2	-	326686
						(100.0)
Average	27.5	41.8	1.6	29.1	-	147730
						(100.0)

Table 24: Damage analysis of event damages : Area 1 SC 16

It is evident from the Table 25 that the total flood loss in Area 2 (SC 1 through 15) predicted in a 2 year flood is about TK 5.7 million, which increases to about TK 8.4 million in a 5 year flood, followed by TK 33.2 million, TK 106.5 million and TK 153.8 million in a 10 year, 20 year and a 30 year flood respectively. The total losses are disaggregated by the five land use sectors and the five damage components.

The residential sector suffers a flood loss amounting to about TK 3.7 million in a 2-year flood. The amount jumps to TK 4.6 million, TK 23.8 million, TK 79.9 million and TK 107.6 million in a 5 year, 10 year, 20 year and 30 year flood respectively.

The business sector incurs a flood loss amounting to TK 0.7 million in a 2 year flood. The amount estimates to as TK 0.8 million in a 5 year flood, followed by TK 2.6 million, TK 8.6 million and TK 10.8 million in a 10 year, 20 year and 30 year flood respectively.

The industry sector incurs a flood loss amounting to about TK 1.1 million in a 2-year flood. The amount increases to TK 1.4 million, TK 4.0 million, TK 14.0 million and TK 25.9 million in a 5 year, 10 year, 20 year and 30 year flood respectively.

The office and public buildings sector incurs a relatively a minor flood loss, estimating as 0.09 million in a 2 year flood, followed by TK 0.1 million, TK 0.4 million, TK 1.3 million and TK 1.7 million in a 5 year, 10 year, 20 year and 30 year flood respectively.

(damage value in 000 Taka :98/99 price SC 1-15)

Flood	Sector	Direct damage			Indirect damage		Total
		Structure	Inventory /stock	Machinery /equipment	Primary indirect	Linkage effects	
2 year	Residential	2470	1194	-	-	-	3664
	Business	73	217	-	380	-	670
	Industries	531	107	53	435	-	1126
	Public buildings	72	-	27	-	-	99
	Roads	128	-	-	-	-	128
	Total	3274	1518	80	815	-	5687
5 year	Residential	3102	1502	-	-	-	4604
	Business	82	226	-	443	-	751
	Industries	635	130	64	526	-	1355
	Public buildings	91	-	34	-	-	125
	Roads	1613	-	-	-	-	1613
	Total	5523	1858	98	969	-	8448
10 year	Residential	16554	7200	-	-	-	23754
	Business	343	731	-	1551	-	2625
	Industries	1736	411	213	1673	-	4033
	Public buildings	267	-	100	-	-	367
	Roads	2456	-	-	-	-	2456
	Total	21356	8342	313	3224	-	33235
20 year	Residential	55662	24251	-	-	-	79913
	Business	1172	2261	-	5161	-	8594
	Industries	6097	1417	733	5752	-	13999
	Public buildings	981	-	361	-	-	1342
	Roads	2648	-	-	-	-	2648
	Total	66560	27929	1094	10913	-	106496
30 year	Residential	74882	32691	-	-	-	107573
	Business	1470	2867	-	6486	-	10823
	Industries	8339	8990	971	7598	-	25898
	Public buildings	1209	-	451	-	-	1660
	Roads	7806	-	-	-	-	7806
	Total	93706	44548	1422	14084	-	153760

Table 25: Estimated potential damage in floods of different return periods: Area 2 (SC 1-15)

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The damage (direct damage) to roads infrastructure also estimates at a relatively major amount. The flood damage to this sector is relatively insignificant in a 2-year flood, amounting to TK 2.7 million. However, the amount sharply increases in the larger floods, to TK 34.3 million, TK 52.3 million, TK 56.4 million and TK 166.2 million in a 5 year, 10 year, 20 year and a 30 year flood events respectively.

Sector and Damage Analysis of Event Damages for Area 2 (SC 1-15)

Table 26 demonstrates the sector analysis, while the Table 27 demonstrates the damage analysis in the various selected events for Area 2 (SC 1 through 15).

As is evident from the Table 26, averaged over all the five flood events, small, medium and large, the residential sector in the Area 2 appears to be the most vulnerable sector in the whole CPPs rural economy, accounting for the major proportion in the total rural loss, e.g. about 71.4%. The proportion of industrial damage in the total loss on an average amounts to about 15.1%, while that for the business account for about 7.6%. The sector, roads infrastructure, accounts for 4.8% in the total CPPs rural loss. The sector, office and public buildings constitute a minor part, about 1.2% in the total loss.

As can be seen from the Table 27, averaged across damage components over the 5 flood events, the damage component structure accounts for the highest proportion e.g. 61.9% in the total loss in the rural economy. This is followed by the next highest proportion of damage caused to inventory/stock constituting about 27.4%, primary indirect loss (production loss) constituting 9.8%, and machinery/equipment about 1%.

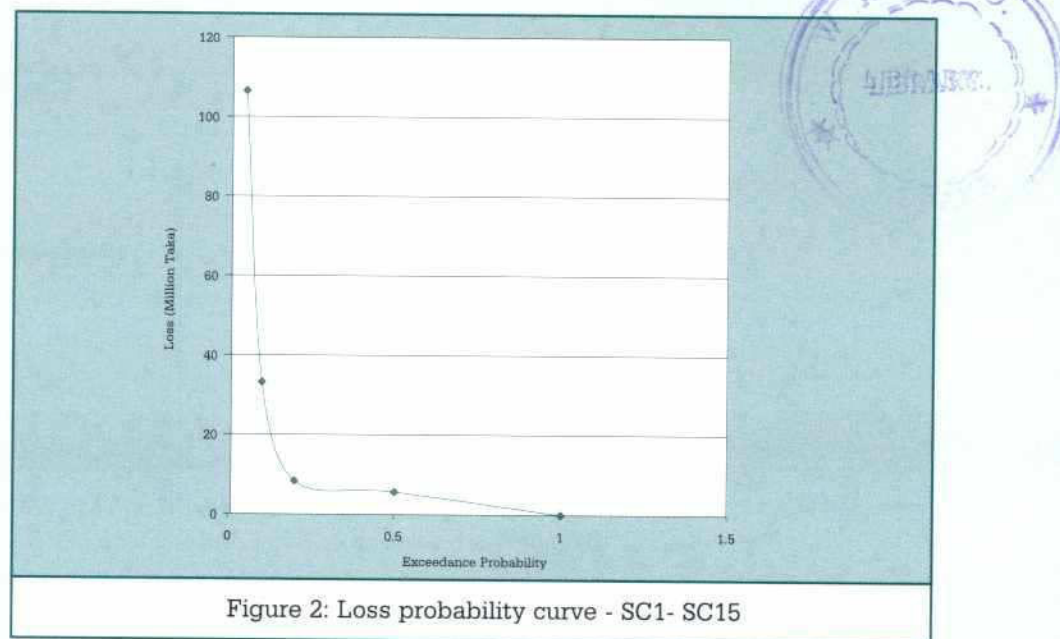
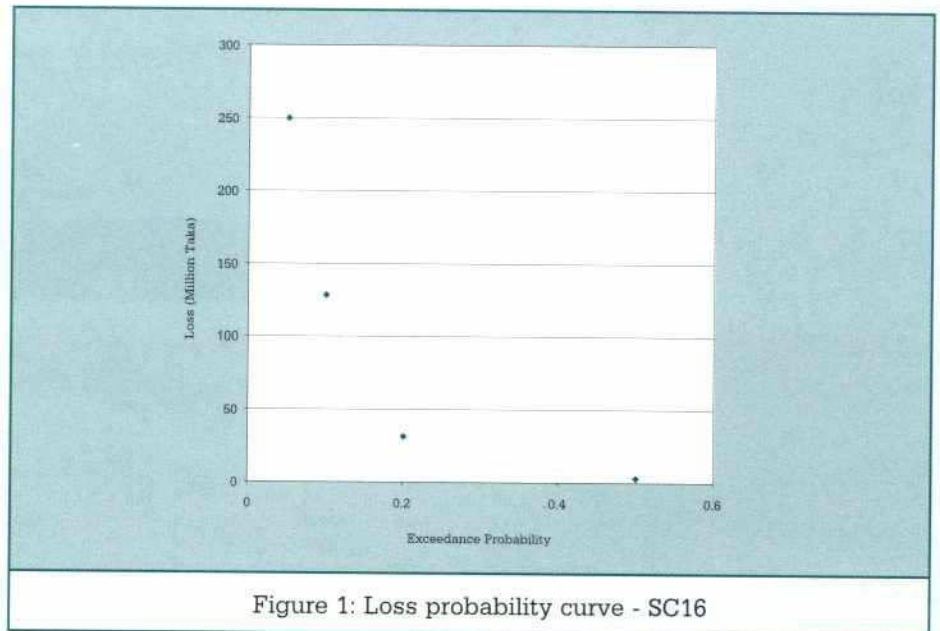
Assessment of Expected Annual Damage (EAD)

The ultimate output of the unit-loss model is the estimated expected annual damage (EAD), which is equivalent to the expected annual benefits of protection, from which the present value of benefits can be assessed. The present value of the benefits is the commonly used single parameter to represent the feasibility of mitigation schemes, by comparing the discounted benefits with the discounted cost of the protection. The analysis has considered a 20-year flood as the CPP's standard of protection. However, it has not contemplated the annual over standard benefit or the post-scheme residual damages, potentially arising out of any extreme event of the magnitude higher than the designed standard of protection.

Two estimates of the present value of the benefits are accomplished incorporating two test discount rates, 10% and 15%, with a hypothetical 50-year scheme life. FORTRAN program software was used for the estimates of EAD.

(damage value in 000 Taka :98/99 price)						
Flood return period	Sector loss (%)					Total events loss (000 Tk.)
	Residential	Business	Industries	Office & public building	Roads	
2 year	64.4	11.8	19.8	1.7	2.3	5687
						(100.0)
5 year	54.5	8.9	16.0	1.5	19.1	8448
						(100.0)
10 year	71.5	7.9	12.1	1.1	7.4	33235
						(100.0)
20 year	75.0	8.1	13.1	1.3	2.5	106496
						(100.0)
30 year	70.0	7.0	16.8	1.1	5.1	153760
						(100.0)
Average	71.4	7.6	15.1	1.2	4.8	61525
						(100.0)
Table 26: Sector analysis of event damages : Area 2 : (SC 1 - 15)						

(damage value in 000 Taka :98/99 Price)						
Flood return period	Component damage (%)					Total events loss (000 Taka)
	Direct damage			Indirect damage		
	Structure	Inventory /stock	Machinery /equipment	Primary indirect	Linkage effects	
2 year	57.6	26.7	1.4	14.3	-	5687
						(100.0)
5 year	65.4	22.0	1.2	11.5	-	8448
						(100.0)
10 year	64.3	25.1	0.9	9.7	-	33235
						(100.0)
20 year	62.5	26.2	1.0	10.2	-	106496
						(100.0)
30 year	60.9	29.0	0.9	9.2	-	153760
						(100.0)
Average	61.9	27.4	1.0	9.8	-	61525
						(100.0)
Table 27: Damage analysis of event damages : Area 2 (SC 1 – 15) (Pre-project situation)						



Assessment of EAD in Area 1 (SC 16)

Table 28 shows the loss-probability relationship and the expected annual benefits for SC 16 of the CPP. Thus, for SC 16 the expected annual benefit for non-agricultural sectors estimates as TK 23 M.

			Value in million Taka : 1998/99 price	
Return period	Exceedance probability	Event loss (M.TK)	Annual benefit	Discounted
1	1	0	-	-
2	.50	3.0	-	-
5	.20	31.2	-	-
10	.10	128.1	-	-
20	.05	249.7	-	-
Total	-	-	23	228

Table 28: Loss probability analysis : Area 1 (SC 16)

All values (except for last column) in million Taka : 1998/99 price				
Discount rate %	Expected annual benefits	Annual multiplier	Present value(PV) of benefit (M.TK)	PV per property (TK)
10	23	9.914814	228	15876
15	23	6.660515	153	10684

Table 29: Summary table for present value of benefits at 10% and 15% discount rates : Area 1 (SC 16)

Table 29 presents the summary table for the present value of benefits at 10 % and 15% test discount rates. So far as the non-agricultural sectors are concerned, the present value of benefits of the flood protection of SC 16 at a 10% discount rate estimates as TK 228 M to the 20 year standard. At a 15% discount rate, the present value of the benefits amounts to TK 153 M.

In other words, assuming 10% as an opportunity cost of money, at least TK 228 M is the capital sum worthwhile spending on flood protection to non-agricultural sectors to the 20 year standard in SC 16 (Tangail town). This estimate excludes any account of intangible damages. The field survey reveals that a 20 year flood is likely to last up to more than one month, and inundate a large majority of residential houses so that the intangible impacts such as damage to health or lives could be considerable in a flood of this magnitude⁶.

⁶ In a flood of this magnitude, 88% of the total households in SC 16 are flooded. Floods have a strong influence on the incidence of diarrhoeal diseases. Hence, the flood impacts on health may be considerable.

The loss-probability Table (Table 29) also gives the estimated present value of benefits per property in SC 16, which amounts to TK 15,876 and TK 10,684 at the two discount rates, 10% and 15% respectively, with a 50 years scheme life.

Assessment of EAD in Area 2 (SC 1-15)

Table 30 shows the loss-probability relationship and the expected annual benefits for the Area 2 (SC 1 through 15) of the CPP. Thus, for the Area 2, the expected annual benefit for non-agricultural sectors estimates as TK 9 M.

Value in million Taka : 1998/99 price				
Return period	Exceedance probability	Event loss (M.TK)	Annual benefit	Discounted
1	1	0	-	-
2	.50	5.7	-	-
5	.20	8.4	-	-
10	.10	33.2	-	-
20	.05	106.5	-	-
Total	-	-	9	89
Table 30: Loss probability analysis : Area 2 (SC 1 -15)				

All values (except for last column) in million Taka : 1998/99 price				
Discount rate %	Expected annual benefits	Annual multiplier	Present value(PV) of benefit (M.TK)	PV per property (TK)
10	23	9.914814	228	15876
15	23	6.660515	153	10684
Table 31: Summary table for present value of benefits at 10% and 15% discount rates : Area 2 (SC 1-15)				

Table 31 presents the summary table for the present value of benefits at 10% and 15% test discount rates. So far as the non-agricultural sectors are concerned, the present value of benefits of flood protection of the Area 2 of CPP at a 10% discount rate estimates as TK 89 M to the 20 year standard. At a 15% discount rate, the present value of the benefits amounts to TK 60 M.

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In other words, assuming 10% as an opportunity cost of money, at least TK 89 M is the capital sum worthwhile spending on flood protection to non-agricultural sectors to the 20 year standard in the Area 2 of CPP. This estimate excludes any account of intangible damages.

The loss-probability Table also gives the estimated present value of benefits per property in the Area 2 of CPP, which estimates as TK 1854 and TK 1256 at the two discount rates, 10% and 15% respectively, with a 50 years scheme life. These estimates of present value of benefits per property in Area 2 (SC 1-15) work out as 8.5 times less than those in SC 16.

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Annex H
Women in Development



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Introduction

This report describes the experiences, achievements and failures, as well as the lessons learned during the design and implementation of CPP's gender strategies. On the basis of these lessons, recommendations are given on how to address the issue of women and development in the framework of compartmentalization.

From its early design phase onwards, women have formed a special target group of CPP. During its years of implementation, CPP has tried out various strategies to involve women as both actors and beneficiaries. In addition, attempts have been made to assess the effect of CPP interventions on various categories of women. However, women in Bangladesh, and in Tangail Compartment, do not form a homogeneous group. Multiple categories of women can be distinguished according to the social class they belong to, their occupation, land ownership, land type, age and other factors. In this report the concepts of both "women and development" and "gender and development" are used. Women and development refers to the specific needs and interests of women in the development efforts. In conformity with the common terminology used in Bangladesh, women and development is abbreviated as "WID". The term "gender" refers to the economic, social and cultural attributes and opportunities associated with being male or female. It takes into account the different activities men and women undertake, and their differences in access to and control over resources and in decision making power. These differences, vary among classes, cultures and ethnic groups, and are not static. The crucial aspect is that they are not just gender differences, but fundamental gender inequalities.

The second chapter briefly provides some background on policies on women's development in Bangladesh and those of the financing agencies. It briefly describes the position of women in the project area. The third chapter analyses the way women and development in CPP has been addressed during the design and preparation phases of the project. The actual implementation of gender strategies is described in the fourth chapter with a focus on the three most relevant CPP components, that have taken up most of the time and energy of the WID staff, i.e., institution building, agriculture and preventive maintenance. The chapter describes the main gender issues at stake, the implementation strategies, results, as well as the lessons learned. The fifth chapter deals with the effects of CPP on women's position, compared to the position of men. Effects have been measured in both quantitative and qualitative ways, and concern the direct effects of the women in development (WID) activities of CPP, as well as the indirect effects of CPP interventions on various categories of women. The final chapter summarizes the lessons learned and the conclusions, and provides WID guidelines on do's and don'ts for any future compartmentalization project.

The Context

Bangladesh is a poor country. In the ranking of countries according to the Human Development Index (UNDP, 1996) which classifies countries according to standard of living, life expectancy and educational standards, Bangladesh ranks 143 out of 174 countries. The UNDP Gender-related Development Index (GDI) adjusts the HDI for differences in performance between men and women. For the GDI, the ranking of Bangladesh is four places lower. This implies that the country performs relatively worse in the field of gender equality than on average achievements. With respect to the Gender Empowerment Measure, which examines the ability of men and women to participate actively in economic and political life and to take part in decision-making, Bangladesh ranks 77 on the list of 104 countries, which is higher than for instance India (93) or Pakistan (101). This is primarily due to the fact that a number of seats in Parliament are reserved for women.

Structures and Policies for Women's Emancipation in Bangladesh

Since independence the Government of Bangladesh (GoB) has gradually increased its attention to women's development. Following the First International Women's Conference in 1975, Bangladesh was among the first countries that took steps to promote gender equality. In 1976, a National Women's Council was created to identify important areas of gender discrimination and to propose actions. In 1977, steps were taken to reserve seats for women at various levels of local government and in 1978, a separate Ministry of Women's Affairs was established. To ensure that the other ministries would not ignore women's issues in their programs, donors and women's organizations pressed the government to set up Women and Development (WID) Focal Points in 23 ministries. Most of these positions are filled by men, who tend to consider their responsibility as donor-driven and difficult to implement. Special quotas were set for women in government services, as well as for the position of primary school teacher. Hitherto, none of these quotas has been filled. In Parliament, thirty seats are reserved for women, but they are not directly elected by the people.

In GoB development policies for women's emancipation, a gradual shift in focus can be noted. Whereas the first three Five Year Plans directed funds for women under the social welfare sector, and emphasized population, health, education and employment generation, the Fourth Five Year Plan (FFYP 1990-1995) acknowledged the role played by women in agriculture. Among the objectives was the need to increase women's participation as beneficiary and agent in the main development sectors of Bangladesh, including natural resources management. The women and development aim of the Fifth Five Year Plan (1997/98-2001/2) is to integrate women's development

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into the macro-framework and to reduce gender disparity in all sectors through the integration of women into the mainstream development efforts. However, this aim is not reflected in the chapter on the Water Resources Sector of the FFYP, where women's role in flood control related projects is primarily perceived as workers in the construction and maintenance of embankments under the Food for Work Program.

The need for women's involvement and gender equality in water resources management is further developed in national water policies. The Bangladesh National Water Policy (September 1998) aims to enhance women's role in water management and to take into account women's specific needs in this domain. The policy emphasizes gender equity, social justice and broad public participation in water management plans. The Inception Report of the National Water Management Plan writes:

"Gender equality issues will be mainstreamed in the NWMP through developing gender focused policies targeting women; including, where feasible, services that address the needs of women". (Inception Report NWMP. Annex A. p.2-3, December 1998).

The donor agencies play an active role in the promotion of gender equality in the development process. This is true of CPP, which is financed by The Netherlands and the German governments. Both donors have a policy for development cooperation that wants to alleviate poverty, to protect the environment, and to improve the position of women. Improvement of women's position should be seen in the light of the fight against poverty, since women are among the poorest of the poor. The women and development policies aim at improving women's economic, social, political and physical position. Women's needs and interests must be included in project design, and women from the target groups should be active participants during project implementation, both in quantitative and qualitative terms.

In addition to government structures, a huge number of NGOs are operating in Bangladesh. Some of their programs are considered quite successful in the field of women's emancipation at grassroots level, in particular through the promotion of women's access to credit facilities. NGOs such as the Grameen Bank and BRAC have earned worldwide recognition by demonstrating women's credit worthiness, and by contributing to the empowerment of women in Bangladesh.

The Position of Women in the Project Area

An estimated 263,000 people live in the project area. About 40% of the population lives in Tangail town, whereas another 60% lives in the rural area. The average household size is calculated at 5.5, so that the number of households roughly varies between 40,000 and 50,000 (Household Survey, 1992). Landless make up about 70% of the population, whereas the other 30% are farm households. Most of the landless people in the project area are wage laborers and artisans. One percent of the rural households are professional fishermen. Farmers in the project area are mostly small farmers. Sharecroppers and big farmers are among the minority (see Table 1).

Class of farmers	% of farmers	% of owned land
Share croppers	4.5	0.6
Marginal farmers	23.5	12
Small farmers	51.5	40.8
Medium farmers	15.2	25.6
Large farmers	5.3	21

Table 1: Classification of Farming Households

Source: CPP Tangail Interim Report 1992 (page 124)

Literacy rates prevailing in the compartment are higher than the national literacy rates, in particular for women. Literacy rates for women were 40% (CPP Household Survey, 1992), whereas at national level women's literacy rate was 25% in 1993 (UNDP 1996). Between 50% and 70% of the girls in Tangail District go to school, (UNICEF 1995) against 34% at national level in 1993 (UNDP 1996). For men literacy rates are respectively 50% in Tangail, which is close to the national average.

Institutions in CPP Area Involved in Women and Development

A range of non-governmental, governmental and semi-governmental organizations operate in the project area. Part of these organizations, in particular a number of NGOs, are active in the field of women and development. Most of them focus on landless women, through the provision of credit (Grameen Bank), literacy and education (BRAC), social services (SSS). In many villages women groups can be found that participate in these programs. CARE is engaged in a Road Maintenance Program with destitute women.

Not many organizations work with farm women. An example is the Krishni Grameen Foundation (irrigation) and Ubinig (farm women training). The Department of Agricultural Extension (DAE) provides extension services to the farmers. Most of the extension workers are men. In 1994, for instance, the department employed 326 Block Supervisors, of which 15 were female. At the start of the CPP, DAE had little experience in working with women farmers. Since women's farm work takes mostly place at the bari (compound), DAE did not perceive women as farmers.

The Ministry of Women Affairs has an office at district level. It has scarce financial, material and human resources and is mainly engaged in traditional women's activities, such as weaving, sewing and embroidery training for distressed women.

Women's Position in the Project Area

As elsewhere in Bangladesh, the prevailing ideology of patriarchy in the project area puts women in a subordinate position to that of men. Women have a low status, little say in public affairs and a limited mobility. Although they enjoy equal rights in the Constitution, only few of these rights can be practiced. The average age of marriage of girls is very low (14 years), and dowry is a burden that confronts households and sometimes the girls themselves with high debts. There are fewer women than men in the compartment (sex ratio = 108).

Most women in the project area have a heavy workload. They are in charge of both reproductive and productive activities. Women's reproductive work includes those activities that aim at the reproduction and maintenance of the (household) labor force. They include cooking, cleaning, washing, water collection, childcare and taking care of the sick family members. This takes place within the homestead area.

For most of these activities women need access to both good quality and sufficient quantity of water. Women (and children) fetch water for household activities from all kinds of available water sources. These include pumped water, wells, and open waterbodies like pagars, ponds, beels, khals and rivers.

Traditional experience with flood has created a flood culture in the area, in which women play an active role. In addition to up-leveling the house, some traditional flood preparedness measures are:

- have a portable chula (homemade pot) ready;
- have jute sticks ready as fuel; and
- Have a banana stem at hand to use as a boat.

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At the same time women mentioned that they welcome seasonal flooding of the homestead, as it gives the opportunity to wash away the dirt and garbage.

According to the household survey, the percentage of employed female labor force is low in the project area. Two percent for women from farm households, 3% for non-farm women, nil for women from the fishery communities, and 1.5% for women from urban households. Although these figures reflect a high unemployment rate among the female population, they do not take into account women's reproductive and productive work at bari level; nor do they reflect the temporary and non-registered income generating activities executed by women. Typical jobs of women in the project area are domestic servant (housemaid), rice husker, bidi maker and net maker.

Farm women in the project area can roughly be classified in the same way as male farmers (see Table 1). In general, female farmers have limited access to outside resources and services. Only a few women farmers own land. This is because questions of inheritance are not covered by the civil law that is applicable to all citizens equally, but by personal laws of each religious community. According to Hindu personal law, a woman does not enjoy any right to inheritance. In Muslim Sharia law, women's rights to inheritance are limited to half of their male counterpart. When compared to landless women, farm women are little involved in NGO activities such as credit and training programs.

Women participate in agriculture either as agricultural laborer, or as members of a male-headed farming household. Another (smaller) number of women are independent farmers. They are either women heading a household on their own (separated, widowed), or women whose husband is employed elsewhere. Women independent farmers tend to be in charge of all farm-related tasks. They often hire and supervise agricultural laborers, manage inputs and outputs and are more easily recognized as farmers by the agricultural extension workers than the women farmers who are the wives of male heads of farming households.

Most of the work of female members of a male-headed farm household take place in the bari, and focuses on pre-harvest and post-harvest activities. The following agricultural tasks tend to be primarily the domain of women farmers:

- parboiling/drying paddy;
- husking paddy;
- feeding and milking cows;
- looking after poultry;

- preparing land for homestead crops; and
- sowing, fertilizing, harvesting crops in the homestead.

In addition, a number of agricultural tasks are often performed either by the women alone or jointly by men and women. Examples are threshing paddy, storing and preserving seeds and crops, stripping jute fiber and preparing seedbeds and seedlings. Male members of farming households are more engaged in agricultural field work and out-of-village activities, such as buying of inputs, selling of produce and arranging of credit.

Findings of the CPP household survey show that in approximately 36% of the households, women contribute to the household income in cash and kind through the sale of products from homestead gardens and poultry. Of both poultry and vegetables, approximately 25% of the production are sold, and the rest is used for own consumption. On average, 75% of all households have a kitchen garden. In about half of the households interviewed women's opinion was always asked in matters related to family decision making. However, decision making with respect to the recruitment of additional labor force, or what to do with the produce, was primarily in the hands of men.

Women and Development in Project Design and Preparation

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CPP was designed and implemented in two phases. Phase I took place from 1992 - August 1996 and the Final Phase from September 1996 to June 2000. Before the actual implementation of the project, two years of project planning and design took place between 1989 and 1991. During this period the project was identified, formulated, tendered and allocated to a consortium composed of both international and national consultants. A mid-term evaluation took place in 1995, after which the project was reformulated and allocated to another consortium of consultants.

Project Design and Preparation

From the early project design onwards, women were considered a disadvantaged group for whom possible negative effects of compartmentalization should be mitigated as much as possible. The Terms of Reference 1990 (ToR) refer to women in the following way:

"The specific objectives of CPP are to establish water management systems, which are feasible, achievable and sustainable by providing disadvantaged groups with employment opportunities, whereby special attention will be paid to the involvement of women." (ToR, 1990, p.4)

Special measures to overcome constraints that might hamper women's involvement were not considered. The ToR and the technical proposal for Phase I of the project made no specific allocations for women in terms of budget and gender expertise.

Inception Report 1992

The Inception Report (1992) recognizes that women have a lower social status and less access to resources than men do. Nevertheless, no other provisions than a part time female sociologist were made to address these constraints. The report refers to the role and situation of women under the heading "Focus on the Disadvantaged" indicating that in relation to compartmentalization, the creation of income generating opportunities will be the most relevant way to contribute to the improvement of women's situation. This will, in particular, be achieved by awarding Operation and Maintenance (O&M) of the embankments to women groups. No differentiation is made between the various categories of women. Women are considered one disadvantaged group on the same line as 'landless', 'fishermen', marginal cultivators, etc. This has resulted in women being one of the four target groups during phase I of the project.

Collection of Baseline Data

During the project preparation, CPP collected baseline data that gave insight into the needs and the social, economic, agricultural, fisheries and urban situation of the population of the project area. The data collection process was not only meant to adjust project planning and design to the needs of the target groups, but also to enable post-project evaluation of the effects of compartmentalization on the population. The baseline survey was composed of three major activities, i.e., a Household Survey (1992), a Needs Assessment Survey (1992) and a Consultation Process (1992-1994).

Household Survey

In 1992, CPP organized a Household Survey in three selected areas, i.e., the project area, adjacent area and a control area. Women were one of the five analytical categories, together with farm households, non-farm households, fishermen households and urban households. In the project area, a total of 364 households were interviewed with the help of questionnaires. Half of the field investigators were women, who interviewed the female members of the households.

Although women were interviewed directly linked to the household type they belong to, in the reports "women" are taken apart as one separate category and the link to their specific household background is left out. Information on women mainly concerns women's reproductive role (their role as mother and wife and their household responsibilities). Other relevant information are not analyzed and reported in a gender specific way, so that women's role and responsibilities in crop production, marketing, storage, access to credit, fisheries, water management, etc. have not been specified. The results of the survey can, therefore, not be used to evaluate project effects on women and gender relations.

Needs Assessment Survey

The objectives of the Needs Assessment Survey (NAS), executed in 1992, were to get a broad overview of the existing situation, of the water management related practices, problems and needs, and to find out people's opinion on potential solutions to overcome identified constraints. The planning team used the output to draw up a number of alternative options for developing the compartment. These options were to be discussed with the people during consultation meetings.

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The results of the NAS showed that women have a broad and detailed understanding of water and water control, not only in and around their homestead but also far beyond. The interviews with the women also showed that women encounter common problems related to flood and heavy monsoon, but that there are also multiple differences in the way women are affected. Common problems are related to women's household tasks, family care responsibilities and health situation. During floods and severe monsoon periods, women encounter difficulties in fetching drinking water and fuel, in cooking, maintaining family health and protecting children. Women also suffer increased risks in reproductive health (pregnancy, giving birth). Differences in the ways women are affected by flood damage are among others related to women's productive role, but also to their economic class, occupation of the household head, location of the settlement, cultural background and age. Farming women, for instance, encounter difficulties in post-harvest activities and in drying and storing of seeds and food. Improved drainage through excavation of khals and the construction of culverts figured among the priorities mentioned by farming women. Landless women complained that flood damage affected their employment opportunities. They gave high priority to improvement of roads and bridges, which should increase their mobility and their access to employment opportunities.

Consultative Meetings

As a result of the NAS, CPP developed four water management options that were to be discussed with the stakeholders. Improved drainage facilities played an important role in these options, because this appeared to figure high among the priorities of the stakeholders, including women farmers. Just before the start of the consultation process, GoB authorities intervened and prescribed that only the compartmentalization option that envisaged total flood control by placing regulators in the main rivers could be discussed with the population. For internal water management, all options were open.

Stakeholder consultation took place in three stages: initial meetings with different interest groups, follow-up meetings and combined meetings with representatives of local elite and interest groups. The consultation process was organized sub-compartment wise, and female field staff of participating organizations (Bangladesh Rural Development Board and NGOs) was actively involved in organizing the women to attend the meetings. They invited primarily women from the organized groups with whom they work. In order to facilitate women's attendance, the meeting places were chosen carefully; for instance in, a closed area instead of an open field, near women's houses. The timing was adjusted to women's homestead responsibilities, with female staff present to stimulate women's participation in the discussions. Since few farming women were members of such NGO women groups, the participation of women from

farm households in the consultation process was limited. The women who participated in the meetings were mostly assetless and landless women.

The consultation process ended in January 1995. A total of about 8,500 people attended the consultation meetings, of whom an estimated 3,080 were women. The attendance rate of women in the meetings ranged between 34% and 42%. Women present during the meetings endorsed most of the CPP proposals, and came up with a number of their own suggestions. Roughly 30 requests came from women, of which eight were approved by CPP. As could be expected, most of these requests of women reflected the needs of landless women. They argued that better roads, bridges and more culverts would improve their mobility and consequently their employment opportunities. It has not been monitored to what extent the structures have indeed improved the mobility of the women concerned.

Requests by women (4 clusters)	Number	Approved by CPP
Re-opening/re-excavation or closing of khals	7	1
Earthwork	3	3
Culvert	10	1
Adjustment of regulator	1	
Reparation/construction of road	2	
Bridges	4	2
Various	3	1

Table 2: Requests for Water Management Structures Made by Women

Sources: Reports on Proceedings of Consultation Meetings Cluster 1-4, 1992-1994

Design of CPP-WID Program Phase I

Halfway through the consultation process the project was equipped with WID expertise for the first time. The first WID specialist started to work in the project in March 1993. She was a national consultant and worked in the project until July 1994. She was assisted by an associated expatriate WID expert, who worked in the project from September 1993 until October 1995. During the first phase, the project staff also included a WID field coordinator during the period January 1994 - September 1996. A new national WID specialist joined the project in January 1995. A national WID specialist continued to work in CPP until the end of the project.

It was realized that a lot of valuable information on women's needs and situation was collected during the NAS studies and consultative process. The information was only used and analyzed for the purpose of the consultation process and the design of water

management structures. It did result in a limited number of water management structures requested by women and approved by CPP, but it did not result in activities, strategies or plans on how to address other needs and constraints as expressed by the women. Consequently, the consultants started to review the data on women's position and water-related needs that were collected during the household survey and NAS. They executed additional field visits and used the analyzed data to assess possible effects of compartmentalization on the position of various categories of women. This gender impact assessment was intended to facilitate the design of WID objectives and provide indications for mitigation measures to counteract possible negative effects of CPP on women's position.

The information showed that women are not only a "disadvantaged group", but that they also wanted to participate in project activities and benefit from the envisaged improvements in the field of agriculture, fisheries, water management, operation and maintenance. This was in line with the project's policy of people's participation in planning and design, operation and maintenance. But, like men, women could not be considered a homogeneous group. Different categories of women appeared to have different needs and interests in water resources management, depending on their social and economic status, profession, and age and ethnic background.

A number of actions were recommended, in particular, the design and implementation of agricultural training and extension work for farm women, and income generating activities for small and marginal female farmers and landless women.

In spite of the information available and the proposals made, the design of a Women and Development (WID) Program took a long time to materialize. Various plans of actions and planning schedules were made, but no common agreement could be reached on the objectives of the women and development activities in CPP.

To come up with a common understanding of women and development within CPP and to identify WID objectives for CPP, the project organized a WID Planning Workshop in October 1995, in close collaboration with the Royal Netherlands Embassy. This resulted in a quite ambitious plan of action for WID in CPP that addressed three levels: the Planning Group (management level), the Execution Group (CPP staff, BWDB, NGOs) and the Field Level Group (men and women beneficiaries). Emphasis of the Action Plan was on the creation of good conditions for women's involvement in CPP, in particular, through the design and implementation of training activities and through gender awareness creation at all levels.

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The planning schedule gave an overview of the envisaged activities, but the plan has not been worked out into concrete objectives, an implementation strategy and expected results. This would have enabled a clearer focus and a better common understanding of what CPP and WID were heading.

During the rest of Phase I, the WID section tried out some of the planned WID activities in order to gain experience. These included the setting up of Embankment Maintenance Groups (EMGs) with landless women, their involvement in water management committees, agricultural training of women farmers and compost making. In addition, gender awareness training was given to CPP staff and other actors involved in the project.

Design of the WID Program- the Final Phase

The change from Phase I to the Final Phase was a useful moment to learn lessons from the past that could be taken into account in the planning of the WID Program for the Second and Final Phase. For this reason, the WID and the Institutional Development (ID) section executed a study to review the WID and ID activities, entitled "Appraisal of Water Management Organizations in CPP and Gender Impact" (CPP 1997). The review showed a number of achievements. CPP had been successful in involving women in the needs assessment and consultation process. Women had become members of the Sub-compartment Water Management Committees. The project had created new employment opportunities for poor landless women through Embankment Maintenance Groups and Landless Contracting Societies (LCS). The WID section had successfully organized literacy, health, farm and gender training for different categories of women and project staff, and had improved their awareness and skills in a number of subjects.

The review also showed that not all these activities were successful. Whereas some appeared to be well appreciated by the beneficiaries (EMG, various training activities) others failed, among others as a consequence of weak design. Compost making, for instance, was designed as an income generating activity for landless women (the main target group during Phase I). This appeared impossible because of women's limited access to the resources required for compost making, and because of a lack of markets for compost.

Women were less represented in the water management committees than men and did not participate in structure operation. Women had little say in other committee



affairs. This was not only because women's role in public decision making was a relative new phenomenon, but also because female committee members were mainly landless women. They had no direct interests in water resources management, tended to be illiterate, had a low status in society, felt shy to talk among men, and were not well informed about the water management system, the role of the committees and their responsibilities. Women from farming and fishing households, including female-headed households were not, or hardly, represented in the committees.

The review produced the following lessons from the experiences of Phase I:

- WID efforts were made in a rather sporadic and fragmented way and CPP had not been able to develop a WID agenda in its core program;
- In those cases that women were recognized, this was done in an undifferentiated manner, not taking into account differences between various categories of women;
- In spite of the wish and efforts to integrate WID into the mainstream of CPP activities, in practice most of the WID activities appeared to be specific women activities; and
- Monitoring and evaluation had not received the attention that it needs in a pilot project.

It was concluded that in the Final Phase Development efforts within CPP should focus more on the integration and active participation of different categories of women in CPP with an emphasis on CPP's core activities; i.e, water management institutional development, agriculture, fisheries and environment. This would be in line with the major needs and wishes that women had expressed, in particular:

- To get a say in public water management affairs and water resources control (all categories of women);
- To have increased access to new or improved agricultural information and resources (farmer women); and
- To open avenues for income generation (landless women).

Based on the above findings and conclusions, new WID objectives and implementation strategies were developed for the Final Phase of CPP.

The following specific objectives were formulated:

- To actualize the representation of women in decision making in project institutions, systems and O&M;

- To develop approaches to improve women farmers' access to and control over agricultural resources, information, skills and benefits;
- To develop mitigation measures with women who will be negatively affected by project activities;
- To develop gender awareness and skills among stakeholders; and
- To assess the effects of the project on gender relations and women's sociocultural, economic, political and physical position.

During this Final Phase, CPP's WID approach would pay more attention to farm women than was the case during phase I, because women of farm households are more directly affected by changes in water management than landless women. The WID section chose to cooperate with all the CPP sections, to ensure that women participate in and benefit from the interventions. Special attention was paid to gender differentials, inequalities, and specific measures, steps and activities were foreseen to overcome social, cultural and other constraints that hinder women's full participation. These measures could be of a very practical nature, but there was also a need to address power relations, male attitudes and behavior towards women. For this purpose, gender awareness development at all levels was planned, as well as the empowerment of women through capacity building, skills development, and organization.

WID Staff Resources

At the beginning of the Final Phase, female staff in general, and WID staff in particular, were scarce resources in the project. At that time, the WID section was composed of one head of section and two field workers. During the implementation of the Final Phase, the two field workers left the project and six new WID field staff members were been recruited. Their appointment took place in a very late stage in the project cycle (two staff members joined in November 1997, three others only in March '98, and the last one in February '99). Except for one female field worker in the fishery section and the WID section staff, CPP had no female staff among its personnel, neither at field staff nor at management level. This lack of gender balance has hardly improved during the implementation of the Final Phase.



Women and Development in Project Implementation

This chapter will give an overview of achievements and main problems encountered during the actual implementation of CPP's WID program. The emphasis of this chapter will be on the Final Phase experiences, because the actual implementation of the WID activities took mostly place during this phase. The WID program comprised the following components:

- Women and Institution Building;
- Women and Agriculture, Fisheries and Environment;
- Embankment Maintenance Groups;
- Monitoring of Effects; and
- Supporting Measures.

The chapter will give a description of the major gender issues at stake, the strategies developed, the results achieved and the lessons learned. Emphasis will be put upon those project components that have taken up most of the financial, time and staff inputs, in particular:

- The involvement of women in water management committees;
- Women's access to and control over new agricultural technologies; and
- Women's employment in embankment maintenance.

Institution Building

In the Final Phase of the project, CPP has re-reformed all Chawk and Sub-compartment Water Management Committees in order to increase the level of representation of the committees. This provided the opportunity to ensure that different categories of women would be represented in the new committees. The process included a large number of meetings with the rural population, during which the need for the re-formation was explained, candidates were proposed, committee members elected and committees formed. The process finalized with the organization of training for committee members.

The women and development objective was three-fold:

- To achieve the participation of at least 33% of women in the reformation meetings and in the new committees;
- To ensure that the elected women would be representatives of the various female interest groups in the area, i.e, farm women of different land types, fishery women and landless women; and
- To empower women to actively play their role in decision making and actions.

As a first step, the WID section organized focus group discussions with different categories of women to obtain their views and wishes. The discussions showed that women had a clear interest in becoming members of the Water Management Committees (WMC). Farm women wanted to participate in decisions on water management issues, wanted to be informed, to increase their knowledge and skills and to be empowered to really have a say in the discussions. This was, in particular, the case with women who headed or managed a farm household, because they have full control over the land and are in charge of the whole production process. According to the findings of the Participatory Rural Appraisal Study executed by CPP in 1997, an estimated 15% of the households in the CPP area are Female Headed of Female Managed Households. Farm women from Male Headed Households explained their motivation to become a member of the water management committee by stating that they play an active and increasingly recognized role in agriculture. An estimated 60-70% of all the farm work is executed by women (see Appendix 2 to this Annex). Landless women considered the committees as an opportunity to have access to jobs, whereas fishery women wanted to defend their interests related to a decrease in fishing opportunities, that might be one of the consequences of the project.

Gender Issues

Before the reformation process, and during a pilot phase, a number of gender issues and constraints for women's participation were identified that required special measures. The most important ones were:

- Women in Tangail compartment are usually not well informed on activities that take place at community level, because the public/political areas tend to be the domain of men. Husbands do not automatically transmit information to their wives;
- People are not used to mixed male-female meetings in public places, and male members of the family are reluctant to let women participate in community meetings;
- Many women are not used to (make their voice heard in) public mixed meetings;
- Certain hours of the day are not compatible with women's household and other obligations; and
- Women do not have easy access to a number of locations, in particular not to the bazar and its surroundings, the mosque and its surroundings, graveyards and madrashas.



Implementation Strategies

An implementation strategy was developed that envisaged an active role for the WID section in the whole reformation process. Multi-disciplinary Cluster Teams were created, composed of the staff of the water management, agriculture, ID and WID section. In 1998, new WID staff were recruited to take part in this. The new WID staff were young women, based in Tangail, who had a Masters or Bachelors degree. Most of them had little experience in the field of women and development. Their lack of experience was compensated by a high level of motivation and enthusiasm, as well as by the apparent wish of women in the project area to become involved.

The following measures were taken to overcome some of the gender specific constraints:

- The invitation letter for the meetings was addressed to the man and the woman of the household, and the need for and importance of women's participation in the meeting(s) was explained to both the man and woman of the household. For this purpose a male as well as female local facilitator were used;
- WID field staff specifically visited the women before the meeting to stimulate them to attend;
- Timing of meetings was adjusted to women's needs (10.00 or 11.00 hrs, or 15.00 hrs)
- Location of venue took into account women's constraints in this respect; and
- Seating arrangements were changed in women's favor, and women were stimulated to speak up.

In addition, the WID section organized gender awareness training for project staff, for male committee members as well as for female committee members of all the SCWMC and the four pilot chawks. The WID staff also set up network meetings with female WMC members. The objectives of the network meetings were to increase women's level of information and understanding of the water management systems, to facilitate exchange on women's experiences during flood and to discuss women's role in the committees.

Together with the institutional development staff, a gender specific monitoring system was setup with a view to monitor the participation of men and women both in quantitative and qualitative terms. Various surveys were held to assess the level of women's participation in committee's affairs and decision making, as well as their level of satisfaction with the water levels in their locality.

Women's Representation in SCWMCs, ChWMCs and Compartment Forum

The WMC reformation process was finalized in the beginning of July 1998. The efforts to adjust the reformation process to women's needs and opportunities brought about a surprisingly high attendance rate of women in the information, nomination and election meetings. Female attendance rates were even higher than targeted (44% as compared to 33% target). A total of 110 ChWMCs and 15 SCWMCs have been put into place. Women constitute 453 members of the total of 1,240 ChWMC members (37%), and 127 members of the 399 SCWMC members (32%). Twenty five percent of the office bearers of the ChWMC's are women, whereas this percentage is 27% for the SCWMC. Most women are cashiers, but in the ChWMCs 47 women have also been elected as Vice-president. Women committee members are representatives of the various categories of female stakeholders: female farmers from high, medium and low land, fishery women and landless women. During Phase I of the project, five women were represented in the Water Management Committee at Compartment level (at that time entitled Project Council). During the Final Phase this Project Council was reformed in a temporary committee, called the Compartment Forum. There were no women members. This is on the one hand a consequence of the composition of this Forum, which was mainly composed of male WMC presidents and vice-presidents. On the other hand, it is due to a number of problems and uncertainties related to the role and composition of the Forum. Table 3 gives an overview of women's representation in the WMC during the two phases of the project.

		No. of WMC formed	Total members	No. of women	% of women	% of female office bearers
PHASE I	ChWMC	99	891	-	-	-
	SCWMC	15	269	29	11%	0.2%
	Project Council	1	79	5	4%	-
THE FINAL PHASE	ChWMC	110	1240	459	37%	25%
	SCWMC	15	399	127	32%	27%
	Compartment Forum	1	32	-	-	-
Table 3: Women's Representation in WMCs						

Women's Participation in WMC Meetings and Decision Making

Women appeared eager to attend the WMC meetings. CPP's monitoring data as well as the results of a survey on women's level of participation in water management (1999) confirm that most women committee members actually do so. Women's

attendance rate was highest among the Executive Committee (EC) members of the SCWMCs and lowest among the members of the ChWMCs. Women from these executive committees appeared also to participate more actively in the discussions and sometimes in decision making. They were relatively well informed on the tasks and responsibilities of the WMC, whereas the level of understanding of female members of the ChWMC was rather low. This was mainly because the members of the SCWMC and the ECs have received more training (including gender training) from CPP, than the other committee members.

Network Meetings

In Phase I, 15 network meetings were held with women members of the Sub-compartments, whereas in the Final Phase, female members of the ChWMC also participated in these meetings. These meetings were well attended and appreciated by the women and have enabled them to exchange experiences on water levels, on flood protection, and on other water related issues. It helped them to better understand the water management system in their area and it allowed discussion of the role women could play in the committees.

Lessons Learned

For both men and women in rural Tangail compartment, the participation of women in public meetings was a rather new phenomenon. Nevertheless, it appeared that it was possible to break some of these gender barriers, because the women were very motivated to get involved. It should be recognized that the representation of women in the water management committees does not automatically imply that the majority of women will be involved in decision making on structure operation and water control problems in their area. Although training activities have helped to increase the acceptance of women's participation in the committees, social stratification and patriarchy in rural areas in Bangladesh are very strong, so that it cannot be expected that in a few years traditional decision making patterns can be turned upside down.

Nevertheless, an increase in the level of women's self-confidence and self-esteem was visible. Factors that appeared important to achieve women's representation in the water management committees were:

- The involvement of the WID section in all phases of the reformation process (from planning to implementation, to monitoring);
- The elaboration of a clear strategy and division of tasks and responsibilities;

- The special attention paid by the WID section to invite women and stimulate them to participate in the meetings, as well as the involvement of female facilitators;
- The preparation and use of a number of visual aids to discuss women's role in the family and the community and the 'why' and 'how' of women's participation in the committees;
- The systematic use of monitoring formats; and
- The support from project management.

The creation of opportunities for women's participation needs a high level of motivation of the project field staff and a close monitoring of the various steps in the process. Constraints that impeded the process of women's involvement in the WMCs were, therefore primarily of institutional nature. They had among others to do with the lack of experience and motivation of male staff members, as well as with the limited number of WID field staff when compared to the amount of inputs required.

Women and Agriculture

The assumption that CPP's improved water management would result in changes in farmers' land use and cropping patterns has guided the design of the agricultural program. It focuses on two main activities:

- Impact monitoring of changes in seasonal growing conditions and in land use; and
 - Participatory assessment of new cropping options, through on-farm testing and demonstration of appropriate new technologies, in order to explore with the farmers how they can adapt their land use and improve the productivity of farming.
- This program is called the On Farm Testing and Demonstration (OFTD) Program .

The programs are executed in close cooperation with the Department of Agriculture (DAE) and with the Bangladesh Agricultural Research Institute (BARI). During the first phase of CPP, the agricultural program also included crop demonstration activities.

Gender Issues

Women farmers were interested in increasing their knowledge and skills in agriculture, and improving their access to new resources and technologies. Consequently, the Women and Development objective defined in the framework of

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CPP - agriculture was to develop approaches to increase the knowledge and skills of women farmers and their access to and control over new appropriate technologies.

A number of specific gender issues needed attention. Male and female farmers have different access to agricultural inputs, play a different role in decision making and do not have the same control over the outputs. Since women's role in agricultural production is less visible (taking place at bari level), implementing agencies tend not to perceive women as farmers. Differences in tasks and responsibilities in agricultural production are not only determined by gender, social class and age, but depend also on women's position in the household. Women heading or managing a farm household on their own (widows, single women, and wives of husbands with another occupation) tend to be fully in charge of decision making and organization of the farm work. Women whose husband is also engaged in farming have less control.

Implementation Strategies

CPP's main WID activities in the field of agriculture were farm training for different categories of farm women, and women's participation in the OFTD program.

During phase I, CPP's WID program has organized various farm-training activities in cooperation with DAE and CPP's agricultural section. The trainees were heads of farming households, members of Sub-compartment Water Management Committees and wives of the demonstration farmers engaged in the T. Aman demonstration program. The training included both classroom sessions and field visits. A total of 49 women farmers participated in the training. The training appeared to be much appreciated and showed that women were not only very eager to learn new skills, but that they would like to increase their access to new technologies, preferably in terms of crop diversification. Consequently, CPP decided that the Final Phase activities in the field of women and agriculture would focus on women's participation in the on farm testing and demonstration program.

The On Farm Testing and Development Program was setup in the four pilot chawks with the aim to test and demonstrate new cropping options and technologies together with interested farmers. CPP's agricultural section implemented the program in co-operation with DAE, BARI and CPP's WID section.

A first step in the OFTD program was the execution of a Participatory Rural Appraisal (PRA) with a view to better understand the situation of the farming communities, their agricultural production patterns, and to ask their priorities for agricultural

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interventions. By adjusting the PRA methodology and tools in a gender specific way, major differences in interests, constraints and opportunities between male and female stakeholders were identified.

This information formed the basis for the design of a WID component in the OFTD program. It was envisaged that a distinction between female headed/managed farm households and male-headed farm households would be made and that there would be a focus in first instance on the involvement of female-headed farm households. It was thought that mainly women managing or heading a farm household would be interested to participate in the OFTD, because they were able to control the new technologies and to make their own decisions. Therefore, they should be supplied with the same options as male farmers who wanted to be involved in the program. Further data on female headed/managed households would be collected, to confirm the relative high representation of these households. This was not done among others because the staff was eager to start up the program as soon as possible. They wanted to involve as many women farmers as possible, both from male and female-headed households.

The WID section has been active in inviting women farmers for the meetings, in the identification of interested female farmers, as well as in providing additional support to female farmers when required. Special meetings with female farmers were organized to exchange experiences. When it appeared difficult to ensure that women farmers were put upon the 'shortlist' of interested farmers, the OFTD approach gradually changed into a 50-50 gender approach. In each household one man and one woman were identified and trained to participate in the program.

Results

Analysis of the results shows that among the participating farmers, men outnumber women with: 579 male against 283 female farmers participating in the OFTD program. These differences developed during the first year of the program, when men and women were identified individually. They could only qualify if they had a suitable plot of land. This was more often a problem for women than for men, since only few women own land. It was in any case a problem for the field staff, because more effort was required to find women farmers who had control over a plot of land that fulfilled the criteria. But, although the number of women farmers involved during this period was smaller than that of men, the benefit for those women farmers was that they were able to take decisions in their own right.

When in the early 1999 the program started to involve male and female household members, the balance between participating male and female farmers became equal. This does not imply that both male and female farmers benefited to the same extent. Analysis of the level of adoption of the new technologies and of the attendance rates of male and female farmers in meetings organized by CPP/DAE, showed that women were in particular interested in summer vegetables and mustard. Male farmers took up the new rice and jute varieties more easily. Women's interest in summer vegetables (okra, Indian spinach) appeared to be related to the fact that these crops were traditionally considered a woman's crop. This implied that the women had more control over the outputs and were able to take decisions on the product (what to use for own food, what to sell). This was not the case for new varieties of jute and rice that were tested during the OFTD program, that appeared primarily a men's affair. Women were also more interested in, and positive about the, introduction of new mustard varieties, because they use the seeds for household purposes (oil) and for their skin. It was too early to assess the adoption rate, because the experiences related to mustard concerned only one rabi season. Generally, the women spent the money on household purposes and on the education of their children. Although the head of the family generally owned the plot of land, this appeared not to be an influencing factor. Men also appreciated the replacement of jute by vegetable production because it was economically more attractive.

Box 1 Example of a Female OFTD Farmer Cultivating Okra

Tara Banu is a female farmer in pilot chawk 28C. She and her husband, Sumejuddin, are both farmers and have 50 decimal* of land for jute, 45 decimal for paddy, 100 decimal for irrigation. She owns no land of her own. The OFTD field staff requested her to participate in the test program for a high yield variety of okra during kharif I. She received the seeds from CPP in May and started to cultivate okra on 10 decimal of land that was formerly cultivated with jute. After one and a half months, she could start to harvest the okra. She harvested every two days 10kg, of which 1-kg was used for home consumption and 9 kg were sold for Tk 10 per kg. Her son sold the okra at the market but she could decide on her own what to do with the money. In total she has earned Tk 2500 during the production period. When used for jute the same 10 decimal valued only Tk 1000.

* 1 decimal is 40m²

Lessons Learned

Various WID agricultural activities have been tried out during project implementation. In addition to farm training and OFTD, these included compost making with landless women and demonstration vegetable gardens. The last two activities appeared to be unsuccessful for a number of reasons, in particular:

- Wrong target group and design (compost making); and
- Top-down implementation, leaving little space to the women to make their own choices (vegetable gardening).

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Other lessons learned are based on the experiences gained in the OFTD program. At institutional level, the program was confronted with a number of constraints. These concern in particular the lack of female agricultural extension staff, insufficient motivation for gender equality among male OFTD staff, insufficient specification of the division of roles and responsibilities between the WID and agricultural sections, the limited number of WID field staff and their lack of agricultural experience. Although gender awareness training has been organized to increase the level of motivation of the male actors, and agricultural training for the WID staff, it took a long time before these efforts started to show positive effects.

During the implementation of the OFTD program, various changes in the gender approach have been made. These concerned a shift from female-headed/managed farm households towards male-headed farm households, from involving women on an individual basis towards involving one male and one female member of each household. These changes took place based on experiences. The implications of these changes were not sufficiently analyzed beforehand. This would have allowed identifying the differences in control over the various technologies between male and female farmers, and consequently, their level of motivation and benefits.

The inclusion of gender issues in the PRA activities as well as in the OFTD program would have been more effective if more time was reserved for the preparation. This would have allowed to better agreement on institutional arrangements and the division of roles and responsibilities between the actors involved in the implementation of the program. Additional steps and efforts that were required to involve female farmers heading/managing a household could have been identified better and discussed with the (male) field staff. A regular assessment of and discussion on results and problems encountered with all actors involved would have allowed understanding the gender differences in interest and control. In this way, the testing and demonstration activities for summer vegetables and mustard could have been addressed more directly to female farmers and those for high yield variety (HYV) rice and jute to male farmers. This would have improved the balance between male and female farmers in terms of participation, benefits and control over the outputs.

Embankment Maintenance Groups

One of the WID objectives of CPP from the beginning onwards was to setup income generating activities with poor and landless women in order to mitigate the expected negative effects of the project on this category of women. In the framework of CPP objectives, earthwork seemed to provide the best opportunities. A considerable part

of the infrastructure of the compartment is composed of embankments, of which the crests and slopes are liable to erosion and damage due to human, animal, rain or flood influences. A comparison between the different types of maintenance required to keep the embankments up to standard, showed that preventive maintenance needs a high frequency of repairs and a relatively low amount of earthwork. Preventive maintenance was, therefore, identified as an activity that was in particular favorite to the involvement of women who could be organized into Embankment Maintenance Groups (EMG). The setup of an Embankment Maintenance Group program with poor and landless women would therefore serves two purposes:

- To create employment opportunities for poor women; and
- To realize preventive maintenance of the embankments.

The EMG program was implemented from September 1995 until October 1998. A total of 100 landless women from the poorest group of society participated in the program. From the beginning onwards the sustainability of the program has been a difficult issue. When CPP looked for partners at the start of the EMG program, it faced the limited implementation capacity of the BWDB and the lack of interest of NGOs to participate in the program. Alternative institutions were looked for and it was thought that the Sub-Compartment Water Management Committees (SCWMC) could finally be in charge of the management of the EMGs. To start up this process, the WID section would function as Affiliated Agency, and execute a liaison function between the BWDB and the EMGs. Once the implementation strategy would appear effective and successful, the SCWMC and BWDB/office of the executive engineer should take over the program.

Implementation Strategy

As affiliated agency, the WID section was in charge of the recruitment of the female laborers. Women belonging to the poorest of the rural poor were the targeted participants in the program. The women had to be in good health, their family members dependant on her wage labor, and they should not own any agricultural land. The women needed, of course, the willingness to work on the embankment. Preference was given to women who were divorced or separated, and to women who had no alternative source of income, because these women are worse off than others are. Since more women than needed showed an interest in participating in the program, it was possible to sharpen the selection criteria in favor of the most disadvantaged women.

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In most cases, women were recruited with the help of influential members of the Union Parishad and/or SCWMC. This appeared to be an effective strategy, since they knew the poor women of their area, and also because the women needed their support. They contributed to the fact that their presence and work were gradually accepted and appreciated by the communities. Opposition came in particular from landowners who created problems for the women when they wanted to take earth from their land.

One hundred women benefited from the program. They belong to the lowest classes of the society and are generally very poor. They are all landless women, heads of a household, widows, divorced women or married women whose husband is ill or without work. Before being engaged as an EMG the women were either without work, or had temporary jobs as house servant (without salary, but paid in kind), bidi (indigenous cigarette) makers or seasonal agricultural laborers. More than half of the women were beggars. The EMG included women from the fishery folk community, but only a few divorced or separated women from farm families were involved.

Box 2 The Case of Rahela

Rahela lives in Gala village in Tangail District. She was married 12 years ago, when she was still very young. She had one son, but he died. After his death her husband married again and divorced her. She came back to live in her father's house. However, her father was very old and poor and could not take care of her.

May 1996, the UP chairman of Gala appointed her as an EMG member in the CPP project. She was elected as group leader of the EMG Pichuria-Gala. As a leader she was responsible for taking the group salary from the bank, distributing the money to the group members, registering the attendance, raising her voice during training activities, and providing information on the flood and emergency situation to CPP. To perform better, she started literacy courses with a private teacher. At that time CPP's WID section had also started a nine months literacy course. She learned and encouraged her group members to read and write. Her daily wages were Tk 45 from which she received Tk 35 in cash and Tk 10 as savings on her individual bank account. With her salary, the living conditions of her father and herself improved. During the devastating flood of 1998, she and her group played a vital role in patrolling, repairing and warning.

When the EMG work stopped at the 31st of October '98, she became unemployed, but she does not want to go back to her previous situation. She has Tk 8,835 at her savings account. With this money, she bought land to build her own residence. She also leased some land, from which she gets an agricultural yield. Recently her father died.

Women's motivation to participate in the program was high. This was not only shown by the low drop out rate (only 5 women dropped out during the three years of implementation of the program), but also shown by their sense of responsibility. During the 1998 monsoon the women worked many hours overtime, for which they were not paid, but which they justified by saying that they felt it their responsibility to do as much as possible to keep the embankment in shape. They also played an active role in patrolling and frequently went to CPP office to inform the staff about new rat holes, public cuts or other damage done to the embankment.

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The most relevant role the EMGs have played in the framework of CPP has been their work in the field of patrolling. Through an effective early warning system developed by the women, they have helped CPP/BWDB to react quickly in the periods of emergency and flood. Secondly, the EMG's preventive maintenance work has improved the conditions of the roads on the embankment, and have made transport facilities more accessible and cheaper for the inhabitants of the area.

According to observations of the women themselves and of other women from the communities, the acceptance of female earth laborers in the area has broken certain gender barriers, since earth work was commonly considered a man's task.

The EMG women perceived the fact that they earned and received money in cash on a regular basis the most important direct benefit for them. It enabled them to contribute to the living of their family, and it increased their access to resources. Some women were able to obtain loans, others provided loans themselves. A few women improved their control over resources through investments with the money saved. One of the women, for instance, bought a rikshaw with her savings, another a cow, whereas a number of women leased land for agricultural production or bought land to build a house. (See Box 2). An estimated 10-15 women have in this way managed to obtain a better perspective for the future through investment of the money saved. Most of these women have worked for a total period between 2 and 3 years.

Not all women perceive the above-mentioned improvements positively. Frustrations were expressed by a number of women, who after the closure of the project, or the termination of their contract, have not been able to use the savings for investments in new income generating activities. They had no choice but going back to their former situation (maid, seasonal agricultural laborers, etc), with the frustration of knowing that life can be better.

Lessons Learned

The costs of EMGs are relatively high, not so much in terms of financial resources (Tk 30,000 per kilometer per year), but more in terms of staffing and human resources. An estimated 10 person-months of management staff and 64 person-months of field staff have been utilized to run the program throughout the three years. It is difficult to weigh the costs of the program against the outputs and effects, because the major results of the program have a qualitative nature (maintained embankments and improvement of women's social status and self-esteem). Development activities with very poor and illiterate women do by definition require high inputs of human resources.

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CPP's WID section has invested substantial time, staff and energy into program, by providing regular supervision and assistance to the EMG women. In combination with the setup of technical and social training courses, this strategy seems to be an effective way to empower these marginalized women. It has opened new avenues for them in particular through an increased self-confidence, knowledge, mobility and skills. Nevertheless, it should be recognized that the 100 women, who have participated in the program, constitute an estimated point one, of one percent, of the total category of poor landless women in the project area.

Effects on Women's Position

During project implementation, various methodologies have been followed to assess to what extent CPP interventions have affected the position of various categories of women, compared to men. Interviews were held with individual women, case studies made and two surveys were held on the level of participation and satisfaction on water management among female WMC members. During the 1998 monsoon, the WID section organized a series of 11 focus group discussions with specific categories of women to assess the effects of CPP structures and interventions on their position. The purpose of these group discussions was to improve CPP's understanding of:

Women's perception of the most important changes in their life during the last ten years (with a focus on their daily activities and access to/control over the resources)

- Factors that have influenced these changes in women's life; and
- Possible relations between the influencing factors and CPP structures and activities.

A total of 132 women from different locations in the CPP area participated in the group discussions. They were representatives of women from the fishery community, large and medium farming households, small and marginal farmers and landless women.

Most information have a qualitative nature. Although it was not always easy to distinguish the effects of CPP interventions from other influencing determinants, analysis of the perception of the women, in combination with data from agriculture and engineering, has given indications on the way different classes of women have been affected. It appears that the effects on these groups vary substantially. The differences are primarily related to their access to resources.

Changes in Women's Economic Position

Monitoring data from CPP's agricultural and engineering sections confirm that CPP's interventions in water management have brought about a reduction in flooding and a shift in land types. The subsequent changes in land use, production methods and yields have increased the agricultural production in the area. Although changes in land use and cropping patterns also occur in other areas of Bangladesh, comparison between the CPP monitoring data and other Thana's confirm that the overall increase in the CPP area was by far the highest (see Annex E). Taking into account the average changes elsewhere the results of data analysis in CPP area showed that between 1993 and 1997 there was an estimated:

- increase in total HYV T. Aman by 164% (963ha),
- increase in local T. Aman by 21% (416ha), and
- reduction in Deep Water Aman by 26% (775ha).

During the past seven years CPP's fisheries section has collected monitoring data on capture fisheries. Analysis of the data shows that the impacts of CPP on capture fisheries can be considered neutral. The team concludes that there are no changes in the average catches of fish in the area (by professional, occasional, and subsistence fishermen) and that there is no reduction in the average income of the professional fishermen.

Access to Means of Production, Income and Expenditures

During the interviews and focus group discussions, women mentioned the change in cropping patterns as an important benefit of CPP, and in particular a change from two to three crops and an increase in HYV T. Aman cultivation. Whereas the women mentioned CPP as an important determinant, other actors and factors have also played a role in these developments. According to their views the main reasons for these changes were:

- An improved access to HYV seeds, knowledge and technology, which is a general trend and development in the area;
- The psychological effects of CPP: the CPP structures, in particular the Main Inlet and the major operational WMC structures bring about an increased feeling of safety among the farmers; and
- The increasing role of national and local NGOs in the area, and in particular their credit programs.

These changes have not affected all categories of people in the same way. They depend among others of the location of the chawks in the area and the type of land farmer's own (high, medium or low land). The major distinctions in ways women and men are affected appeared not to be related to land type and location, but to social stratification, occupation and land ownership. Different effects can be observed, depending if one belongs to the class of poor landless people, small and marginal farmers, large and medium farmers or fishery community.

Large farmers seem to have benefited most from the changes and improvements. They make up 5.3% of the farm households and own an estimated 21% of the land. Their high level of access to resources (land, credit, inputs, labor, and sharecroppers) has enabled them to adjust their cropping patterns to the changing environment and

to improve the productivity of their land. The women of these farm households primarily mentioned the positive effects of the economic benefits and the increased income of the household. Medium and small-scale farm households make up slightly more than 65% of the farm households and operate more than 70% of the land. They benefited from compartmentalization to the extent that they had access to the resources that enabled them to invest in HYV and changing cropping patterns. Women from these households tended to be very active and motivated to improve their farm productivity, but they still complained that they did not get the required extension and training by DAE block supervisors.

Marginal farmers' households have benefited less than the other categories of farmers, because they have little access to the resources that would have been necessary to bring about the benefits of the improvement in agricultural production, made possible through compartmentalization.

As a consequence of the increased agricultural production, the demand for agricultural labor, either as hired workers or as sharecroppers, has increased. During the interviews with the women, they gave various examples of their increased access to land for sharecropping, and to employment opportunities as seasonal agricultural laborer. These new employment opportunities tend to be less accessible for landless women, because they often do not have the required skills to do this work.

The access to new agricultural technologies (modern varieties seeds, knowledge, skills) for a number of male (579) and female (283) farmers has increased through the implementation of the OFTD program. These farmers are mostly small and medium scale farmers, including households headed or managed by women. As previously indicated, the women farmers have benefited most from the new summer vegetable technologies, because they have a high level of control over the produce.

A total of 200 women and men from the very poor farming, fishery and landless households have benefited from new technologies in the framework of a homestead Magur (catfish) culture program, the Chari in the Bari Program. The project has sold fish fry to these families and given them advice on how to construct a small feeding bucket (Chari) or a hole in the ground of 1m², in which they grow 50 catfish (See Annex F). Although both men and women of the household were targeted and involved, the women and the children basically do the work, mainly feeding of the fish, since the activity is located in the bari. Women, therefore, appear also to be the ones who can take decisions on what to do with the fish (own food, sale) and what to do with the money received.

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The newly developed activities that were either meant to benefit women specifically (EMG), or considered to be a "woman's business" (Chari in the Bari, OFTD vegetables), gave women most of the control over the income derived from it and subsequently more decision making power over the expenditures. In general, it is still the husband who has most of the control over the family budget, although women's participation in decision making on expenditures seems to increase, in particular when her own contribution to the household budget increases. In that case, she can use some of the family funds according to their own wish, especially money derived from her own productive and income earning activities.

Access to Water

There are no clear indications that CPP has caused any changes in access to water, which have affected women in their reproductive and productive work. When asked, women stated that they do not encounter major problems in finding water for their household and productive activities. Most of the households have a tubewell for drinking water, or at least have easy access to one of their neighbors. It is not clear if this was also the case during the dryer years during the project period (1992 and 1994) since no data have been collected to study women's water use. During the project period, the number of shallow tubewells for agricultural production has increased rapidly. Between 1997 and 1999 the number of shallow tubewells in the CPP area grew from 880 to 1,400.

Access to fishing water constitutes a major living condition for people from the fishery community. The fishery community comprised an estimated 355 households with roughly 2,000 people, but their number decreased in the past years to 300 households. The fishermen and women live in concentrated areas in the compartment. They are Hindus and belong to the lower classes of society. Fishing was a full time occupation and a man's job. Gender roles and responsibilities were fixed, with the men fishing during the day and providing the income, and the women taking care of the household and the family. The women also made nets.

In the last ten years, the access to open fishing water for fish capture has decreased for professional fishermen from the fishery community. As indicated in Annex F, there are three main problems the professional fishermen are facing in this respect. These constraints are not directly related to CPP, but are as follows:

- Beel owners have started to protect their beels as a consequence of the fact that culture-based fisheries appeared to be a lucrative activity;

- Jugini beel that was formerly leased out to professional fishermen is taken over by the mastaan in 1992/93 who were the first to introduce culture based fisheries; and
- There is a sharp increase in the number of occasional and subsistence fishermen over the years and the professional fishermen feel that they are being pushed out by other fishermen.

Because of these problems, the situation of the professional fishermen has deteriorated. Whereas formerly they had the monopoly on capture fish, they now have to share the diminishing resources with an increasing numbers of other fishermen.

Consequently men, as well as women, from the fishery community are now-a-days looking for work outside the fishery community. The men try to find work related to fish because, as they say, "It is the only job we have learned". Sometimes they succeed in finding jobs such as net making and netting in farmers' ponds, but more often the men try to develop a business, to become rickshaw pullers or van drivers. But the women also have to cope to make ends meet. While formerly their main tasks were related to household work, at present the women of the fishery community go out and look for jobs, such as earth laborer, maid servant and seasonal agricultural laborer. Their low status in society, high level of illiteracy, as well as lack of professional skills, form considerable constraints to their success in finding work.

Division of Labor and Workload

The increase in production from one to two, or from two to three crops, as well as the change towards HYV paddy production, has brought about an increased workload for all categories of farmers, for men as well as for women. A slight change in the gender division of labor has been observed, with women taking up more productive activities than before and men sometimes assisting the women in household related activities. As a consequence of more crops, women have additional work to do in pre-harvesting and post-harvesting activities, such as selection, preservation and germination of seeds, preparing seedbeds, transplanting seedlings, weeding, preparing food for (more) laborers, threshing, winnowing and storage. Men prepare the land and are in charge of subsequent activities in the production process. They go to the market to sell the products and buy the necessary things for the family.

In general, women work more hours than men, go to bed later and have less leisure time than their male counterparts. This is a consequence of their double burden of both household tasks and productive activities. Although there are differences per

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season, women from the poorer farm households tend to make between 12-16 working hours a day, whereas for men this varied between eight and 12 hours (see Appendix 2).

The changes in the division of labor and workload are not the same for all categories of farmers. For women of large and medium scale farming households the additional workload focuses on the supervision and management of the agricultural work in the homestead, although sometimes their own involvement has also increased. The latter is more the case for medium scale farmers than for women of large farms.

Men and women from small and marginal farming households tend to do all the farm work on their own, since they do not have the extra money required to hire agricultural laborers. In earlier years, women's work was mainly bound to the homestead, or sometimes to working in the house of richer people. These days, men and women mentioned that they are working harder and that they do more activities together in productive and agricultural work to make ends meet. Women also work in the chawk when this is needed. This is a general phenomenon. It seems not directly related to CPP interventions, except for those cases that small and marginal farmers have grasped some of the new opportunities that are created by the changes in cropping patterns (e.g., lease additional land, work as seasonal agricultural laborer).

Effects on Women's Social Status

One of the major results achieved in the field of women and development is an increase in the self-confidence and self-esteem of a number of women. This was the case with women members of SCWMCs, in particular, those women who are member of the executive committees. They are less afraid to give their opinion and to argue their views than when were elected as a WMC member. It was also visible among the EMG women. During the period of contract, they were gradually more respected by the community, more accountable in the eyes of shopkeepers, and their mobility and courage to undertake things increased. In cases of emergencies (cuts in the embankments, flood damage), EMG women played an effective role in warning CPP so that immediate action could be taken. The training in preventive maintenance, in literacy, health and in operating a bank account increased the knowledge and skills of the women. Group leaders and secretaries developed leadership and organizational skills that were not only useful during the contract period but, according to them, also helps them in resolving problems in their daily life. Whereas in the beginning of the contract period most women were not used to discussion with people of other social classes, or even to sit on chairs during training sessions, in the course of the program, their attitude changed, and their self-confidence and self-image increased visibly.



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CPP has made serious efforts to involve women in the water management committees and in WMC meetings. For most women and men in the chawks, this was a rather new phenomenon, and was not easy to achieve. By making some adjustments in the approach (time and location of meetings, motivation of members of the family by the WID staff) and by providing regular training to the WMC members, some of these gender barriers have been broken. The majority of women did not yet have a meaningful say in the meetings or in the committees. Male domination is too strong to expect that this could have been the case. At household level, it seems that women's decision making power has increased to some extent, in particular because of their higher contribution to the household income.

It should also be noted that the female CPP WID staff have functioned as a kind of role models, by visiting women on their own, and by making use of motorcycles, which is not yet a common phenomenon in Tangail Town and surrounding rural area.

Lessons Learned, Conclusions and Recommendations

Project Design and the Scope for WID in CPP

Two major shortcomings in project design and preparation have negatively influenced the effective involvement of women in CPP:

- The limited allocation of resources to women and development; and
- The poor concept of "women's involvement".

According to the ToR, CPP should pay "special attention to the involvement of women as a disadvantaged group, by providing them with employment opportunities". No concrete objectives were formulated in this respect. Financial allocations for women were limited to EMG, and only one part time national female sociologist was charged with the task of "paying attention to women" (Inception Report 1992). Gender expertise was not included.

As a result, it took CPP almost four years to identify relevant and acceptable WID objectives, so that many activities have been undertaken without a clear perception on the why's, how's and who's of women's involvement. It could have been avoided by including gender expertise in project identification and design.

Considering women as a disadvantaged group who can be helped through employment opportunities is not consistent with the project objective of "people's participation" (men and women). Nor is it in line with the women and development policies of the donor agencies that require among others that women should be active participants in project design and implementation. The concept is in line with the chapter on the Water Resources Sector in the Fifth Five Year Plan of the GoB, where women's role in flood related projects is primarily perceived as workers in construction and maintenance of the embankments. This itself is in contradiction with the main WID aim of the FFYP i.e., to "reduce gender disparity in all sectors through the integration of women into the mainstream development efforts".

The interests of women related to water control appeared to be the same as those of men. They are related to the category of households women belong to, and to the main occupation of the husband, except for those women who head a (farm/fishery) household on their own, or whose husbands are employed elsewhere. As is the case with men, the main differences in water interests of women are based on land types (high, medium, low), occupation (farm, fishery, other), as well as on social class. Although women's tasks and responsibilities differ from those of men, in particular with respect to their reproductive activities, it appeared that most of these needs could be addressed due to the relative high density of tubewells in the area.

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The main gender issues, therefore, in the context of a compartmentalization project as CPP, are related to women's low social status in Bangladesh society and to their lack of rights. This requires special measures to address the constraints that women encounter in their access to information, knowledge and resources, and special attention to women's requests to participate in project activities and in decision making on an equal footing with men. Gender issues in CPP are, therefore, issues of gender inequality.

Implementation of the CPP WID Program: Approach and Constraints

The choice to combine a mainstream gender approach and a women-specific approach was a sound choice.

The inclusion of farm, fishery and landless women in WMC was important and necessary although it has been argued by some that farm women are conservative and will not have a voice in decision making. The experiences in working with the farm women have shown that:

- They are both directly, and indirectly, affected by changes in water levels;
- Women farmers are a relatively forgotten group in development activities in Bangladesh. They are very keen to have access to the same information as their male counterparts;
- For most of these women it was the first time that they were recognized as farmers and became member of an organized group;
- They have an eagerness to learn, and the potential and willingness to link with other female farmers in their living area; and
- They can function as an entry group to organize specific training and other activities that answer their needs.

In the particular case of CPP, time was too short to fully develop this potential. It was only at the end of the second formation process (the so-called reformation process) that farm women have been elected as water management committee members. Their membership started to be effective from 1998 onwards. Although from that time the WID section organized special network meetings with the women, it can be concluded that the empowerment of these women will take much more time than the time frame of CPP allowed.

More results could have been achieved had clear WID objectives on the role of women in water management institutions been formulated from the beginning. Together with

the allocation of sufficient resources for WID, it would have allowed a period of seven years to empower women, whereas at present only two years were available for this purpose.

Other constraints encountered in the implementation of a gender sensitive approach in CPP were primarily of an institutional nature:

- For a long time, tasks and responsibilities of the members of the water management committees remained unclear and unfocused. This was due to the complexity of the water management system, and to technical design problems encountered. This was a problem for male as well as female committee members, but is more relevant for women, because their limited role in community development/public affairs requires extra justification, towards the women themselves, but even more so towards the men;
- Whereas the recruitment of a new WID field staff has only materialized halfway through the Final Phase of the project (between November 1997 and March 1998), the recruitment of female staff in other project sections appeared difficult to realize;
- The creation of a full fledged WID section with field staff halfway through the Final Phase of the project allowed it to do the actual fieldwork required (in particular for EMG, ID and OFTD). It has, at the same time, created a substantial imbalance between the WID section (female) and the other sections of the project (all male). In addition, it took some time before the relatively young and inexperienced field staff of the WID section was accepted by the other sections of CPP. Well capable of motivating and empowering women, they did not have the power to influence the behavior of the other CPP sections staffed with older and more experienced people;
- Gender awareness and motivation among management and staff of the BWDB is very low, and traditional perceptions on women's subordinate position and role in society are strong. Co-operation with the BWDB in the field of WID appeared very difficult. It is not expected that this will easily change; and
- The cross-sectoral character of Gender and WID issues requires a good team spirit, coordinated planning and effective co-operation between different sections/sub-programs of a project. This was not always the case. In addition, the institutional setup with mainly short-term expatriate consultants, and mainly local consultants in the long term positions on the CPP team, did not favor the required co-ordination and cooperation. The frequent shifts among local consultants and the change of staff between Phase I and the Final Phase, were other handicaps that had to be dealt with.

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The WID section organized regular gender awareness training to overcome some of the above mentioned constraints. This has indeed created a better understanding of the why's and how's of women's participation. More effective than general gender awareness training, appeared to be the organization of regular meetings between the sections, and the setup of section-wise training. This training was a combination of gender awareness (for technical staff) and technical training (for WID staff). This type of training answered a concrete need, allowed for institutional arrangements between the sections and improved the cooperation.

Sustainability of Results

Technical Sustainability

The most successful WID activities of CPP have been women's involvement in OFTD, in the Chari in the Bari program, and in EMG. These programs have increased women's control over new technologies, in particular, summer vegetables and mustard cultivation, catfish culture and preventive maintenance techniques. It is not yet clear to what extent these results will be sustained in such a way that the women will in future be able to take it up on their own. CPP has taken various steps to increase the chance for independent continuation by the women and men. These include the involvement of local fish fry traders in the Chari in the Bari program; the advice to preserve seeds of the new agricultural technologies, and contacts with the WFP for their take over of the EMG program. There are, a number of constraints that might hamper the sustainability. They are not all within the control of the project. Examples are the risk that high quality seeds might not become sufficiently available in the project area, as well as the fact that men tend to take over activities from women as soon as they appear profitable. It was only to a limited extent that the CPP's women and development program was able to improve the conditions for sustainability. This has been done for instance by bringing the women in contact with local fish fry traders and by organizing study tours and exchange visits with women farmers and WMC members from different areas.

Institutional Sustainability

Women's involvement in the water management committees has contributed to some improvement in the social status and self-confidence of a number of female committee members, in particular the members of the SCWMCs. The majority of female committee members will hardly play a role in decision making in water control matters in the future. This is not only because project time was too short to empower women sufficiently to make their voices heard. It is also due to the existing male-

female relations in rural Bangladesh that are characterized by male domination and oppression, with the men not willing to shift some of their present influence and power to women. In addition, the fact that the BWDB is supposed to take over the CPP activities makes it very unlikely that the women will receive any support in the future.

During the implementation of the EMG program, CPP's WID staff has closely cooperated with the Bangladesh Water Development Board (office of the executive engineer), who handled the technical and financial matters. CPP's WID staff was in charge of the overall supervision of the women and has done so by paying ample attention to strengthen the abilities of the women with a view to improve their social and economic condition. This was done among others by organizing regular training courses for the women, by visiting them at least twice a week, and by assisting them in team building and problem resolution.

It is foreseen that the EMG groups will be taken over by the national EMG program that is financed by the World Food Program and executed by the BWDB in close cooperation with a number of national NGOs. These NGOs do not seem very motivated to participate in the program, because they don't receive overhead costs for their efforts. In addition, the overall approach that is followed does not include a number of the elements that have made CPP's EMG program successful, such as the fact that:

- The women received their salaries in cash, whereas the BWDB/WFP pays the women in wheat. Each EMG woman received a daily salary of Tk 35 that was transferred to a group account;
- In addition, CPP has opened individual bank accounts for the women, to which their obligatory savings were transferred. (Tk 10 per day). This money was not to be touched during a certain period of time;
- Much attention has been given to strengthen women's abilities, e.g., by providing training in functional literacy, in organization, team building and conflict resolution and in operation of a bank account; and
- WID staff visited the women during working hours regularly.

Although this implied substantial staff inputs of the WID program, the results of the EMG program showed that this was worth the efforts.

CPP's agricultural OFTD program was executed as a cooperation agreement between DAE, BARI, CPP's agricultural section and the WID section. In practice, the agricultural

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section was mostly in charge, with the female field staff of the WID section taking care of the women farmers. Although the DAE Block Supervisors (BS) have participated in the program, it is questionable if they will pay special attention to women farmers' needs in their future activities. This is among others because insufficient attention has been given to create a basic level of gender awareness among the (mostly male) BSs. However, it is also due to the standard top-down attitudes and procedures used by the BSs when they address the farmers. This left little room to achieve improvements in their behavior towards women.

The limited sustainability of the women and development activities can not only be attributed to factors such as a lack of gender awareness or male attitudes towards women. Designed as a test program under the authority of the BWDB, CPP's scope for sustainable women and development activities is limited. WID has primarily focused on the creation of conditions for women's participation for which task it appeared difficult to find an appropriate local GO or NGO.

Guidelines for WID: Do's and Don'ts for the Next Time

CPP's interventions in water management have brought about a shift in land use and an increase in agricultural production. As can be expected of a project that improves the conditions for agriculture, women and men from large farm households have benefited most from these improvements, because the project improved the productivity of the land. They constitute the smallest group among the farmers but they have the highest access to the resources required to adjust their cropping pattern to the improvements. Those small and marginal households that have been able to lease additional land or to find work as seasonal agricultural laborers have improved their situation to some extent. However, in general, it can be said that the women and men from the poorer farm, landless, and fishery households have barely benefited from CPP interventions, because they do not have land.

The experience has shown that in the framework of compartmentalization, a number of successful economic activities can be developed with a view to increase women's access to new technologies, productive resources, and income, as well as their wish to be informed, trained and involved. These include the catfish program, the cultivation of modern varieties of summer vegetables, as well as preventive maintenance of the embankments and possibly also of the roads. These activities as such are replicable, but they should preferably be undertaken by local institutions, so that a future compartmentalization project could play the role of technical advisor and financing agency.

It should also be recognized that a CPP-like project has limited scope to improve the position of poorer women, who nevertheless constitute the major group of women in

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Bangladesh. For this purpose a totally different type of project would be needed that aims to improve women's access to resources, such as information and education, knowledge, skills and technologies. It should assist women in increasing their level of organization and mobility, and result in more self-confidence and choices.

A compartmentalization project has the scope to create the conditions that would enable women to participate in project activities, in particular in water management, institution building and agriculture. To achieve this, the gender approach that CPP has tested can be followed again, i.e., a combination of mainstreaming and women specific activities. The latter should aim at women's empowerment so that they will be able to participate as real partners.

Institutional Issues

The major institutional gender issue at stake in a compartmentalization project like CPP are the lack of gender awareness and of female staff in the BWDB and its lack of willingness to work with women. If water projects really want to have some positive impact on women, major institutional and gender changes will be needed at the level of the BWDB.

The need for the involvement of gender expertise in project design and preparation cannot be stressed enough. It will not only enable the definition of more concrete objectives for women and development, but it will also save time and costs. An institutional gender assessment would be of vital importance to enable the involvement of local institutions from the early beginning onwards.

A future compartmentalization project should contain project sections with a least 50% female field staff, in particular the institutional development, agriculture and fisheries sections. This should enable them to address the issue of women's participation in their own activities, on the condition that the female field staff will either have the required technical education, or will be trained by the project in a professional way. Responsibility and accountability for women's participation will be at the level of each section.

At the same time, a separate WID section is needed. It should have an advisory, training and an implementation role. The implementation tasks should concern women specific activities, such as the EMG program, and activities that aim to empower women in such a way that they can participate in project activities on an equal footing with men. Examples are the setup of literacy courses, network meetings and exchange visits, organizational and leadership development and training in

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conflict resolution. For this purpose, the WID staff needs well trained female field staff. The WID section should also have an advisory role. It should assist other project sections and cooperating agencies in the identification of women's needs, and in the design and implementation of gender sensitive strategies. This includes assistance in the setup of a monitoring system that measures changes in gender relations. Finally, the WID section has the task to organize training in gender awareness and gender planning for both project sections and cooperating agencies. These tasks require an experienced gender specialist who should be in charge of the management of the section.

The following recommendations can be given for project implementation:

- A target of 33% women in the WMC follows the national policies in this respect (e.g., 33% of the UP members have to be women), and appeared, therefore, to be acceptable to all parties involved.
- These 33% of women could constitute an entry point for further activities.
- Farm women have a need for good quality seeds as well as for an improved exchange on effective techniques and technologies in pre and post-harvest work. Exchange visits, training activities together with DAE, BARI, and local NGOs could help to find solutions and to create additional skills in these domains.
- Special gender training (awareness training and practical field training) for DAE, BARI and the cooperating NGOs should receive ample attention.
- Monitoring changes in gender relations should receive more attention than it has had in CPP. In a future compartmentalization project, it is important to quantify effects on women's position and on gender relations to the extent possible. This can be done by selecting (inside as well as outside the project area) a number of households from the beginning onwards that are representatives of the main categories of households in the area.
- Monitoring forms should be made on the main issues that influence gender relations in the context of Bangladesh, i.e., workload/division of labor, access and control over means of production and services, income and expenditures, social status.

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Appendix 1

Historic Overview of CPP WID Activities per Sector and Number of Women Involved

Wid Activities per Sector	Period										No. of women involved
	92	93	94	95	96	97	98	99	00		
INSTITUTION BUILDING											
Household visits and focus group discussions (4 pilot Chawks)											
Women,s participation in SCWMC										269	
Women's participation in SCWMC and ChWMC reformation process										9000	
Women's participation in WMC										459	
Network meetings with women WMC members											
Study tours and exchange visits with women WMC members											
AGRICULTURE											
Farm women training										49	
Compost making										30	
Women's participation in potato cultivation											
Vegetable gardening										18	
Women's participation in OFTD										283	
FISHERIES											
Training of female pond operators										282	
Chari in the Bari Program										400	
MAINTENANCE											
EMG Program										100	
Women,s participation in LCS											
Skills training for female LCS members										8 groups	
Literacy and health education for EMG women											
ENVIRONMENT											
Participation in social forestry/tree planting											
Participation in awareness program											
TRAINING											
Gender awareness training of CPP staff											
Workshop on Gender Planning with CPP staff											
Workshop on operational gender planning											
Flood preparedness training for women in adjacent area										117	
Gender awareness and orientation for women WMC members										46	
Training of Trainers for CPP staff											
Gender training workshop for CPP staff											
SURVEYS, M&E											
Participation in Household Survey											
Participation in											
Participation in Consultation meetings											
Monitoring of EMG											
Study on Appraisal of WMC Organization and Gender Impact											
Monitoring of women's participation in WMC											
Monitoring of women's participation in OFTD											
Participation in PRA for OFTD											

Appendix 2

Estimated Percentage Participation of Men, Women, and Children in Agricultural Activities¹

Item	Boro			T. Aman			B. Aman			Jute			Mustard			Homestead vegetables		
	M	W	C	M	W	C	M	W	C	M	W	C	M	W	C	M	W	C
Soaking of seed's	10	90	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Seedbed preparation	70	10	20	70	10	20	-	-	-	-	-	-	-	20	80	-	-	-
Sowing of seeds	100	-	-	100	-	-	-	-	-	-	-	-	-	20	80	-	-	-
Seedbed care	25	50	25	50	25	25	-	-	-	-	-	-	-	-	80	20	-	-
land preparation	100	-	-	100	-	-	100	-	-	100	-	-	100	-	80	20	-	-
Direct sowing	-	-	-	-	-	-	100	-	-	100	-	-	100	-	80	20	-	-
Uprooting of seedlings & carrying	50	25	25	80	20	-	-	-	-	-	-	-	-	-	100	-	-	-
Transplanting	80	-	20	90	-	10	-	-	-	-	-	-	-	-	80	20	-	-
Weed/mulch/ irrigate	80	-	20	100	-	-	100	-	-	90	-	10	90	-	80	20	-	-
Harvest & carrying	90	-	10	90	-	10	90	-	10	80	10	10	70	20	100	-	-	-
Threshing	70	20	10	70	20	10	70	20	10	-	-	-	70	20	10	-	-	-
Winnowing, drying	-	80	20	-	80	20	-	80	20	-	-	-	-	100	-	-	-	-
Drying of straw	40	60	-	40	60	-	40	60	-	-	-	-	-	100	-	-	-	-
Storing	70	30	-	20	80	-	20	80	-	-	-	-	-	-	-	-	-	-
Retting of Jute	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-
Extraction of fibre	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-
Drying, storing jute	-	-	-	-	-	-	-	-	-	50	50	-	-	-	-	-	-	-
Marketing	100	-	-	100	-	-	100	-	-	100	-	-	100	-	-	50	30	20

¹The figure shows the average for the four pilot chawks



Appendix 3

Overview of WID Staff Resources in CPP

	Type of WID expertise	Number of persons	Inputs in person months	Total	Period
PHASE I	Expatriate expert	1	2.1		March '93 – June '94
	Bi-lateral expert	1	24		Sept '93 – Sept '95
	National experts		37		March '93 – July '94
	Field Coordinators	2	33	96.1	Jan '95 – Sept '96 Jan '94 – Sept '96
THE FINAL PHASE	Expatriate expert	1	5.5		Sept '96 June 2000
	National experts		43		Sept '96 – March '99
	Field supervisors	8	146	194.5	June '99 – June 2000 Sept '96 – June 2000
TOTAL				290.6	

Annex I
Environmental Issues

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Introduction

CPP Rationale

The Compartmentalization Pilot Project (CPP, also called FAP 29) Tangail started in 1991 as a part of the Bangladesh Flood Action Plan (FAP), to develop a long-term plan for the flood control, drainage and river management in Bangladesh.

This FAP was developed in response to disastrous floods in the years 1987 and 1988. During this time, almost 65% of the total land surface was temporarily flooded and thousands of people lost their lives, many more became homeless, crops were lost and infrastructure damaged.

	Flooded area %	Loss of live	Homestead inunda-tion	Structure damage	Crop damages	Livestock loss
CPP 1988	90 %	?	90%	84 % of houses	98 %	11%
CPP 1998	60 %	No	1%	<1% of houses	<2 %	<1%
Tangail town	80 %	?	Most streets	No	-	-
Tangail town	few places	no	Very few streets			

Table 1: Natural flood hazards in CPP area in 1988 and 1998 floods

The annual flooding experienced in Bangladesh can be both beneficial for farming and floodplain fisheries, and a constant threat to people, arable land and livestock, infrastructure, rural settlements and towns. As a consequence, management and control of river resources are essential to establish a balance between the requirements for flood protection, drainage, irrigation, water supply, fisheries and bio-diversity conservation. The interrelationship is far too complex for traditional project-to-project planning. Management tools, capable of integrating all of the relevant factors are needed for sensible planning. In recognition of this, the Bangladesh Water Development Board (BWDB) Ministry of Water Resources initiated the FAP with the CPP as an important implementation component.

The goal of the CPP is to test the compartmentalization concept, in which an area enclosed by an embankment; it would then be provided with a comprehensive water control system, designed and operated in order to provide a more secure environment for intensive agriculture, fisheries and integrated rural and urban development. This should improve the economic security and quality of live. Controlled flooding from major rivers into CPP area and within compartments. Benefits should be:

- Controlled drainage (rainwater and river flood) between neighboring compartments and towards downstream sections of the Lohajang River;

- Improving conditions for agriculture and irrigation development;
- Improving conditions for fisheries and aquaculture development;
- Improving communications (access to facilities);
- Involving beneficiaries in planning, design, operation and maintenance of works;
- Providing appropriate local organizations (institutional development); and
- Providing disadvantaged groups, particular women, with employment opportunities.

Upon its closure in June 2000, the CPP is required to assess the sustainability and replicability of the compartmentalization concept for wider application in Bangladesh, and to establish guidelines for technical and managerial inputs required.

Objectives and Emphasis of this Environmental Report

This Environmental Report (ER) is based on the findings of the comprehensive Environmental Impact Assessment (EIA) Study undertaken by FAP 16/19 project in 1992 on behalf of CPP and the implementation of the Environmental Management Plan (EMP 1994). During the period 1994 to 1999, the environmental program of the CPP consisted of special investigations, associated environmental enhancement activities and section reports. 1. In the context of the CPP, the objectives regarding environmental issues are (see TOR 1991):

- To avoid adverse environmental impacts or reducing them to acceptable levels;
- To identify special measures to improve the environment (mitigation plan); and
- To identify effects on soil, waterways, water resources, flora and fauna.

The EMP focuses on monitoring such environmental resources that were identified as sensitive and that are directly affected by CPP activities. These include groundwater levels, water quality, soil fertility, agro-chemicals use, wetland fauna and flora status and homestead habitats, and water-related communicable diseases. Other issues of importance were dealt with in detail by other CPP sections, such as flood damage assessment and flood mitigation, arable land use, fish and fisheries impacts, land tenure and resources access, socio-economic welfare, and Tangail Town drainage infrastructure.

This Report summarizes the findings of the section works as part of the EMP, verifies the impact predictions of the EIA study 1992 and evaluates whether the CPP contributed to develop a sustainable water management system whilst preventing environmental degradation and enhancing the environment.

Framework for Environmental Management

There are several major driving forces that affected the environment in the past decade and that are likely to continue to affect over the next decades in the CPP area: the overwhelming one is the increased pressure on natural resources with inherent potential for overexploitation and encroachment.

While agricultural production has been increasing over time, it will be increasingly difficult to keep pace with future population increases. As cultivatable land becomes scarce, farming is increasingly practiced in a fragile or sensitive floodplain ecosystems.

Land conversion. The production potential of land is changing over time. Considerable increases in rice production (the major staple crop) were - over the past decades - likely the result of wetland conversion to cropland.

The status of **wetlands** is continuously deteriorating in terms of area extent and biodiversity status. Permanent wetlands that are larger than 50 ha are already extinct in the CPP area and smaller wetlands (5 to 30 ha) as well as seasonal wetlands are under threat.

Limited access to common property. Wetlands are traditionally regarded as a common resource with open access, especially for the poor and landless of rural society. The status of wetlands, however, is deteriorating and there are no efforts at local level to conserve floodplain wetlands. One reason is that many perennial or seasonal wetlands are under private ownership, even if presently not used for cropping. There is neither legal base nor other incentives to convert private ownership in communal or state ownership (*khas*), which can secure continued access to common property, e.g. floodplain fish or other wetland products. In some locations, *khas* land was recently leased out to those who could afford lease payment for fishing or other uses (e.g. Jugini beel), creating income for local government.

Homestead plantation degradation. While deforestation is virtually complete in CPP area, there are still some homesteads left which serve as an important refuge for local or migratory fauna and flora species as well as a valuable source for additional food, fodder and material. A clear policy and action planning for homestead conservation would be needed to diminish pressure from further encroachment and indiscriminate use.

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Modern farming systems and land husbandry methods have potential to put considerable risk on soil fertility and long-term biological balances, especially by the indiscriminate use of agro-chemicals and shortened fallow periods or green manuring. Modern varieties require higher agricultural inputs and are more risk prone. Also, less crop residues remain on fields, and grazing areas becomes scarce.

Local resources of biomass are often the only source for fuel and building materials. They are becoming increasingly short for soil fertility management, fodder and other consumptive uses.

Landlessness is a major characteristic in rural areas in Bangladesh

National Water Management Plan (NWMP)

The NWMP for the period to 2025 is under preparation. Topic Papers (TP) are currently issues that address important aspects, e.g. TP 11: Managing the Environment (Nov 1999). The NWMP intends to "safeguard" the environment, not to preserve it in an unchanging state. It will permit judicious exploitation where appropriate and sustainable in order to help alleviate the pressing needs of society, not least caused by the expanding population. Issues of key environmental concerns in Bangladesh are listed below, as far as they are relevant for the CPP area.

Surface Water Quality

Concerns and Trends	National Policies Objectives	Options for Management
<p>(1) <u>Fecal pollution</u> is widespread in contained water bodies and worst in municipalities; in rural areas, the lack of flood-proof pit latrines with proper mechanism for desludging, composting and preventing seepage</p> <p>(2) <u>Agro-chemicals</u>: N, P and biocide applications are low by international standards, due to high prices; reliable and detailed data are lacking but do not appear to be a major problem yet; imports of problematic biocides are a concern; future intensification may encourage increased use, but problem is recognized and IPM techniques are being promoted</p> <p>(3) <u>Salinity</u>: not a problem in Tangail CPP</p>	<p>Set standards and monitor effluent disposal. Improve ability of river system to dilute and disperse pollutants. Reduce Fecal pollution associated with sanitation practices</p> <p>Reduce or prevent agricultural run-off of N and P.</p> <p>Take steps to ensure environmentally friendly agricultural practices, e.g. Organic manure and IPM</p> <p><u>Indicators</u>: SS, TDS, T, BOD, COD, DO, Ammonia, Coliforms, N, P, biocide residues, EC, Cl, SS, Turbidity</p>	<p><u>Command and control methods</u>: unlikely to be practical</p> <p><u>Non-regulatory controls</u>: incentives, emission charges, pollution levies, user charges, administrative charges (for treatment plants etc.)</p> <p><u>Partnership approaches</u>: awareness rising; management plans; audits; shared treatment; suitable credit facilities; non-regulatory, community-based initiatives for surface water clean-up and discharge control</p> <p><u>River dilution & dispersion</u>: reducing pollution levels; stricter enforcement on vulnerable reaches; low flow augmenting; dredging and channel amendments; zoning of land use, particular industrial areas</p> <p><u>Provision of sanitation facilities</u>: rural areas: affordable pit latrines, septic tanks. Urban areas: also piped sewerage treatment, treatment plants with safe effluents</p> <p><u>Changes in agro-chemical use</u>: organic farming and IPM initiatives; reliable data management; monitoring of applications</p>
Surface water quality		

Groundwater Water Quality

Concerns and Trends	National Policies Objectives	Options for Management
<p><u>Arsenic contamination</u>: main threat in Bangladesh, but not in Tangail CPP area (CPP and BWDB data)</p> <p><u>Iron contamination</u>: constitutes a nuisance to human; constraint to crop choice.</p> <p>Note: This is a problem in CPP Tangail in areas with groundwater irrigation</p> <p><u>Fecal and agro-chemical seepage and pollution</u>: data lacking; but do not appear to be a major problem yet; But: CPP data indicate an increasing problem in the wet season</p>	<p>(1) Facilitate availability of safe and affordable drinking water</p> <p>(2) Reduce or prevent pollution by fertilizers and biocides</p> <p>(3) Prevent Fecal pollution</p> <p>Indicators: Arsenic, Fe, heavy metals, BOD, Ammonia, Coliforms, N, P, biocide residues, EC, Cl</p>	<p><u>Reduction of Fecal contamination</u>: surface water clean-up; provide flood proofed, self-draining well heads, regular disinfections</p> <p><u>Iron removal</u>: on-site aeration; chemical treatment in process plants</p> <p><u>Reduction of pollutants</u>: Control of discharges (see surface water), zoning: prevention of wells in contaminated areas; Changes in agro-chemical use: see surface w.</p> <p><u>Controlling water abstraction</u>: regulatory and economic instruments</p> <p>Non-regulatory, community-based initiatives for surface water clean-up and discharge control</p>
Ground water quality		

Environmentally Sensitive Area Management (biodiversity conservation)

Concerns and Trends	National Policies Objectives	Options
<p><u>Wetlands</u>: permanent water bodies and seasonal floodplains, rivers (others are not applicable for CPP) 26 important permanent wetlands are of major concern, of which 6 are environmentally critical areas in B., some already have status of Protected Areas</p> <p><u>Seasonal floodplains</u> of national importance should be identified!</p> <p><u>Management concerns</u>: land use conflicts for human exploitation; erosion and siltation; loss of biodiversity, introduction of exotic species, reduction in dry season flow, inappropriate recreational use</p> <p>Note: There is no nationally important permanent wetland in CPP!</p> <p>People's feedback: only indirectly related to resource uses like fisheries or resources access conflicts</p> <p>Problem: concern for biodiversity conservation is poorly developed, apart from features connected directly with potential for exploitation!</p>	<p>NWPO states that beels, hoars will be preserved. The management implication is that none is to be reduced in extent or depth of flooding at the height of the dry season, and the flow of network that feeds them must be maintained</p> <p>To protect against degradation and preserve natural water bodies for maintaining the aquatic environment and facilitate drainage</p> <p>To stimulate embankment plantation for the direct benefit of the people (social forestry) as well as for embankment maintenance</p> <p>To protect wildlife resources and undertake measures to conserve biodiversity</p> <p>Draft Wetland Policy:</p> <p>To establish key principles for wetland sustainability and unsustainable practices</p> <p>To maintain wetland functions and values</p> <p>Actively to promote integration of wetland functions in resource management and economic development decision making</p> <p>Indicators: flood extent, depth, duration and timing; Connectivity between water bodies and main river system(s); Water quality; State of fish resources (threshold level to be defined at local level)</p>	<p>Awareness raising, building on existing efforts, to produce a radical shift in the prevailing attitudes;</p> <p>Mobilizing public opinion for environmental concerns with clear social and economic benefits (if sustainable use is possible)</p> <p>Attitude changes need to be more profound for concerns without these immediate concerns, e.g. species protection, biodiversity conservation</p> <p>Non-regulatory approaches at local level</p> <p>Management for new integrated wetland management strategy</p> <p>Low flow augmentation</p>
Environmentally sensitive area management (biodiversity conservation)		

Fish and Fisheries Resource Management

Concerns and Trends	National Policies Objectives	Options
Fish habitats, such as permanent water bodies and seasonal floodplains are under threat; fish spawning and breeding grounds, link routes for migratory species Fewer fish species than previously are being caught Fish sizes are smaller Decline in open access to floodplain fish resources Competition with agriculture for land at the edge of dry season water bodies which are crucial fish sanctuary area to maintain stocks for the following year Sedimentation of beels and khals, obstruction and blockage of migratory routes Overfishing, indiscriminate killing of brood and juvenile fishes Agro-chemicals run-off killing fish	NWPO: Preserve natural water bodies to maintain the aquatic environment Minimize disruption to the natural aquatic environment including control structures To improve efficiency and expand of aquaculture Fisheries Policy: To conserve fish habitats Formulate laws against discharges of untreated wastes To conserve endangered fish species and bio-diversity	Fish-friendly construction of structures Decommissioning or rehabilitation of water control structures in floodplains, to a degree that is sufficient for resumption of capture fisheries at levels those preceding construction Low flow augmentation Land zoning: fish sanctuaries and measures to ensure correct water management to enable fish stocks to be maintained Awareness rising for sustainable fisheries practices Culture fisheries: flood proofing of ponds, use of embankment borrows for ponds, awareness rising
Fish and fisheries resource management		

Implications for CPP

CPP addresses almost all of these environmental issues directly or indirectly. To the extent possible, it has sought to provide practical solutions to almost all of the issues mentioned in the NEMAP and the MWMP and that are applicable at local level.

However, effective implementation for environmentally sound natural resources management is seriously hampered by either poor or non-existing national policy guidelines and regulations. For example: on sustainable land husbandry, land use planning, land policy, biodiversity protection, fisheries management, or water pollution control. The current status is exaggerated by the fact that if good policy exists, effective means and capacities for enforcement and implementation are virtually absent. There is, virtually, no capacity at local level to guide and control environmentally sound development.

Amendment of existing policy would be required as well as institutional capacity building, especially regarding planning, management and enforcement capacities, at both national and local level. Therefore, recommendations to amend existing policy and advocacy for the replicability of compartmentalization in the context of sustainable and environmentally sound development are elaborated in chapter 9 of this Report.

The CPP Environmental Management Plan

Methodology of the EMP Tangail

The Environmental Management Plan (EMP) of CPP is based on the recommendations in the EIA Study (EIA 1992, Chapter 8). It considers both the directions given by the National Policy and the perception of local people on their natural resources base in order to achieve sustainable use for social and economic.

The general methodology to develop important environmental components is presented in: Environmental Surveys and Initiatives (CPP 1993) and the EMP Tangail (1994). The starting point is the Environmental Quality Account System that identifies environmental components in a system's approach: biophysical resources, resource uses and associated quality of life values. In a next step, a Cause-Effect Network is developed that identifies relationship between the project interventions and hydrological events in the CPP area and the subsequent network of possible impacts on these environmental components. Finally, Important Environmental Components (IECs) that are likely to be impacted by proposed CPP management interventions were screened and selected for detailed, and the extent possible, quantified assessment (scoping). The following environmental issues were found of specific importance to the EMP: These were:

- Floodplain water regime;
- Surface and groundwater pollution;
- Groundwater level;
- Soil fertility;
- Soil contamination;
- Status of wetland ecosystems;
- Status of terrestrial and aquatic fauna and flora;
- Conflicts over resource uses (including land uses, fisheries, navigation and compliance with existing policy); and
- Water-related diseases.

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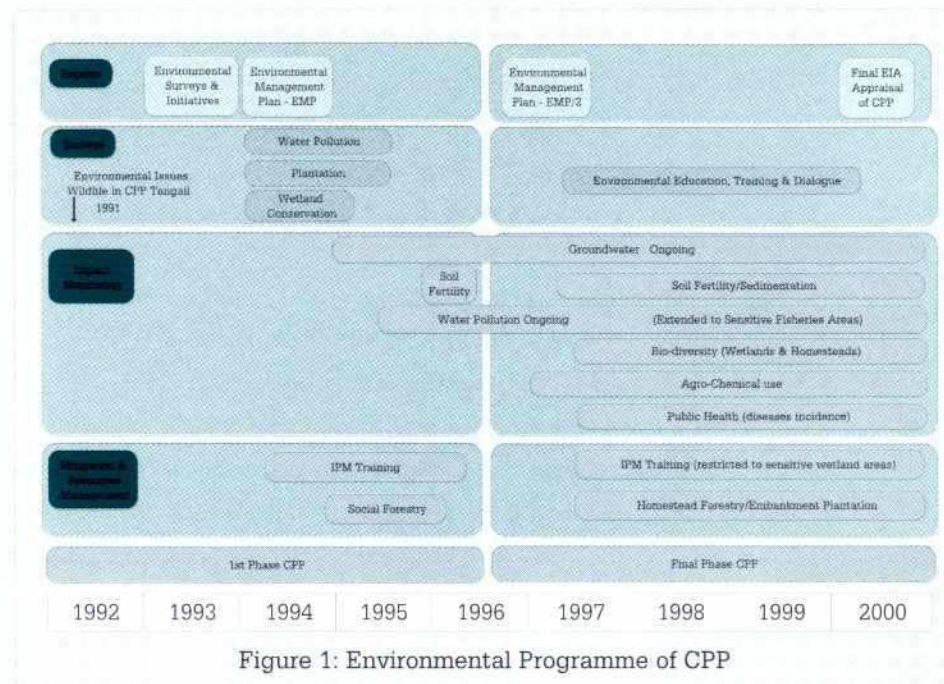


Figure 1: Environmental Programme of CPP

The EMP is an instrument to manage impacts once the project plan is defined. The EMP describes measures to avoid or reduce impacts, resolve conflicts associated with the project, and defines follow-up activities such as monitoring and evaluation. Four elements of the EMP are important:

- Environmental **protection plan** which includes recommendations for impact management through anticipatory planning and operation, mitigation, contingency, and compensation;
- Plan for impact and compliance **monitoring**. Impact monitoring should detect the magnitude of significant impacts by regular data collection and evaluation. Compliance monitoring checks whether existing laws, regulations and standard codes of good engineering practices, agronomic best management practices and site-specific environmental quality goals are observed.
- Continuous **public participation** and **information** program related to environmental concerns of people or institutions affected; and
- **Framework for implementation**, including details of cost estimates, schedules, accountability and reporting, proposals for institutional strengthening, education, training, information systems, and technical assistance.

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The set-up of the CPP EMP is shown in Figure 1. Elements of the EMP are:

- Proposals to adopt site-specific environmental quality goals; definitions of standards and indicators;
- Recommendations for impact management through anticipatory planning: targets for structural interventions (water supply and distribution systems, flood control, drainage, farm roads, etc.), agronomy and land husbandry;
- Mitigation plan to reduce adverse impacts. e.g. on other land users, water supply, habitat restoration/amelioration; in some projects, limits of acceptable change have been defined for specific environmental components, with agreement on subsequent mitigation action if they are exceeded;
- Compensation plan for residual impacts, for example land compensation, habitat replacement;
- Contingency plan to prevent accidents or to minimize natural hazards;
- Action plans to enhance resource uses other than current project activities, e.g. social forestry / Homestead plantation program;
- Impact monitoring should detect the magnitude of significant impacts by regular data collection and evaluation. This gives early warning of significant impacts that demand immediate action to secure the sustainability of the project. Also, it serves to check the predictions of the EIA study to allow a final appraisal of environmental changes during the operation of a project. Environmental impact monitoring must focus on important components and their indicators because it is costly and requires skilled personnel for data management and evaluation;
- An environmental information system improves skills and attitudes towards sustainable management: environmental education, training and dialogue. The action plan defines the type of information and the means of dissemination amongst interested parties; and
- An environmental control system is designed to check at regular intervals whether the project is consistent with the environmental goals and other aspects of the EMP. At regular intervals, the EMP must be adapted to changing framework conditions and adjusted operation plans or new technologies and practices.

The scope of works consisted of special surveys, monitoring activities and initiatives for mitigation or environmental enhancement measures, outlined in chapters 6.2 and 6.3.

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Limitations. Considering the complexity and interlinkages of direct and indirect environmental effects in the area under study, it was impossible to obtain data for all environmental components at a desirable degree of detail within a project's lifetime and beyond. Major attention in CPP was given to agricultural development and fisheries resources, which are directly impacted by CPP interventions. They were subject to separate CPP Sections (see Final Report, Annexes E and F) and, therefore, not treated in depth in the EMP.

Institutional collaboration was hampered by the fact that there is still very little capacity in Bangladesh to support environmental management initiatives at local or implementation level. Much time was spent by the national and expatriate consultants to identify suitable organizations who had the capability and preparedness to conduct some of the environmental surveys and monitoring. Even more time was spent to follow up implementation by contracted organizations. Given the pilot character of the CPP, it was decided to mainly involve other organizations in environmental monitoring and hence, to prove whether there is capacity in Bangladesh to implement an EMP, even if all funding comes from outside resources. It appears that there are substantial further efforts required within existing governmental institutions, including research and universities, to strengthen capacity to guide and implement environmental management in integrated water resources development at the desired level.

The Environmental Protection Plan

In a first step, recommendations for consideration in planning, design and operation of structural interventions were proposed in 1993. They were based on environmental quality goals for sustainable floodplain water management that should be integrated into existing short-term production oriented targets for agriculture and fisheries.

These environmental principles for anticipatory planning and management had been introduced to other CPP sections, namely engineering, water management, fisheries, agriculture, institutional development and participation, and women in development. The achievements are subject to separate CPP reports. The EMP emphasized that environmentally sound planning should meet the following criteria:

- **Design** and number of water management structures should consider maintaining or restored the natural flow pattern into and within the floodplains to a desired degree, regarding discharge rates and spill heights in *khals* and *beels*;

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- **Operation** should be that abnormal floods are controlled and normal floods are regulated to the desired degree, in due consideration of different stakeholders view and (wetland) conservation issues; and
 - Ensure that all precautions are taken to avoid or minimize environmental pollution during construction: sanitation and service facilities, public health and safety standards, constructor's site installations, services and pollution control, operation and disturbances, rehabilitation and reclamation provisions.

The Environmental Monitoring Plan

Throughout the life of CPP, monitoring activities were carried out. These included:

- Monitoring of the effects of water and flood management (compartmentalization approach) on deposition of river flood sediments and biochemical processes during the inundation period in the monsoon season;
- Monitoring of soil fertility changes under intensified crop production;
- Bio-diversity monitoring in ecologically sensitive habitats: i.e. *beels* and homesteads;
- Monitoring of agro-chemical use and storage;
- Monitoring of groundwater availability;
- Monitoring of water pollution in groundwater, ponds, *khals* and some *beels*; and
- Public health issues, related to water related diseases.

Soil Fertility and Flood sedimentation Monitoring 1996-1999

Collaboration with: Soil Resources Development Institute (SRDI) contracted for field and laboratory works; annual reports and final report Jan 2000.

1st phase: Soil fertility monitoring. A detailed program was outlined in 1993 to monitor changes in soil water and nutrient balance on 20 selected sites, which unfortunately did not materialized due to administrative and organizational shortcomings and other project priorities at that time. Eventually, the program was scaled down and started in 1996 with the monitoring of soil properties on 27 selected sites, in coordination with the newly appointed CPP agronomist. Analysis was partly done by CPP environmentalist using test kits and partly by SRDI office at Tangail/Dhaka lab. This program was continued as part B in the Final phase of CPP.

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Final phase: Soil fertility and sedimentation program involved a continuous monitoring of river-borne sedimentation at 15 sites in and outside of CPP area including soil and water sampling and laboratory analysis. In addition an annual monitoring of soil fertility at 20 intensively cultivated soils inside and outside of the CPP area. Unfortunately, the program started only in Jan 1998, due to administrative and organizational delays. After two sampling season, practical issues related to the methodology of field sampling, lab analyses, data management and interpretation had been resolved. The SRDI would now be capable, with some methodological modifications and close supervision by soil and water specialists, to continue the monitoring program (SRDI Final Report Jan 2000). The data and interpretation presented here are, therefore, tentative and should be verified in future monitoring activities.

Monitoring objectives: 1. Verify EIA predictions with regard to possible negative longterm impacts of flood control on soil fertility. Inform policy makers about these local impacts and their long-term implications. 2. Provide project and district decision-makers with information about soil fertility changes under controlled water management in order to take actions at local level to stop soil degradation by depletion of nutrients or unbalanced supplies, if required.

Assessment of Methodology. The surveys in 1998 and 1999 showed that previous field and lab analysis undertaken by SRDI at Dhaka and the CPP by using field lab and test kits during the period 1995 to 1996 are flawed. This is due to either sampling errors, storage and processing problems, and analytical errors; or because the use of modern equipment and new chemical analytical methods since 1998 does not allow the comparison of results. It is strongly recommended to harmonize the methodology at national level (Universities, SRDI, National Research Institutions) and to conduct regular quality control assessments. The use of test kits (e.g. Hach equipment) can only be recommended for rapid assessments. It is also advisable to perform field and lab analysis with qualified chemical technicians only.

1st phase (1994-1996): Wetland Conservation Study.

Collaboration with: Nature Conservation Movement (NACOM)

CPP investigated the possibilities to initiate a wetland conservation program in the area in order to promote compensation of expected (continued) conversion of wetlands and aquatic habitats into arable land or settlements. Objectives were:

- To monitor the state of fauna and flora in the context of controlled flood measures,
- To provide insight for opportunities to enhance bio-diversity within the context of rural livelihood,
- Selecting two wetland sites with potential for implementing a Community Wetland Program in cooperation with an NGO,

NACOM was contracted in Oct 1994 and carried out field surveys in 1994-1995. The final report was eventually submitted in November 1996. A proposal for Community Wetland initiative at Jugini beel, was abandoned in 1996 because the *beel* was already leased out for a private businessmen. In addition, the conversion to farmland was already intensified at the southern boundaries by those villagers who claimed traditional land use titles on that land.

Final Phase (1997-2000): Biodiversity Monitoring Program

Collaboration with: Biologists from Dhaka University and Tangail College teachers; Work. Selection of two representative *beels* inside the CPP area. Continuous monitoring of indicator species of bio-diversity of wetlands and two neighboring homesteads.

Overall objectives:

- To verify environmental impact assessment (EIA) predictions with regard to possible negative impacts of flood control on wetland extent and bio-diversity. Inform policy makers about these local impacts and their long-term implications;
- To provide local people, project and district decision-makers with information about the bio-diversity status of their environment.

The monitoring program was conducted in dry and wet seasons in 1998 and 1999 at two locations: Baria and Atia Kumari *beels* each with two neighboring villages/homesteads. These sites represent the two ecosystems with highest bio-diversity under prevailing conditions of intensive human development activities in the Tangail floodplain.

The work included Ecological description of fauna and flora species in the area: common, rare, endangered and threatened; description of their economic value and existing consumption by different rural users. For each wetland, keys indicator

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species (representative for the local ecosystem functioning and structure) were identified out of the list of total species of fauna and flora. These key species were monitored during the period 1998 and 1999 in the wet and dry seasons and the changes of their habitat were described. The inventory on fauna and flora included also endangered species, and changes of their habitat were described, including changed caused by CPP water management and intensified agricultural uses. Based on the findings of the first inventory in 1998, a program for environmental education and awareness was designed for promotion of the conservation and the wise use of wetlands in floodplains of Tangail. The final report for the observation period 1998-1999 was completed in January 2000. For an assessment of the status of bio-diversity and trends of development in CPP area, the results of the studies conducted in 1998 and 1999 were compared with previous investigations in 1991, (CPP TNT-91/23), EIA Study field survey (1992) and 1994 (NACOM) findings and proposals.

Water Quality Monitoring

Systematic water pollution monitoring started in 1995, after a rapid field survey was carried out to identify the state of environmental pollution in the Tangail CPP: Environmental Pollution Survey (CPP Publication TN 94/05). 15 'hot spots' for regular monitoring of the water pollution level were selected in various habitats and it generated data on the status of pollution in rivers, *khals*, *beels* and ponds. 11 parameters are continuously recorded from April 1995.

Water pollution - especially in open water bodies - is one of the most challenging environmental problems in Bangladesh because it affects human health, can be a source of animal diseases and it contributes to the degradation of natural habitats, especially wetlands. A major factor to pollution is the limited access of many people to clean water but also the indiscriminate multifunctional use of open water bodies for all kind of human and livestock consumptive and disposal uses. These include drinking water source, for bathing, washing, watering livestock, latrines, waste-water disposals, Faecal and other waste disposals, etc. Organic pollution by various domestic sources is most important in rural areas, although at some places indiscriminate use of agricultural pesticides and the discharge of effluents from handloom factories are also a matter of concern.

Changes in flood pattern by compartmentalization or other human interventions (roads, settlements, etc.) can both negatively and positively influence the state of water pollution by:

- Directly through the re-distribution of disease vectors and water-washed diseases;

- Directly through diluting high concentrations of wastewater;
- Directly through facilitating the removal (flushing) of stagnant wastewater in *khals* due to improved drainage;
- Indirectly by modification of open water bodies and the process of groundwater re-charge;

However, there is evidence of a rapid increase of water-related diseases during the flood season, especially in years with very high flood peak level. This probably is attributed either to:

- The spread of water-related pollutants and water-washed diseases over large floodplain areas;
- The distribution of diseases from polluted ponds onto the floodplains; and
- Reduced access to clean water or groundwater, especially for poor villagers during the flood season.

Groundwater Monitoring

The program aims to monitor any negative trend in groundwater availability in rural areas during the implementation of CPP and the final evaluation here should estimate the amount to which CPP water management has contributed to any change in water tables, if recorded over the 10-year period. Mitigation measures would be recommended, if required and feasible.

Groundwater data for upper aquifers were collected by CPP since 1994 with 17 sites (13 DPHE wells, 4 BWDB wells) while 9 additional wells from adjacent areas were included to observe the regional trend in groundwater development

Groundwater is of specific importance to the agricultural development in Bangladesh because the expansion and intensification of agricultural production depends in many areas on dry season irrigation of rice HYV.

The groundwater in floodplains, e.g. CPP Tangail floodplains, is recharged by local rainfall, seepage from main rivers and by floodwater entering the floodplains. There is the possibility that both the total amount of river floodwater inundating the floodplains as well as the flood duration will be reduced by CPP interventions or gate operations. Hence, there is a risk of reduced percolation and replenishment of local upper aquifers.

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Agro-chemical Use Monitoring Program

In 1994, CPP started the IPM program to train farmers to control agricultural pests by biological means and minimizing the need to use of agro-chemicals. The monitoring of agro-chemical uses complements this IPM program to provide data on actual sales and uses by farmers. Monitoring was conducted from 1995 to 1999. The methods used were:

- On-farm monitoring of use of agro-chemicals. 15 farmers close to the soil monitoring sites were selected to record storage, handling and field application of pesticides and fertilizers. Farmer's interviews were conducted annually, after the *Boro* season/before monsoon season. Further information was collected during PRA surveys in 1997/1998 in collaboration with the DAE and BARI;
- Records of sales of fertilizers and pesticides at wholesalers in Tangail Town and retailers at bazaars in Tangail CPP (annual surveys in Apr/May); and
- A special survey was carried out in 1999 to interpret and check these data and to collect further data from available sources at local and national level.

Environmental concerns. Intensification and diversification of crop production, especially in the dry season, will likely yield to higher demands for fertilizers and pest control measures. The use of chemical fertilizers is advised to balance the increased nutrient depletion from crop withdrawals in order to maintain the soil fertility. Chemical fertilizers are needed because there is increasing shortage of organic supply of nutrients at farm level, but relatively high costs of fertilizers make their indiscriminate use unlikely; environmental risks are, therefore, rather low.

This is probably not the case with agro-chemicals to control agricultural pests and diseases, despite the fact that the level of endemic (crop) pests is low in comparison to other areas in Bangladesh. First, highly toxic and persistent agro-chemicals (e.g. carbamates, chlorinated hydrocarbons) are still available at local shops, and they are affordable for many farmers. Secondly, many farmers are not aware of environmental pollution and health risks caused by improper handling, storage and the indiscriminate application of pesticides. Most of them have little or no knowledge about the harmful impact of most pesticides to non-target animals which may be useful to maintain the ecosystem's balance, e.g. pest predators such as birds or other insects. With an expected increase of cropping intensity, especially during the dry season, pest problems are likely to increase. The problems may be aggravated by water management activities such as controlled flooding under farmers control, which may change the flood regime in most areas towards more dry land conditions, and,

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thereby, creating favorable habitats for many pests. There is concern, on the other hand, that favorable habitats of pest predators are reduced, for example wetlands areas and trees in farmland that provide shelter and breeding of predators.

Public Health (water-related diseases) Monitoring

Compartmentalization will bring some changes in the normal flood pattern and therefore, habitat condition for some disease vectors can also change. This may eventually increase health risks associated with water related and vector borne diseases. Monitoring of disease incidences will provide information for verifying the EIA predictions for increased vector borne diseases as an impact of the project.

Data were collected annually from the Office of the Civil Surgeon, Department of Health, in respect of total number of patients received and treated for different diseases at all Union Health Sub-Centers, Rural Health Centers, and Government Clinics and Hospitals.

Public Participation Process

A program of environmental education, training and dialogue initiated to address various groups of key stakeholders was undertaken by the project. This included dialogue with farmers and other directly affected people in the CPP, with regular meetings to discuss matters of environmental or natural resources management concern. Additionally, a program on environmental education and training of villagers was launched to promote the conservation and wise use of sensitive ecosystems, e.g. wetlands and homesteads, to implement technical measures for improving safe water use, sanitation and domestic waste management.

Stakeholders. The CPP is dealing with water and flood management in the floodplains of Tangail. There are individuals or groups directly affected: farming families (landowners, tenants), other landowners, fisherman, boatmen, etc. with the national environmental management plan and that addresses effectively environmental (flood related) issues of concern in the view of perception of local people.

The important stakeholders in the context of CPP are (tentative ranking):

Directly involved	Institutions with mandate	Interested public, others
1. Individuals such as farmers, landowners, other local resource users and rural villagers (fisherman, boatman, villagers collecting common goods from wetlands or homesteads, etc.) inside the CPP area	5. Governmental institutions directly involved such as BWDB, DAE, DPHE, LGED, SRDI, etc.	9. Non-governmental organizations such as Proshika, BRAC, Grameen Bank
2. Organizations of local people, such as the water management groups organized with assistance of CPP; hawk and subcompartment committees, water committee; or professional fishermen groups	6. Local government	10. Other scientist or sector specialists from environmental disciplines: water, agriculture, soil, geography, ecology, biology, etc.
3. Other people living in the CPP area who also benefit from flood control measures which aim to minimize flood damage to houses, infrastructure and agriculture (crops, livestock, homesteads, farmsteads, irrigation facilities) in case of very high floods (e.g. peak flood 1988)	7. Other governmental institutions such as MOA, MOEF, etc.	11. Press, media 12. Other local individuals or pressure groups 13. Other national individuals or pressure groups
4. People (individuals, farmers groups, etc.) outside the CPP area but who are affected by flood control activities of CPP: adjacent and downstream floodplains	8. Scientists from Research institutions	14. International donors 15. International pressure groups

The environmental program aimed to address all of the various groups of stakeholders including:

- Key stakeholders from groups 1 and 2 were addressed by the environmental education and training program: training and awareness regarding safe water use, waste water and waste disposal in rural areas, water sanitation, bio-gas production; the programmes on wetland conservation, homestead plantation (increase bio-diversity), and integrated pest management are already mentioned elsewhere;
- Dialogue with groups 1 and 2 on the progress of CPP to address environmental issues of concern of local people with informal meetings: four meetings with some 20 villagers per year in various sub-compartment; selection in cooperation with the CPP water management groups, teachers and imams;
- Continuous dialogue with other relevant government institutions was ensured through the environmental monitoring program;
- The dialogue about environmental issues were enforced with local and national media, NGOs and other local and national pressure groups. An annual meeting in the CPP Information Dissemination Center at Tangail was held;

- Environmental awareness building program regarding the conservation, preservation and wise use of natural resources in rural areas:
- Training of villagers on soil and water pollution. The role of human pollution, types of pollution, standards, impacts on human and animal health, pollution control measures, applicable for rural areas; Two training sessions for some 30 villagers (including teachers and imams) per year (1998 to 2000) in 4 villages in SC 9-11, 14.
- Training of villagers on general issues of conservation of habitats and species diversity; special training of villagers on issues of the wise use of wetlands (in combination with the biodiversity program). One training sessions for 30 villagers (including teachers and imams) in 1997 to 1999 in 4 villages in SC 9-11 and 14. Selection of participants in cooperation with the CPP SCWMCs.

Impact Monitoring and Appraisal

Impacts on Water Resources

The change of flood pattern, flood depth and duration is the primary impact of CPP that cause further direct or indirect effects on important environmental components. Therefore, effects of controlled flood and improved drainage are described in detail:

Flood Level and Pattern.

The CPP design consists of peripheral and internal structures. Peripheral structures determine the river flood inflow into the CPP area during the monsoon season and the drainage that into rivers at the end of the flood season. Internal structures determine the flood pattern within the floodplain, influenced by river inflow and local rainfall..

The assessment of controlled flooding and drainage design and implementation at field level during the period from 1993 to 1999 shows that it is possible to implement a concept of partial flood control. There are no means to augment river flow into the floodplain, beyond the flood level that occurs in major rivers. Indeed, the water level in the Dhaleswari River was too low in most years to allow full controlled flooding to the degree wanted by farmers. Also flood timing can only be controlled partially, because this again is controlled by the arrival of flood waves from the Jamuna River into the Dhaleswari River. In summary, floodwater scarcity is a matter of concern for rural livelihood as well as high, prolonged or untimely floods.

The complexity of the floodplain system and the different user demands for various water management options made it unrealistic to assume that full water management control at the sub-compartment or even chawk level can be achieved.

Drainage rates cannot be met under real field conditions. Therefore, flood model predictions usually results in slightly higher flood levels and area inundation than field observations reveal (see Table 2): the range is estimated to about +17 to 19% of the total area. However, the present model, based on the revised digital elevation model and calibrations of flow pattern from field observations since 1994, produces land type maps (inundation depth F0 to F3) that are within an acceptable range of $\pm 20\%$. The use of the new model can also explain the differences between impact predictions made in the EIA Study 1992 and the flood levels under different scenarios presented here.

Method	March 1994	August 1998
CPP Hydrological Model 1999	1028 ha	6064 ha
Radar satellite images RSI Corrected radar image by +2 %, cRSI		5012 ha 5112 ha
Satellite images (deep water >30cm) Corrected satellite image by +15% for shallow + deep water areas, cSat	766 ha 880 ha	
% deviation CPP Model vs. cRSI or cSat	+17%	+19%
Table 2: Inundated areas for August 1998, calculated by CPP model and classified radar satellite images and satellite images (Source: EGIS Dhaka, corrected)		

Source: CPP 1999, Annex F, Fisheries Report. Note: The radar sat image is corrected by +2% because open water surface in beels (≈10% of total area in the monsoon season) that is thickly covered by aquatic plants is not shown as "open water area". Satellite images may underestimate open water area because they do not encounter shallow water (<30 cm). Therefore, a correction factor of +15% was applied for a rough estimation.

The revised flood model of CPP shows that river flood levels in CPP are determined by largely by the monsoon flood level in the Lohajang River. This in turn depends on Dhaleswari water levels and eventually the Dhaleswari Spill channel that connects to the Jamuna River.

Station	1995		1996		1997		1998		1999	
	max	date	max	date	max	date	max	date	max	date
Jamuna	12.97	20.7	12.70	15.7	13.57	11.7	14.10	8.9	13.32	25.8
Lohajang	12.46	12.7	12.21	22.7	11.76	16.7	13.19	9.9	12.30	31.8
Karatia	9.56	19.7	9.33	29.7	9.30	17.7	10.56	11.9	9.54	11.9
Table 3: Water levels for different stations from 1995 to 1999										

Source: All records in m (+BWDB) from CPP WM-section files. Locations: Jamuna: at Jamuna river bridge, just upstream of Dhaleswari Spillway Channel. Lohajang: u/s of main inlet, some 3 km from Dhaleswari-Lohajang junction; Karatia: outlet at the southern CPP border.

The record of water bodies in CPP shows that there are very high variations in the area extent, depending on flood conditions and human interventions into the flow pattern (CPP or non-CPP interventions):

There is some evidence that dry season (January to April) water levels in several wetlands are falling, causing the reduction of wetland area.

It is difficult to establish a reasonable impact appraisal that quantifies the direct effects of CPP interventions. There are too many other non-CPP activities ongoing in CPP area that also have an impact on flood water management and status of

Year	Area	Dec/Jan	Apr	Oct/Nov
1992 (EIA)	CPP (Clusters 1-4) Only beels	233	77	
1993 Land use survey	CPP (Clusters 1-4) Culster 1			1745 522
1996 Land use survey	CPP (Clusters 1-4) Culster 1			1024 145
1997 Land use survey	CPP (Clusters 1-4) Culster 1		99 21	476 144
1998 Land use survey	CPP (Clusters 1-4) Culster 1	63 23	185 55	5263 664
Table 4: Seasonal variation of water bodies/ponds in CPP (area in ha)				

wetlands. These include LGED roads, Jamuna by-pass road and railway, private local development initiatives, and other uncontrolled uses.

Drainage Congestion

The EIA study (1992) calculated the areas with severe and prolonged drainage congestion to some 1549 ha, i.e. some 17% of the net cultivatable area (NCA) of 9197 ha. In 1993, the CPP made a survey to determine areas that are fallow because of prolonged inundation: about 4276 ha were affected by drainage congestion, i.e. 43% NCA

It is estimated that actually some 500 to 1500 ha (status of 1999) are affected by serious drainage congestion, depending on the flood levels, actual rainfall, gate operations and proper maintenance of *khals* (low siltation rates) and embankments (no breaches):

Scenarios	PS 01 scenario	PS 03: year 1996	PS 04: year 1997	After CPP
F 2 and F 3 land	1572 ha	472 ha	862 ha	800 ha

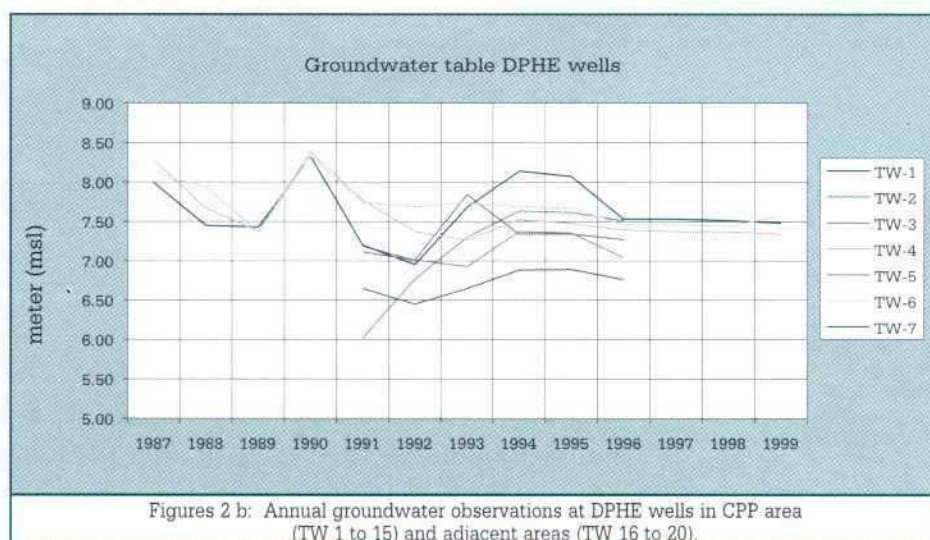
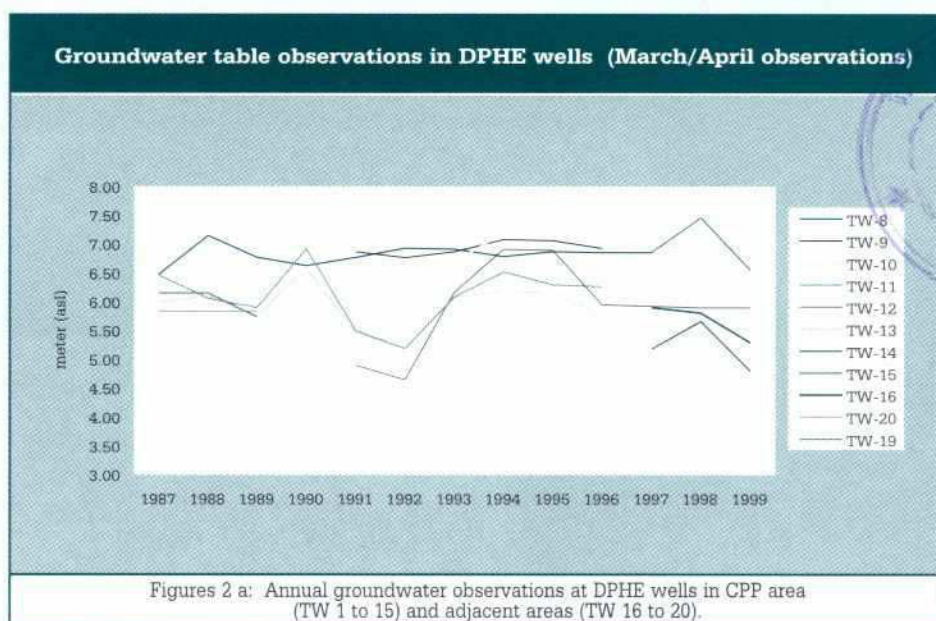
The final impact of CPP is estimated to reduce the areas with continued drainage congestion in the post-monsoon period to some 800 ha, assuming average flood and rainfall conditions.

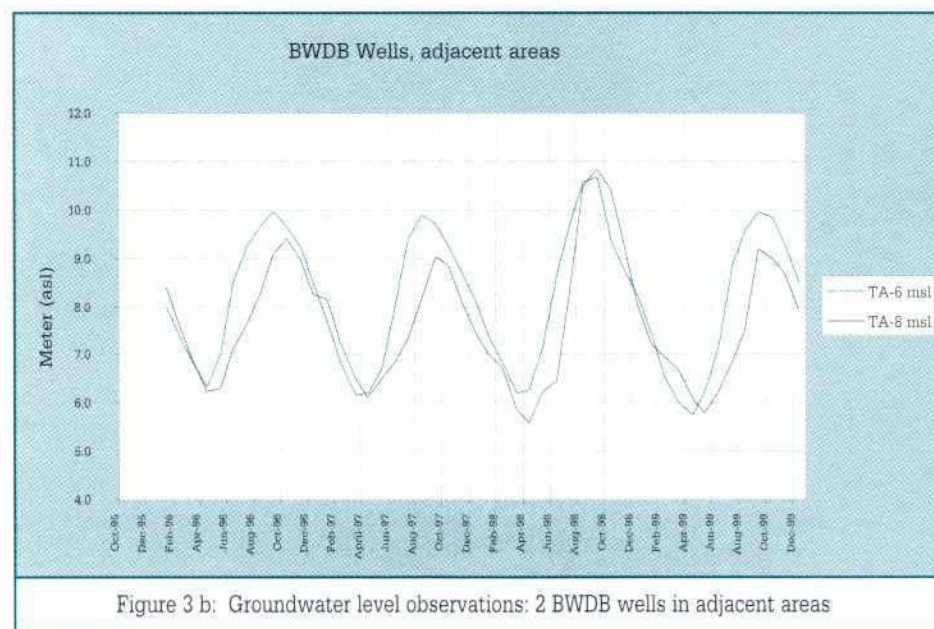
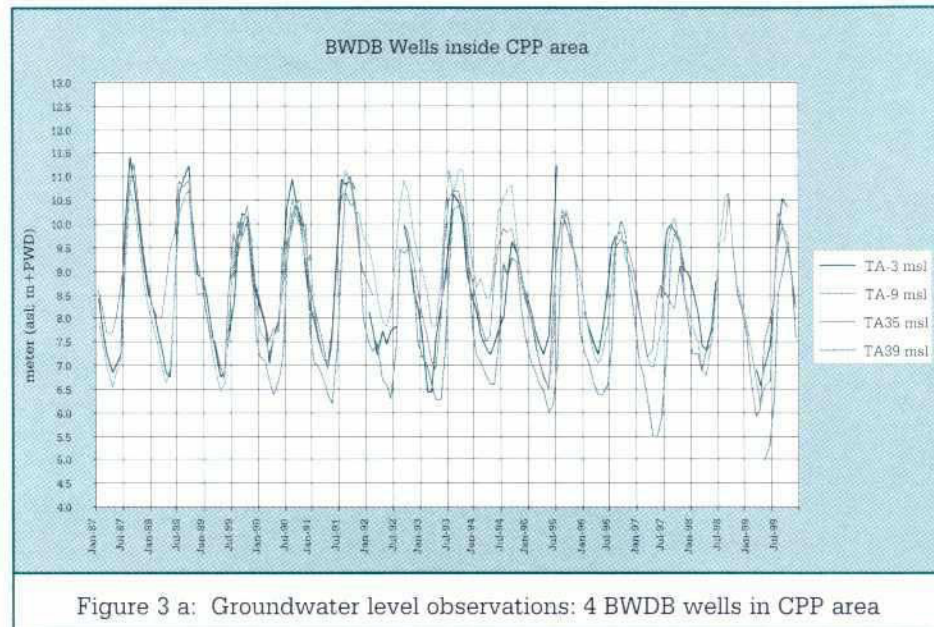
Groundwater Monitoring

Over exploitation of upper groundwater aquifers is a general matter of concern in

Bangladesh. The major potential impact of a regional water resources project can be direct by reducing the floodwater inflow into the floodplain and thereby reducing the volume of groundwater recharge. Or indirect: by enhancing agricultural development towards increased irrigation areas under paddy (e.g. boro). Irrigated agriculture is mainly by the use of shallow tube wells for dry season water supply. The number of wells has considerably increased over the past decade in CPP area (see Agricultural annex).

CPP collected groundwater observation data from BWDB and DPHE wells over the past years. The trend of these records is presented in Figures 2a, 2b, 3a and 3b.

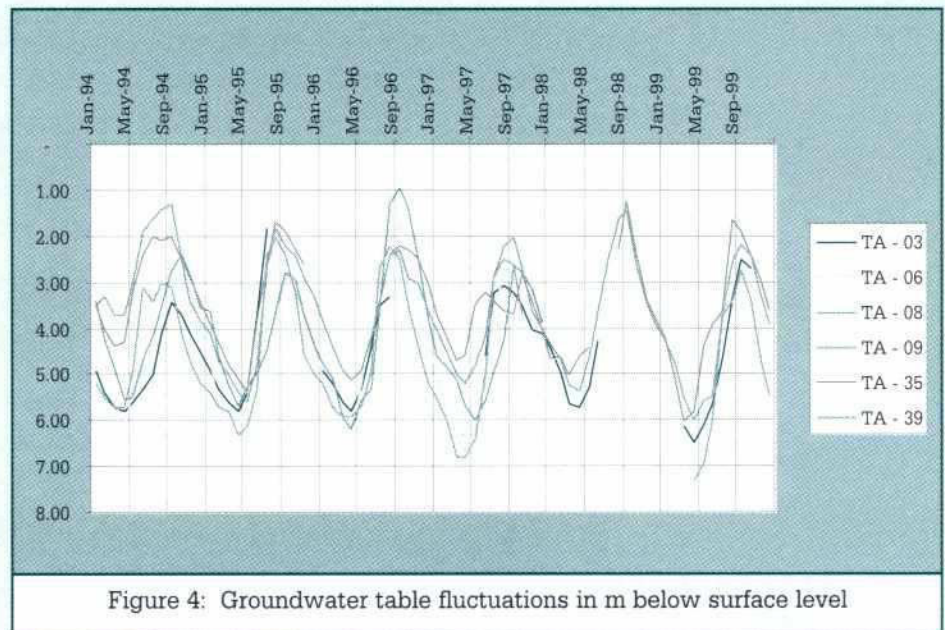




Interpretation. The most striking feature is a pronounced seasonality of groundwater fluctuation: the lows are usually recorded in March-April. With the beginning raining season in May-June and the river flood from July to September, the groundwater table rises to high levels during September. The average increase is in the range of 4 to 5 m. The rise in groundwater table coincides with the peak water levels in floodplains

suggesting a rapid infiltration into the upper aquifers. The main conclusion is, that groundwater recharge during the monsoon season can replenish the upper aquifer, which is heavily exploited during the dry season, mainly caused by irrigation extraction. None of the data - to date - indicate any definite trend of continuous lowering of groundwater level. The lows that are presently observed had already been observed in the late 80s.

However, recent data also indicate that dry season groundwater abstraction is reaching a high level in some wells, i.e. the lowest ever observed levels (in masl) dry season draw-downs were recorded in 1998 and 1999 (and also expected for 2000). This, of course would have important implications on groundwater availability from STD and especially hand pumps that provide rural domestic water supply. If the trend continues, many shallow wells will run dry in the dry season, although there is - at present - no evidence until 1998. Figure 4 shows groundwater levels below surface level for selected shallow wells. The records in 1997 and 1999, however, may be interpreted as the turning point towards a continuing downward trend in seasonal groundwater fluctuation, resulting from the steadily increasing number of STDs and Tangail Town water supply abstractions.



Data from the water balance suggest, that provided the gates are open to allow the "beneficial part" of the river floodwater to enter into the CPP area, that there is

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sufficient groundwater replenishment. Even in a year of below average water level, such as 1999, the total river flood inflow was calculated to amount some 233 MCM. For 3 out of 5 years, the CPP model calculated storage of some 80 to 120 MCM ($\text{m}^3 \times 10^6$) for the period July-September of the monsoon season. This storage comprises of losses due to evaporation (*beels*) or transpiration (crops, plants) plus changes in soil moisture contents; the remainder is likely the groundwater recharge. The following Figures for the actual recharge and potential recharge are estimated (Sources: MPO groundwater water studies 1991; estimates in CPP TT 1994 Geo-hydrology study):

- Potential recharge amounts to some 600-700 mm (flood and rainwater minus surface flow losses and rejected recharge due to changing deep percolation rates);
- Actual recharge amounts to some 200-300 mm/y (usable recharge less rejected recharge during the time of inundation and natural losses due to evaporation/evapotranspiration, deep lateral or vertical percolation, etc.);

The tentative figure of some 300 mm of actual recharge in Tangail area matches the *indicative estimates of groundwater recharge* under CPP flood conditions:

- Actual storage: 80 MCM on average during the peak monsoon season (range of 80 to 120 MCM/Jul-Sep in normal years period plus some storage and percolation during early and late monsoon that is not quantified here);
- The overall average inundation depth is calculated to 606 mm (80 MCM / 13,200 ha) that is available for potential recharge in the entire CPP area;
- Evaporation (ET_o) and evapotranspiration (ETP = ET_o * 1.10) losses in the range of 3.7 mm/d amounts to ETP = 372 mm/Jul-Sep.
- The actual replenishment of soil moisture storage capacity to wet conditions is already counted for within the period April - June by local rainfall (see above); and
- The actual recharge is $606 - 372 = 234$ mm (without lateral seepage gains or losses).

The amount of lateral seepage from major rivers remains a matter of speculation without further hydrological investigations. However, lateral seepage is a common feature in floodplains with horizontal strata of sandy and sandy-silty layers. The NW Region Groundwater Study (NWRS FAP 2, 1992) showed that there is a noticeable

influence on river levels with groundwater levels up to a distance of about 3 to 5 km from rivers. Therefore, it is likely that also the CPP area gains some groundwater recharge from this lateral seepage, independent from CPP interventions or pre-CPP embankments.

In general, the geology of the Tangail Younger Brahmaputra Floodplain consists of three main lithological strata, which usually refer to upper and lower aquifers:

- *Upper strata* of silty clay, clay or loam, 0-12 m thickness; variable permeability; this layer is relatively thin and heterogeneous in Tangail area;
- *Intermediate* fine to medium sands, 15-30 m thickness; horizontal permeability $20 \text{ m} \pm 10 \text{ m/day}$; vertical permeability 5-12 m/d. This strata usually contains the upper aquifer which is tapped by most STD and hand tubewells; and
- *Lower main aquifer* with uniform medium to coarse sands and gravel, 50-60 m thickness, permeability $80 \text{ m} \pm 40 \text{ m/day}$.

The upper clay/silt can locally be semi-confined in the upper aquifer, but on dewatering it is likely to become unconfined. The upper clay/silt unit is bounded to faults and forms of scour channels of the old riverbed of the meandering Jamuna River. This accounts for the variations in the upper aquifer and gives rise to distinctive unconfined or semi-confined aquifer characteristics.

Observations from infiltration rates of medium highland and medium lowland with pre-dominant sandy loamy soils suggest that these are the areas where most deep percolation into the upper aquifer during the monsoon season takes place. Most *beels*, on the other hand have very low percolation rates, due to silty-clayey layers and the sealing of plant layers and detritus at the *beel* bottoms. Therefore, deep percolation from inundated areas during the dry season (after November-December) is marginal.

In summary: although the upper and lower aquifer sequences seem to be sustainable to a large withdrawal of groundwater, there is increasing risk of mining. This should draw immediate attention to water policy makers to develop a groundwater management plan and to regulate the withdrawal of groundwater especially by irrigated agriculture.

CPP impact: It is apparent that replenishment of groundwater mainly depends on deep vertical percolation from inundated floodplains during the monsoon season. Any substantial reduction of water inflow (from river floods) by flood control interventions will reduce the potential groundwater recharge. The risk of interventions by CPP is

presently less adverse because they permit a substantial inflow of the monsoon river flood into the floodplains.

Water Pollution and Controlled Flooding

Monitoring water quality within CPP has been a key issue since its inception. The EMP designed a program to monitor water at 25 selected environments (hot spots): Rivers, *khals*, ponds, wetlands, drinking and irrigation wells (Figure 5). The analytical results compiled and the changes identified in some of the locations within CPP are summarized in Table 6.

Despite some methodological (analytical) and organizational (discontinued sampling) problems encountered, the existing data suggests that there are no substantial changes within CPP area over the period 1994 to 1999 that can clearly be attributed to CPP flood control interventions. Any change must be interpreted against the background of extreme seasonal changes in water quality and the site-specific characteristics, depending on a complex balance of polluted inflow, rainfall and surface flooding. These parameters are highly variable in every year, depending on seasonal rainfall and river flood levels within CPP floodplains. CPP has some impact by influencing the river water inflow, water flow between *chawks*, and drainage, since major infrastructure works are completed during the period 1996 to 1999. The potential beneficial CPP impacts are:

- Slight increase of river inflow (if gates are open): beneficial impact by allowing more freshwater entering the floodplains and *beels* (compared to before CPP);
- Reducing very high river flood levels: beneficial impact by reducing housing areas, hand tubewells and homestead vegetation (trees) that are inundated;
- Increasing flow between *chawks*: beneficial impact by reducing areas with stagnant water and increasing flushing effects;
- Improved drainage: beneficial impact through flushing effect; increase of flow velocity and reducing stagnant water pool areas (outside *beels*); however: effective flushing in CPP areas can create problems in downstream reaches that receive the polluted water; and
- Reducing flood inundation period of homesteads and other highland: beneficial impact by improving accessibility and communication in rural areas; easier access to safe drinking water or food supply, safe storage of grains, etc.

The extent of beneficial impacts is directly related to the operation of gated structures that allow fresh floodwater entering the floodplain and water flow between *chawks*. The CPP water quality data are used here to monitor the seasonal changes that occur within the CPP floodplain, and to assess to what extent seasonal flooding contributes to seasonal dynamics of water quality.

Location	Parameter	1994		1995		1996		1997	1999	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Dry	Wet
Lohajang River	p ^H	7.7	7.7	7.9	7.8	8.2	7.8	7.5	8.6	7.7
	NH ₃	1.1	0.6	0.2	0.7	0.5	0.6	1.2	0.01	0.03
	COD	21	19	18	32	39	29	9	30.6	8.3
Baro beel	p ^H	-	-	8.2	9.5	7.7	7.8	7.3	7.4	7.6
	NH ₃	-	-	0.6	0.6	0.5	1	1.1	0.1	traces
	COD	-	-	8	60	29	43	9	40.8	16.3
Tangail khal	p ^H	7.1	7.5	8.4	7.8	8.2	7.9	7.9	7.2	7.1
	NH ₃	4.5	3.0	7.1	10.8	10.8	16	-	0.52	trace
	COD	58	48	50	20	20	35	-	61.3	73.5
Jugini beel	p ^H	-	-	8.0	8.2	9.4	8.3	9.5	7.5	7.6
	DO	-	-	8.6	9.0	10.2	9.0	8.5	4.9	7.5
	Hardness	-	-	68	86	103	68	51	62.0	-
Hand tube well site 14	p ^H	6.8	6.8	7.3	7.3	7.3	6.8	8.4	7.0	6.9
	Fe	10.1	1.7	16	12.2	12	10.5	16	13.1	11.4
	Fecal	0	1	0	0	0	0	0	1	100
Deep tube well site 1	p ^H	-	-	7.2	-	7.6	-	-	6.8	-
	Fe	-	-	8	-	8.0	-	-	1.5	-
	Fecal	-	-	0	-	-	-	-	1	-

Table 5: Selected Water Quality Parameters within CPP Area

Note: Analysis 1994 to 1997: CPP field laboratory, Dhaka laboratories; 1999 Analysis: Dhaka University
Sources: Water Pollution Report 1994; Annual Reports 1995 to 1997; Water Quality Monitoring 1999

The results show that most water quality indicators within CPP deteriorate during the dry season but returns to normal in monsoon season. Hence, rainfall and floods are required to improve most water quality parameters. However, very high floods can have detrimental effects due to pollution of shallow tubewells, dispersion of toxic materials (e.g. from handloom factories), overflow of fish ponds and limited access to safe water resources.

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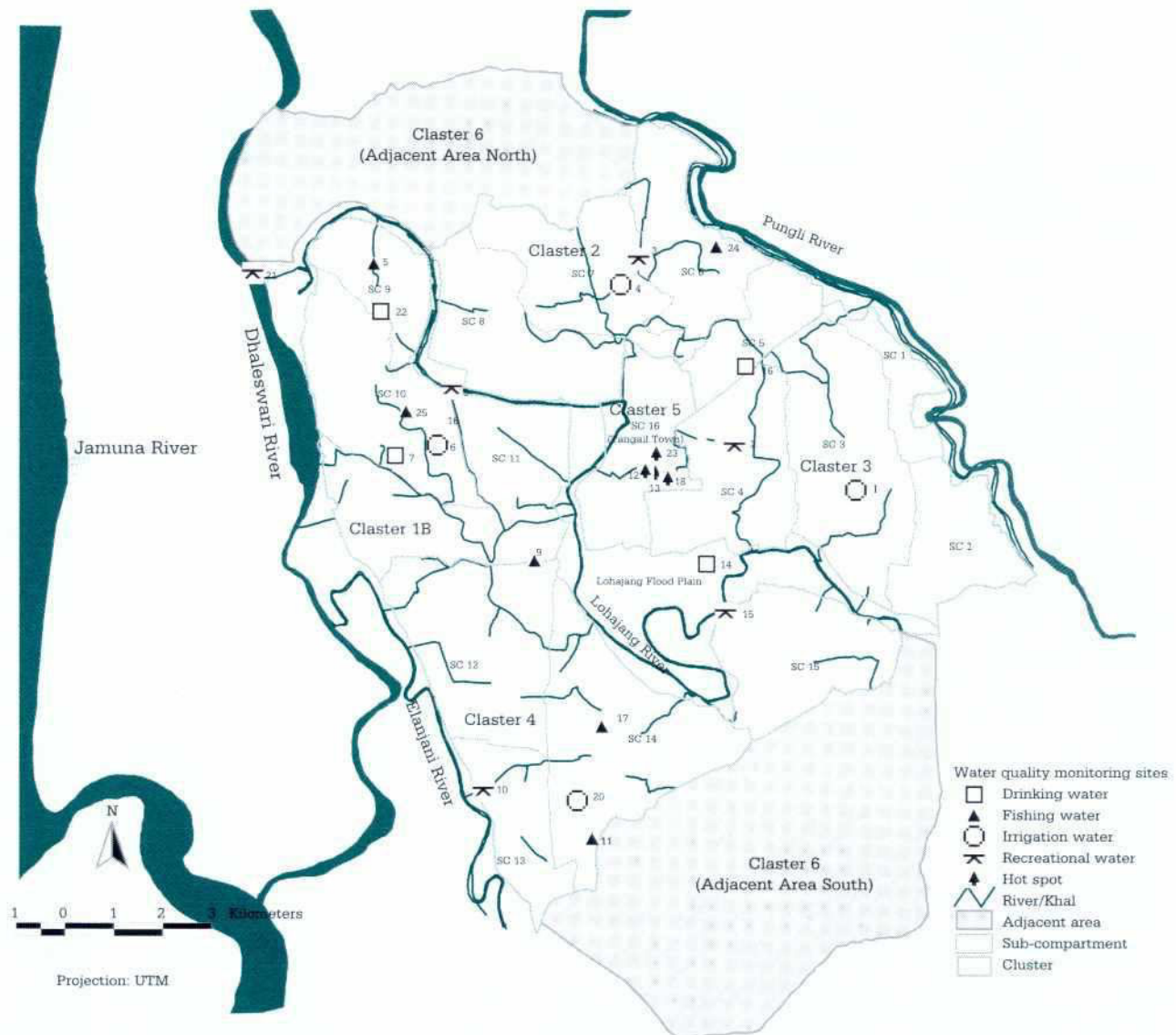


Figure 5: Water Quality Monitoring Sites


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The p^H measured for surface waters (Lohajang River, Boro beel) generally varied between 7.3 and 9.5 without having any significant changes over the last six years. The presence of dissolved NH_3 and COD, however, declined significantly during the period. Further analysis is required to establish a firm relationship to improved flooding and drainage conditions within CPP area; other site-specific characteristics such as reduced inflow from effluents may have caused the improvements at these locations.

In some locations, lower COD concentrations may also be attributed to the reduced use of agro-chemicals in 1998/1999, as compared with the previous years, caused by the high flood and reduced cropping intensity in the monsoon season 1998.

Major findings of the analysis in 1999 are:

- Most recreational, wetland and pond water within CPP undergo processes of deterioration during the dry season. Low oxygen concentrations, high COD and subsequent rise in dissolved NH_3 concentration in the water bodies are identified as the major determining factors. High 'dry season' temperatures, favorable p^H , presence of sufficient inorganic nutrients are conducive to the processes involved. The implication of such surface water quality deterioration could be serious particularly on fish production. Processes of eutrophication are also very active during the dry season and the recreational value of most water bodies is almost zero;
- With the arrival of the monsoon floodwater and rainwater, the situation returns to normal and surface water quality in terms of dissolved oxygen concentration improves significantly. The presence of NH_3 , chemical oxygen demanding substances and inorganic nutrients shows minimum levels.
- Drinking water quality, however, worsens during the wet season. All drinking water is being heavily contaminated with coliform bacteria and excessively high iron contents are found completely unsuitable for drinking during the period;
- The changes in water quality appear to be natural and are comparable with the processes active in any floodplain ecosystem. However, the changes should be further monitored in a program that considers all factors inside and outside of CPP area. Particularly, changes in Fe contents in drinking and irrigation water require being long-term monitored considering the source, dissolution process and mobility in soil-sediments under flood control conditions. The



contamination is attributable to geologic deposits and the overall changes in hydrology due to the implementation of the project and/or heavy ground water abstraction at present condition in CPP are possibly contributing to the processes.

Important findings with regard to selected water quality parameters are:

p^H. The surface water and groundwater p^H measured during dry and wet seasons varied from 7.0 to 8.6 (neutral to moderately alkaline) and 6.7 to 8.4 (slightly acidic to moderately alkaline) respectively. A decrease in p^H in general in all surface waters was noticed in the second dry season samples. These changes from alkaline to acidic p^H of the surface waters may be attributable to inorganic and organic acid produced by the decomposition of aquatic plants and other organic materials under warm stagnant aquatic environment;

Significantly higher p^H at 8.25 was measured for in general all recreational, some wetland (Kumari Beel and Ghatakbari Beel), Hand Tubewell at Site-7 and Site-16 and tap water at Site-12 in the first wet season samples. The reason for this increase in p^H during wet season is not quite clear. However, the nature of the changes in contrast to the presence of very low CaCO₃ suggest that Fe⁺⁺ could possibly contributed to the initial rise in p^H during wet season. Significantly high Fe contents were measured for in general all water samples during the wet season. Rain water could also contribute to the processes. The initial monsoon rain water p^H measured at Mahbubur was as high as 9.0;

Dissolved Oxygen (DO). Dissolved oxygen concentration measured for most surface waters varied from 4.9 to 6.6 and 5.1 to 8.5 mg/l during dry and wet seasons respectively. Significantly low DO concentrations 1.1, 3.7 and 2.6 mg/l were measured for Baruha Khal, Agbetur Dighi and one pond in the second dry season samples. Comparatively, higher DO concentrations (between 5.5 and 8.5 mg/l) were, however, measured in all surface water in the first wet season samples. The concentrations even in Baruha Khal, Agbetur Dighi increased very significantly up to 7.6 (0.4 mg/l and returned to normal. Low oxygen concentrations measured for some of the surface waters, particularly in the second dry season samples indicated the deterioration of water quality. This is due to the dominance of consumptive processes and can be ascribed primarily to the effect of temperature on microbial metabolism. Reduced solubility of oxygen in warm waters and high rates of photo-oxidation and microbial decomposition of dissolved organic matter may also contribute to these low oxygen concentrations;

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The DO concentration measured for drinking water varied between 3.1 and 6.9 mg/l. A declining trend in oxygen concentration was observed in most drinking water sources during the wet season. Reduced transportation of oxygen to the ground water is one of the reasons for this decline. DO concentrations in drinking water during wet season in general were below Bangladesh Standard (6.0 mg/l);

Electrical Conductivity (EC). A very low EC was measured in all water samples during the investigation. The EC in surface water during dry and wet seasons varied from 170 to 511 and 30 to 350 $\mu\text{S}/\text{cm}$ respectively. The highest surface water EC of 511 $\mu\text{S}/\text{cm}$ was measured for Baruha Khal in the second dry season samples and the lowest 30 $\mu\text{S}/\text{cm}$ for Kumari Beel in first wet season samples. Drinking and irrigation water EC varied from 211 to 390 and 150 to 450 $\mu\text{S}/\text{cm}$ during dry and wet seasons respectively. The highest well water EC 450 $\mu\text{S}/\text{cm}$ was measured for the Tap site-12 in the second wet season samples. EC in all water samples are much below Bangladesh Standard (500 - 750 mg/l);

TDS and SS. Total dissolved solids (TDS) measured for drinking and irrigation water during dry and wet seasons varied from 200 to 800 and 150 to 250 mg/l respectively. The highest well water TDS of 800 mg/l was measured at a tap in the dry season. The TDS measured for two wells was much above the permissible limit values (500 mg/l). Significantly, low TDS contents were however, measured in all drinking water during wet season. Surface water TDS varied from 200 to 1600 and 50 to 320 mg/l during dry and wet seasons respectively. Recreational waters generally had higher TDS (400-800 mg/l) than the wetland waters (200-600 mg/l) during the dry season. Remarkably, high TDS at 1600 mg/l was measured for Lohajang River. Significantly, low TDS contents were however, measured in all surface waters during the wet season;

The presence of suspended solids (SS) in drinking and irrigation waters was almost nil during dry season. Some SS loads (32-48 mg/l) were, however, measured during wet season. These were mostly iron precipitates. Quite a few surface water samples namely Baruha Khal; Rasulpur Khal, Atia Kumari Beel and Agbetur Dighi had substantial SS loads during dry season. Most significant of which were Rasulpur Khal (1600 mg/l) and Agbetur Dhigi (800 mg/l). The suspended solids present in these waters were mostly the fragments of partially decomposed aquatic plant leaves and roots;

Dissolved NH_3 . Ammonia (NH_3) is naturally present in surface water, ground water and domestic sewage. It is produced largely by deamination of organic nitrogen containing compounds and hydrolysis of urea. In water bodies, it is produced naturally by the reduction of nitrates under anaerobic conditions. Concentration above certain threshold values can have serious toxic effect particularly on fish;

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Dissolved NH_3 concentrations measured for some of the surface water during dry season were much above the permissible limit values (0.075 mg/l). Notable of which were Dhaleswari River (0.5 mg/l), Jugini Beel (0.2 mg/l), Santosh Dighi (0.15 mg/l) and Agbetur Dighi (0.15 mg/l). Very low NH_3 concentrations at 0.01 to 0.03 mg/l however, were measured for these surface waters during wet season;

Traces of NH_3 were detected in irrigation and drinking waters during both wet and dry seasons. The NH_3 concentrations measured for surface and ground waters in 1999 season, however, were much lower than those reported in the EIA case study (CPP 1992) and the Environmental Pollution Survey Report (1994);

Soluble-N, $\text{NH}_4^+ -\text{N}$ and $(\text{NO}_3^- + \text{NO}_2^-) -\text{N}$. Surface water soluble N content other than Baruha Khal varied between 1.4 and 3.4 mg/l during dry season. Between 7.6 and 7.8 mg/l soluble-N contents were measured for Baruha Khal during the same period. Wetlands generally had higher soluble-N than river and recreational waters. Compared to this significantly low soluble-N contents (0.1-1.8 mg/l) were, however, measured for in general all surface water except Dhaleswari River, Lohajang River, Ghatakbari Beel, Jugini Beel, and Kumari Beel. No changes in soluble-N contents were monitored for these waters during the wet season. The highest soluble-N contents 40 to 67 and 10 to 30 mg/l were measured for Tangail Khal during dry and wet seasons respectively;

Drinking water soluble N contents varied between 1.5 to 3 mg/l with slight increase during wet season. Deep Tubewells had soluble-N contents between 3 and 3.6 mg/l in the dry season. $\text{NH}_4^+ -\text{N}$ contents in most surface waters varied between 0.7 and 2.3 mg/l during the dry season. The concentrations, however, were significantly reduced down during the wet season: 0.1 to 0.7 mg/l $\text{NH}_4^+ -\text{N}$;

The surface water $(\text{NO}_3^- + \text{NO}_2^-) -\text{N}$ other than Baruha Khal varied from 0.3 to 1.9 and 0.1 to 4.1 mg/l during dry and wet seasons respectively. Between 3.2 and 5.2 mg/l $(\text{NO}_3^- + \text{NO}_2^-) -\text{N}$ were measured for Baruha Khal during dry season. Significant increases in $(\text{NO}_3^- + \text{NO}_2^-) -\text{N}$ were monitored for most rivers, khals and beels during the wet season. $(\text{NO}_3^- + \text{NO}_2^-) -\text{N}$ were the dominant soluble-N fractions in almost all the water samples during the wet season. The highest $(\text{NO}_3^- + \text{NO}_2^-) -\text{N}$ of 31 mg/l was measured for Tangail Khal during the wet season;

High $\text{NH}_4^+ -\text{N}$ and $(\text{NO}_3^- + \text{NO}_2^-) -\text{N}$ concentrations were found in some recreational, groundwater and wetlands that may be attributable to surface run-off and/or leaching from the surrounding agricultural lands. Domestic sewage and run-off from agricultural lands could provide nutrients in natural settings and cause eutrophication of the receiving water bodies. Algal blooms and large amount of other

aquatic weeds as a result of eutrophication could present an aesthetic scene and disturb recreational uses of water. In the process of eutrophication, the water bodies can eventually lose all dissolved oxygen. Baruha Khal and Agbetur Dighi may presently undergo this process;

Phosphate. Addition of phosphorous from anthropogenic sources could further accelerate the eutrophication processes active in aquatic systems. The results show that surface water in general in CPP are containing relatively low PO_4^{3-} concentrations but enough to induce processes of eutrophication. Eutrophication conditions can occur in surface waters when P concentrations exceed 0.01 to 0.03 mg/l. The concentration measured in CPP varied from 0.04 to 1.07 and 0.03 to 0.61 mg/l in surface waters during dry and wet seasons respectively. The highest PO_4^{3-} concentrations between 0.77 and 1.07 mg/l were measured for Baruha Khal during dry season. Concentration between 0.10 and 0.30 mg/l were measured for Lohajang River, Rasulpur Khal, Jugini Beel, Santosh Dighi and Atia Kumari Beel during the same period. Significantly higher PO_4^{3-} concentrations were measured for some of the wetland waters during wet season. Notable of which were Santosh Dighi (0.51-0.61 mg/l) and Agbetur Dighi (0.13-0.23 mg/l);

Comparatively low PO_4^{3-} concentrations between 0.03 and 0.23 mg/l were measured for drinking and most irrigation waters. The PO_4^{3-} concentration in Tangail Khal varied from 2.8 to 5.3 and 0.4 to 1.3 mg/l during dry and wet seasons respectively. The reason for generally low PO_4^{3-} concentrations in surface water in CPP could be the burial of inorganic phosphate compounds in the sediments particularly in the form of ferric phosphates. Phosphate ions form insoluble compounds with several positive ions including Al^{+3} , Ca^{+2} and Fe^{+3} . In fresh water the most important of these chemical precipitates is frequently ferric phosphate (FeSO_4). The precipitate sinks to the bottom and is effectively trapped in sediments;

Iron. The analytical results showed that drinking water in general in CPP area are heavily contaminated with Fe. The concentration varied from 1.5 to 13 and 5 to 32 mg/l during dry and wet seasons respectively. The concentrations measured for drinking water during wet season were significantly higher than those measured during dry season. All the measured values were much above the maximum allowable concentration of 0.3 mg/l. The maximum Fe contents between 11 and 32 mg/l were measured for a hand tubewell. Irrigation water Fe contents varied from 0.5 to 1.6 mg/l compared to those from drinking waters. The maximum Fe contents between of some 1.6 mg/l were measured for deep tubewell during dry season. High Fe contents in groundwater at Tangail from 0.8 mg/l to as much as 10.8 mg/l were also reported by ADB (1993) and DPHE (1989);

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Surface water Fe contents varied from 0.3 to 1.2 and 0.2 to 10.6 mg/l during dry and wet seasons respectively. Significantly high Fe contents between 6 and 10.6 mg/l were measured for Dhaleswari River, Lohajang River, Baruha Khal and Santosh Dighi in the first wet season samples. Iron content measured for Tangail Khal varied between 0.90 and 3.69 mg/l during the investigation;

Sulfate. The SO_4^{2-} concentration measured for surface water in general varied from 1.7 to 25 and 5-20 mg/l during dry and wet seasons respectively. The highest and the lowest SO_4^{2-} contents 25 and 1.7 mg/l were measured for Agbetur Dighi and Ghatakbari Beel respectively. Compared to dry season significantly high SO_4^{2-} contents were measured in all surface and drinking waters during wet season. The drinking and irrigation water SO_4^{2-} content varied from 1-18 and 4-16 mg/l during dry and wet seasons respectively. Among the well waters the highest SO_4^{2-} contents ((15.0 mg/l) were measured for a shallow tubewell during dry season and a hand tubewell during wet season. Sulfate concentration in Tangail Khal varied between 10-15 mg/l during the investigation. In general, all water samples in CPP had SO_4^{2-} concentration much below international Standard (250 mg/l);

Chloride. Very low Cl concentrations between 11 and 78 mg/l were measured in all river, recreational, wetland, irrigation and drinking water. Among the surface water the maximum Cl concentrations of some 75 mg/l were measured for Baruha Khal during dry season. A hand tubewell had the maximum Cl contents of some 58 mg/l among well waters. Significantly low Cl contents were however, measured in all water samples during wet season. The Cl concentration in Tangail Khal varied from 114 to 166 and 23 to 209 mg/l during dry and wet seasons respectively;

Chloride concentrations measured in CPP water samples were below international standard (250 mg/l);

Zinc. Very low Zn concentrations between 0.01 and 0.35 mg/l were measured for in general all surface and ground water during the investigation. The maximum concentrations of 0.18 to 0.35 mg/l Zn were in Baruha Khal during dry season. Drinking and irrigation water generally had much lower Zn concentrations (0.01-0.04 mg/l) than the surface waters. However, Zn contents in the range of 0.1 to 0.15 mg/l were measured for a hand and a shallow tubewell during dry season;

Significantly low Zn contents were measured in all water samples during wet season. None of the water samples have been shown to contain Zn concentrations above the Bangladesh limit values (5.0 mg/l) set for drinking and irrigation water;

Chemical Oxygen Demand (COD). The COD measured for surface waters in general varied from 20 to 82 mg/l during dry season. The highest COD of 71 to 82 mg/l was

measured for Baruha Khal and the lowest 20 to 31 mg/l for Lohajang River and Kumari Beel. The COD measured for drinking and irrigation water varied between 10 and 20 mg/l during the same period. Traces up to 8 mg/l of COD were measured in water samples during the wet season;

The COD measured for Tangail Khal varied from 31 to 71 and traces to 73 mg/l during dry and wet seasons respectively. In general, the COD in all water samples during dry and wet seasons were much above Bangladesh Standard (4.0 mg/l);

Microbiological. Results of microbiological analysis showed that almost all the water samples including drinking water were heavily contaminated with coliform bacteria during wet season. Total coliform counts in surface water varied between 1.1×10^2 and 3.7×10^4 c.f.u/100 ml. The highest and the lowest counts 1.15×10^4 to 3.7×10^4 and 5.6×10^2 to 1.3×10^3 c.f.u/100 ml were made for Jugini Beel and Ghatakbari Beel respectively. Among the recreational waters, Baruha Khal had the highest total coliform counts (between 1.8×10^3 and 9.1×10^3 c.f.u/100ml) during wet season. The total coliform count in Tangail Khal during wet season varied between 2.01×10^3 and 4.12×10^4 c.f.u/100 ml.

Dry season. In drinking waters contents varied between 3.0×10^2 and 1.4×10^4 c.f.u/100 ml; the highest 1.4×10^3 and lowest 3.0×10^2 c.f.u/100 ml were counted for two hand tubewells. Comparatively low total coliform counts were made in all surface water during dry season: counts varied from 1.1×10^2 to 1.2×10^2 and 4.4×10^3 to 1.2×10^4 c.f.u/100 ml.. Drinking and irrigation waters did not contained coliform bacteria during dry season; some counts between 6 and 64 c.f.u/100 ml were made for one deep and one shallow tubewell. Tangail Khal had the highest total coliform counts (between 2.4×10^3 and 6.5×10^4 c.f.u/100 ml);

Wet season. Significantly high Fecal coliform counts were also made for in general all surface and ground waters during wet season. Compared to dry season surface water counts of less than 1.0 to 1.8×10^2 between 75 and 7.0×10^2 c.f.u/100 ml Fecal coliform were made during wet season. Significantly high Fecal coliform counts between 64 and 1.37×10^2 c.f.u/100 ml were also made for drinking waters particularly in the first wet season samples as compared to almost no counts during dry season. Tangail Khal also had significantly high Fecal counts of 2.00×10^4 c.f.u/100 ml during wet season as compared to roughly about 2.5×10^2 c.f.u/100 ml during dry season. The sources of this microbial pollution could be open defecation, latrines or untreated sewage from small settlements. Jute rotting could also contribute to the processes. The reason for significantly high total and Fecal counts could be the spread of rain and floodwater during the wet season;

Pesticide Residues. None of the water samples in the present investigation had detectable residues of pesticides (organophosphorous and carbamate) commonly used in the region. However, trace levels (0.08-0.10 mg/ml) of organochlorine pesticides namely Lindane and P,P'-DDT were detected in Nagar Jalpai Khal Outlet and Gharinda Beel in dry season samples. The permissible limit value of P,P'-DDT in non-potable water is 0.042 ng/ml (FAO/WHO, 1993);

Impacts on Land Resources

Change in Land Types.

The revised hydrological CPP model was used to simulate the impact of CPP by applying long-term statistical averages for both river flood (44 years) and rainfall (38 years) on the basis of 1 in 5 year maximum water levels outside the compartment (Jugini 12.72m+PWD); together with a one in 5 year 3-day maximum rainfall, corresponding to 1966 flood data and 1977 rainfall data. Land types were then defined on the basis of the simulated flood map at the time of maximum outside water levels and with all CPP infrastructures in place. The "base model" assumes that all gates are open, the "after CPP" simulation presents the operation of gates (boundary conditions are described in Annex B; there are also other gate operation options for less flooding and more drainage possible). The results are shown in Table 6.

Land types in CCP w/o Tangail Town	Flood depth	GIS EIA 1992	CPP GIS 1996	CPP GIS 1999			
				Base in ha and %		After CPP in ha and %	
F ₀ highland	0.0 to 0.3 m	576	223	3209	32	5178	52
F ₁ medium highland	0.3 to 0.9 m	1821	1737	3819	38	3232	25
F ₂ medium lowland	0.9 to 1.8 m	4248	4063	2617	26	1327	10
F ₃ lowland	>1.8 m	2552	3740	313	3.1	220	1.7
Total net cultivable		9197	9763	9958 ha	75 % of total	9957 ha	75 % of total
Total CPP		12 999 ha	13 200 ha	13200 ha	100 %	13200 ha	100 %

Table 6: Land types in CPP area according to Flood Depth (base data and after CPP)

Note: Previous hydrological models were based on different digital elevation data and on different criteria to define the average flood depth. In the following, only data from GIS 1999 are used
Sources: GIS Atlas 1992 (EIA Study 1992), CPP Atlas GIS 1996; CPP Atlas GIS 1999

These Figures show that substantial areas of F₂ land will be converted. That is land that is prior to CPP - flooded in 1 of 5 years at 0.9 to 1.8 m, is converted to land that is less frequently and less deeply flooded for prolonged periods. The same applies to changes from F₃ to F₂ land and so on, which eventually results in less prolonged and deep flooding conditions in CPP area. The model, therefore, suggests that the CPP

interventions can provide improved water management for cropping through improved drainage in the pre-monsoon season and reduced monsoon flood depth to allow a shift in monsoon rice production to HYV-Aman; and earlier drainage at the end of monsoon period allowing earlier planting of Rabi crops.

Changes in Agriculture

Are subject to a separate annex. Not all changes observed in CPP area can be attributed to CPP interventions because the time since completion of the project's infrastructure appears too short for a permanent change in farmers' perceptions. More changes are likely to be observed in future with the adoption of proposals elaborated by the new and participatory OFDT program by the CPP in collaboration with the DAE Tangail. In general, it can be concluded that the favorable water management situation in CPP area has contributed to more intensive and productive land. It remains to be seen whether the combination of extended area and high yield, especially for Rabi crops can be maintained.

Agro-chemical Uses and their Potential Environmental Hazards

The annual monitoring and special survey carried by CPP during the period 1995 to 1999 showed that farmers increasingly use both fertilizers and pesticides. The applications - to date - do not cause environmental harm beyond the normal level observed in Bangladesh. Urea is the mostly used fertilizer followed by SSP, MP, Sulfur and Zinc. The order of magnitude of the fertilizers being used is as follows:

Urea > SSP > MP > GYP > TSP > Zn

Trends in fertilizer use in CPP area over the period 1993 to 2000 (projected) were calculated from Tangail Sadar Thana data. These figures were multiplied with the input per unit crop area in Tangail Sadar Thana and the annual crop area of 20,900 ha in CPP. There was a cumulative growth of about 29% in the overall fertilizer use in CPP between 1993 and 1999, however, there are considerable differences between years. No major change in the use of individual fertilizers however, was observed during the period. The rates of fertilizer application are close to crop specific recommendations (SRDI Tangail). Maximum fertilizers are used for Boro (HYV) crops. It is assumed that a substantial portion of fertilizers brought in Tangail is sold/distributed outside the CPP Thana. Data obtained on the distribution of fertilizers from DAE, Tangail show a considerable gap between actual consumption and distribution.



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Year	Crop area	Tangail Sadar								CPP	
		Fertilizer applied in metric tons (MT)							MT	Kg/ha	
		Urea	TSP	SSP	DAP	MP	GYP	ZN	Total fertilizer input	Input per unit crop area	Calculated fertilizer input MT
1999/2000*	29989	8441	2084	115	1759	1735	940	147	15221		
1998/99	29989									194	4053
1997/98	29989	2246	303	1663	6	1042	524	23	5807	194	3485
1996/97	32432	2296	265	1698		1031	562	22	5874	181	3799
1995/96	32216	2453	355	1929		1361	818	77	69993	217	4216
1994/95	37648	2544	277	1896		1159	622	27	6525	173	3243
1993/94	38036	2527	229	1965		1212	720	91	6744	177	3128

Table 7: Trends in fertilizer use in Tangail Sadar and CPP area

* projected by DAE Tangail. Source: Tangail Agricultural Office 1999. CPP » 75% of Tangail Sadar

Farmers' interviews suggest that the use of fertilizers is close to recommended dosages. However, different dosage schedules are maintained and applications are variable. Advises from the agriculture extension workers are poor and in most of the cases the farmers apply their sense and experience gathered (farmers views). Crop responses to fertilizers are said to be generally good. Many farmers complain that demand for fertilizers is increasing during the last years. Very few farmers use organic fertilizers and green manure. The use of cattle dung is marginal.

Total sales of wholesale dealers in Tangail and retailers at local bazaars showed that sales (in MT) in 1999 were slightly lower than calculated from Tangail Sadar data:

1999 Survey	Urea	SSP	TSP	MP	DAP	Total MT	75% of Tangail Sadar (see Table 7.40)
Wholesaler	1700	400	140	120	100	2560	3039
Retailer	850	170	NA	70		1090	-

Table 8: Sales of wholesalers and retailers in Tangail area

Trends in Use of Pesticides in CPP

Use of pesticides in CPP as compared to other regions in Bangladesh is generally low because occurrence of pest infestation in Tangail is generally low. Occasional infestation of endemic pests of stem borer, rice hispa and brown plant hoppers are reported. Organophosphate and carbamates are commonly used pesticides in the CPP area.

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The trends in use of pesticides in CPP compiled from individual company sales databases are presented in Table 9. Six major companies namely Novartis (Bangladesh) Ltd., Padma Oil Company Ltd., Setu Corporation Ltd., Rhone-poulenc Agrovet (Bangladesh) Ltd., Auto Equipment Ltd. and ACI Ltd. are selling their products in CPP area. A good number of pesticides are being used notable of which are Organophosphates and Carbamates. Basudin (Organophosphate) has got the highest sale in CPP followed by Furadan (Carbamate). Amongst the pesticides used in CPP, insecticides account for nearly 95% of the total sales. The use of only herbicide Ronstar (Oxadiazon) is showing an increasing trend amongst all other pesticides.

		1992	1993	1994	1995	1996	1997	1998	1999
Novartis (Bangladesh) Ltd.	Sales Vol. '000' (Tk)	1504	1870	1553	1675	1387	2447	1824	2034
	Main Product.	Basudin 10G Dimecron							
Padma Oil Company Ltd.	Sales Vol. '000' (Tk)	740	810	800	860	780	1010	570	350
	Main Product.	Furadan 5G Ripcord							
Setu Corpora- tion Ltd.	Sales Vol. '000' (Tk)	60	110	125	140	121	190	150	170
	Main Product.	Sunfuran 5G Malathion							
Rhone- poulenc Agrovet (Bangladesh) Ltd.	Sales Vol. '000' (Tk)	42	52	60	70	120	250	450	750
	Main Product.	Ekalux 5G Ekalux 25Ec			Ekalux Ronstar			Ronstar Regent	
Auto Equipment Ltd.	Sales Vol. '000' (Tk)	30	40	52	80	110	140	120	130
	Main Product.	Furaturb 5G Darsban							
ACI Ltd.	Sales Vol. '000' (Tk)	30	40	50	60	70	140	230	300
	Main Product.	Furacurb 5G Cymbush				Breefar 5G Cymbush			
Total		2406	2922 +22.0%	2640 -8.60%	2885 +7.65%	2588 -10.3%	4177 +61.0%	3344 -20.0%	3734 +12.0%
Table 9: Pesticides sales analysis: Tangail Sadar-Basail-Delduar									

Source: CPP Agro-chemical use monitoring report. Compiled from marketing company databases 1999

The data on actual amounts of pesticides used in CPP are calculated from sales at Tangail Sadar, Delduar and Basail Thanas by different companies. They show a marked increase (cumulative growth of about 65%) in pesticide usage between 1992 and 1999. The sale in 1998 was low because of the monsoon high flood.

Information on agrochemical use at farm level showed that most farmers had experience with occasional pest infestation and they use pesticides as suggested by the local dealers or traders when required. Basudin and Furadan are said to be the most common pesticides used by the farmers in the territory. Stem borer, rice hispa and brown plant hoppers are identified by the farmers as major pests. Rabi crop (mustard) during last 1998-99 was reported to be severely damaged by cutworm. None of the farmers had any knowledge about pesticide formulations, their usage, dosage schedule and personal health hazard. Some farmers had knowledge about IMP and some had their training from CPP. However, farmers in general seem to be reluctant in practicing them in a systematic approach.

The survey on Wholesale Dealers/ Stockists showed that the highest sale of pesticides of about 13.0 MT was recorded for Basudin (Organophosphate), followed by Furadan and Biesterin (both are Carbamates). About 4.0 MT of Furadan and Biesterin was sold. Almost 60% of the total agrochemicals consumption occurs during Boro crop production. The sales of Basudin and Furadan at the retail shops varied roughly between 2 and 1.5 MT.

The wholesalers receive adequate information from the respective companies in the form of posters, leaflets and brochures etc. However, their knowledge about different pesticide formulations is shallow and found incapable of communicating the information to the farmers level. General storage condition is not up-to the mark and no safety standards are seen to be maintained. The general safety standard, knowledge about different pesticide formulations and health hazard are almost zero among the retailers. In many cases, groceries are selling food items along side agrochemicals.

Year	Class	Pesticide sold or used by farmers			Total MT
		Basudin	Furadan	Others	
1998-99	Wholesaler	10.5	2.8	1.25	14.55
	Retailer	4.0	1.2	1.0	6.2
	Farmers	0.17	0.03	0.5	0.7
1997-98	Wholesaler	12	15	33.78	60.78
	Retailer	3.02	3.48	0.93	7.43
	Farmers	0.01	0.01	Trades	0.02
1996-97	Wholesaler				33.03
	Retailer				12.2

Table 10: Sales and uses of pesticides in Tangail and CPP area

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Conformity with Code of Conduct	Wholesalers	Retailers	Farmers
Knowledge about pesticide formulation	Moderate	Poor	Poor
Knowledge about application	Good	Moderate	Moderate
Safety standards during storage and handling	Moderate	Poor	Poor
Accidents	Not recorded	Not recorded	Not recorded
Storage facilities	Sufficient	Poor	Poor
Table 11: Safety and knowledge in use of pesticides			

It is evident that the application of pesticides is highly variable, depending on pest infestation of crops. This explains low applications in 1998/99 caused by the high monsoon flood and the reduction in cropping area. However, all interviewed sources state that application rates are higher than 5 years before.

Data from different sources are often inconsistent, and sometimes contradictory from the same sources - if asked one year later. It is, therefore, recommended to develop standards for questionnaires and instruction of DAE field staff.

Soil Fertility Status of Agricultural Soils

CPP conducted soil tests on several agricultural sites in 1996, 1998 and 1999 to monitor selected parameters important for crop growth, see Figure 6. The results are presented here, although further tests are needed for verification and for quantified assessments. Fertility changes usually follow long-term trends and, with consideration of the high variability of flood events under natural conditions, all changes are a combination of natural and human-made factors. A clear link to CPP interventions is not yet possible, considering that the full impact of hydrological changes is only effective since 1997. The results presented here should, therefore, serve primarily two purposes:

- To establish baseline conditions for future soil fertility monitoring activities in relation to flood / water management projects;
- To assess the potential impact of floods on soil fertility.

The following section summarizes the analysis of top soil in CPP and neighboring areas. The results are from

- SO 1 (A-topsoil, A-subsoil horizons in May/October);

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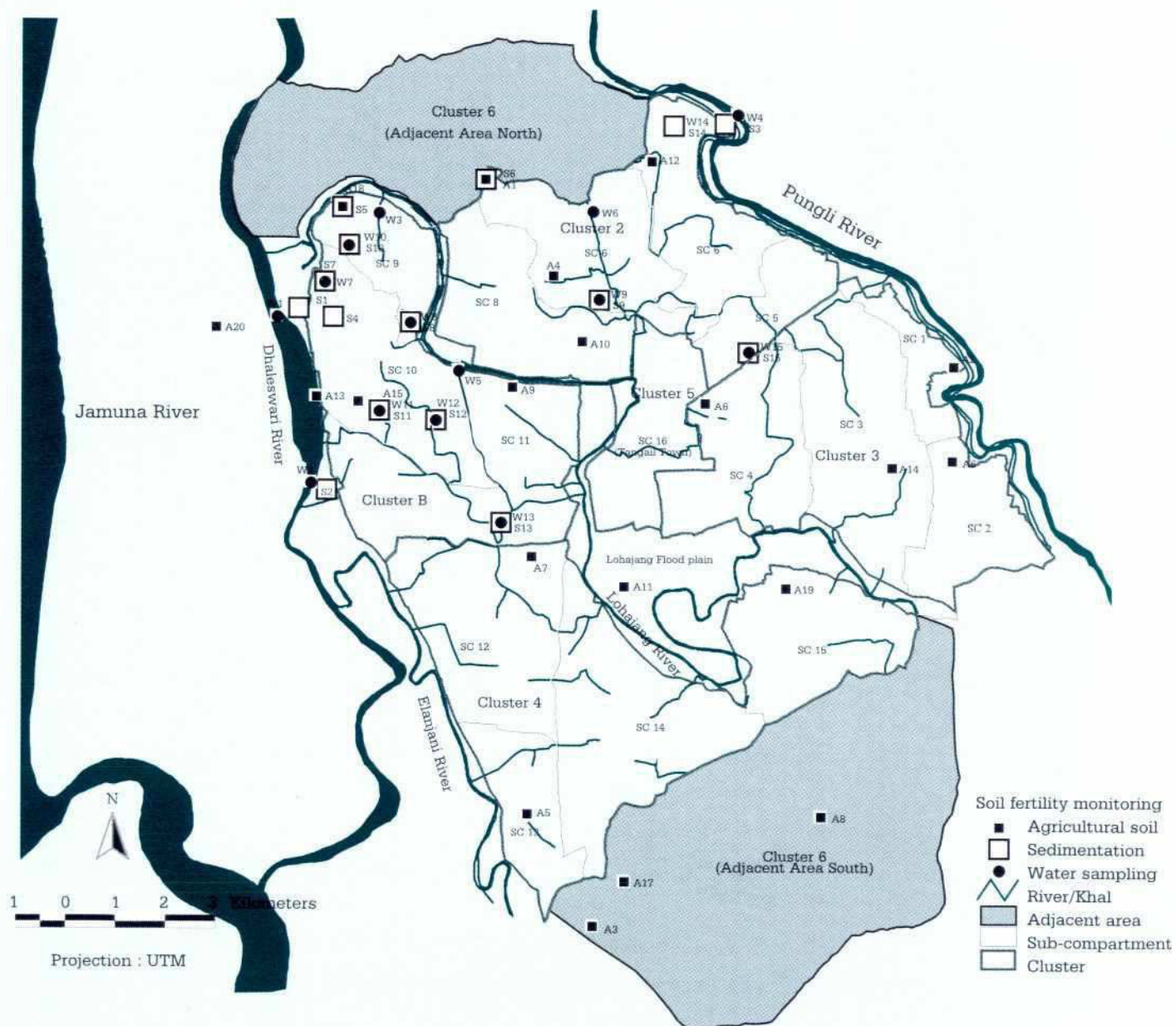


Figure 6: Soil Fertility Monitoring Sites

- SO 5 (A-topsoil horizon 0-15 cm in February) ;
- SO 3 samples (A-topsoil 0-10 cm below new sediment layers in October/November after flooding).

The results should be interpreted as baseline data to future regular soil monitoring at micro-level. Due to the change towards modern analytical methods and sampling techniques, comparisons with previous soil tests should be undertaken with caution.

All soils show distinct seasonal changes and most fertility characteristics differ also in highland soils (HL), medium highland (MHL), medium lowland (MLL), and lowland (MLL FP) soils in active floodplains. These differences are likely to be more important than changes that can - to date - attributed to CPP interventions. However, they are valuable indicators to quantify the dynamics of floodplain soils and to assess the role of regular flooding to contribute to soil fertility.

Soil reaction (a general measure of fertility and availability of nutrients) is slightly declining in the monsoon season (Oct). SO1 samples taken in March and October showed that P^H is higher in subsoil (10-20 cm) than in topsoil (0-10 cm). The range varies from slightly acid (6 to 6.5) to neutral or slightly alkaline (7 - 7.8). Topsoil that had been deeply and prolonged flooded in CPP area showed moderately acid P^H values in 1998: MLL (SO3 samples). Soil samples (SO 5) of topsoil taken in Jan/Feb show values that are usually moderately to strongly acid: P^H 5 to 6 with a distinct increase to slightly acid to neutral (P^H 6-7) in Jan 1999 compared with Jan 1998. This is probably a result of the high flood in 1998. In general, there is no uniform trend in P^H and this may be due to site-specific dynamics, which do not allow an overall assessment. It is recommended to conduct P^H measurements in the field (real aeration conditions) and to use modern P^H -equipment.

Electrical conductivity (EC) is a measure of salinity and the presence of soluble constituents. It is generally low in all soils inside CPP and well below threshold limits for major crops (< 1 dS/m). There is a slight decrease in EC in 1999 compared with 1998, which may be attributed to the leaching effect of the monsoon flood in 1998 that is reflected in 1999 samples. EC is slightly lower in active floodplain soils (MLL FP) than inside CPP or neighboring areas (SO 1 and SO 5 samples).

Organic matter (OM) is an indicator of soil fertility and the availability of nutrients: There is a distinct increase in OM from highland to lowland soils. This reflects the higher silt and clay contents of lowland soils prolonged anaerobic periods that favor

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accumulation of OM. OM contents are generally low to medium, although this is typical for arable soils: 0.8 to 2% in HL and MHL soils and 1.75 to 3% in MLL topsoil. Soils in active floodplains contain lower OM contents especially in topsoil (all sites of SO1, SO3 and SO5 samples). The comparison of OM contents before and after the flood showed no distinct differences (see SO1 and SO3 samples).

Total Nitrogen, the most important macro-nutrient for crops is available at very low to medium levels: 0.03 to 0.23 %. There is a slight increase in N_{total} after the flood season (Oct). N_{total} contents in sandy HL and MHL soils are generally very low ($<0.12\%$) and they are above 0.1% (average about 0.16% N) in lowland loamy or clayey silt soils. Total N in active floodplain soils is very low (MLL FP) but shows an increase from 0.05 to 0.1 % after the monsoon inundation period (see SO1 and SO3 samples). Generally, N% contents were higher after the 1998 monsoon season in comparison with 1999 (low or no inundation). The increase in 1998 was in the range of 0.1 to 0.4 N %: comparison of May vs. October values. However, inorganic N has little residual effect because of rapid denitrification and leaching.

Potassium, a macro-nutrient for crops is available at medium to high levels: 0.1 to 0.3%. This is normal for soils in the Brahmaputra floodplains because of K-bearing mica in the clay fraction. There was no distinct seasonal change and values differ only from highland to lowland soils. Contents in HL or MHL soils are lower and in the range of 0.1 %, reflecting their higher sand contents. There are no distinct differences observed in active floodplain soils and CPP areas or neighboring sites (except one MLL site in 1999).

Phosphorus is very low in CPP soils: 1 to 6 ppm with higher contents in loamy lowland soils. P contents in active floodplain soils are generally lower than in CPP area soils. Contents are also higher in 1999 compared to 1998. Further tests should verify any significant change.

Boron contents are low in all soils and considerably lower in subsoil (10-20 cm). Highland soils (HL) and active floodplain soils (MLL FP) have low contents, whereas medium highland and lowland soils (MHL, MLL) within CPP have slightly higher topsoil contents: 0.2 to 0.3 ppm. There are little seasonal variations.

Zinc is an important micro-nutrient. It is available at very low to low contents: 0.2 to 0.8 ppm. Lowland topsoil (MLL 0-10 cm) have slightly higher contents in comparison with other soils. Topsoil in CPP lowland (MLL) had slightly higher Zn contents than

topsoil in active floodplains (MLL FP). A slight increase was measured during the observation period in highland soils (HL, MHL).

Sulphur is available at medium to optimum ranges: about 10 to 35 ppm, except in highland (HL) soils which contained less than 10 ppm in 1998. Topsoil (0-10 cm) have usually slightly higher contents than sub-soil layers (10-20 cm). Soils which had been flooded in 1998 showed an increase in S contents in topsoil layers: MLL, MLL FP, and MHL.

In summary: soils in CPP area have a low to moderate fertility status: highland soils (HL) are sandy loamy and less fertile than loamy or clayey silty medium highland (MHL) and especially lowland soils (MLL) that have usually higher contents in all macro and micro-nutrients, organic matter contents and N_{total} . Soils show distinct seasonal changes in P^H values and the availability of some of the nutrients. Soils in active floodplains show generally lower contents in all nutrients than soils inside CPP area. There are no distinct trends or differences observed that could be attributed to CPP interventions. However, the effect of the monsoon season has distinct effects on soil properties and nutrient availability. Any flood intervention that reduces inundation will affect soil properties.

Sedimentation in floodplains soils. The analysis of new flood sediments shows distinct differences between the two flood events in 1998 and 1999.

Soil tests in 1998 and 1999 showed the following sedimentation rates after the flood:

Samples of SE 2 test	Sedimentation rates observed		Sedimentation
	1998 (very high flood)	1999 (average flood)	Estimated average values
Active floodplain: S1, S2	2-8 mm	2-4 mm	2-4 mm
Close to active river bed: S3	130 mm	25 mm	Highly variable
Medium highland: S8, 10, 14	<1 to 3 mm	1 mm (range 0.1 to 1 mm)	1-2 mm
Medium lowland: S9, 11, 12, 13	1-3 mm	1 mm (range 0.1 to 1 mm)	2 mm
Table 12: Sedimentation rates in floodplain soils in 1998 and 1999			

Note:

Sedimentation rates on polyethylene sheets are shown. The deposition on mats, clods and traps are usually slightly higher on CPP floodplain soils (1-2 mm), but considerably higher on active floodplain soils: +4 mm and +200 mm near the active river bed. This indicates a high percentage of sediment transport as bed-load near the surface. Traps therefore produce higher sedimentation rates because they count the accumulated depositions. The sedimentation rates observed in CPP area and active river floodplains compares favorably with the rates observed in a study of sedimentation conducted by ISPAN-FAP 19/FAP 16 in 1995 close to the active Brahmaputra in younger floodplain soils: 7.6 mm/y.

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Grain size distribution. Flood sediments in active floodplains usually contain more silt and clay deposits than on soils within CPP. The clay + silt percentage is usually >92% in floodplain soils, except close to the active river bed where also high percentages of sand had been deposited: 21%. In CPP floodplain soils, the sand depositions had been in the range of 5 to 40%. The percentages of clay and silt depositions are variable, depending on site-specific characteristics: location within the floodplain, flood duration/height. On all sites inside and outside CPP, silt percentages are predominating. Silt is usually beneficial to improve soil fertility.

Soil reaction (P^H) of sediments was slightly acid to slightly neutral. Sediments in active floodplains showed slightly higher values in 1999 compared with 1998 and higher values than in CPP floodplains. In CPP area, P^H values of new sediments are generally in a similar range than in soils.

Electrical conductivity (salinity measure) of new sediments showed distinct differences between active floodplain and CPP floodplain depositions: In active floodplains, salinity is much lower: 0.35 dS/m compared to 0.5 to 1 dS/m on average. In active floodplains, differences between 1998 and 1999 were marginal whereas in CPP floodplains values in 1998 were generally higher compared with 1999.

Organic matter deposition is moderate to low in active floodplain soils (0.5 to 1.7%) but considerably high on CPP lowland soils (3-6.8%), especially during the high flood in 1998. Deposition of OM in CPP soils is obviously derived from re-transportation (erosion and deposition) within CPP arable land. Depositions in 1998 were considerably lower in CPP area in comparison with 1999, but in a similar range in 2 out of 3 active floodplain soils between 1998 and 1999. Generally, new flood sediments contain about 0.75 to 1% OM, i.e. less than topsoil in CPP areas contain.

Sulphur contents of new sediments are in the range of 10-30 ppm S in active floodplains. In 1998, contents were considerably lower than in 1999 flood sediments. Sediments deposited in CPP area contain more S than new sediments in active floodplains.

Boron in contents of new sediments in active floodplains is in the range of 0.2 - 0.3 ppm B (except sample S1 in 1999). This is considerably lower than sediments within CPP area: about 0.4 to 2 ppm with an average of some 0.7 ppm. Medium lowland soils receive more B than highland (MHL) soils, reflection some erosion and re-deposition within CPP area.

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Zinc in active floodplain sediments was observed in the range of 0.5 to 0.8 ppm, except in more sandy deposits close to the active river bed, which contain less Zn in 1998 flood than in 1999. Zn concentrations in active floodplain sediments in flood 1998 (high flood) were lower than in 1999 (low flood). Sediments on CPP floodplains contain Zn in the range of about 0.9 to 1.5 ppm.

Calcium was in the range of 8 to 14 meq/100 g soil in active floodplain sediments with marginal variation between 1998 and 1999 floods. Ca concentration in sediments of CPP floodplain was generally higher in the flood 1998: 15 to 20 meq/100 g soil in 1998. In 1999, the values were in similar in active floodplains and CPP floodplains.

Magnesium concentrations in active floodplain sediments were in the range of 2.2 to 3 meq/100 g soil with marginal variation between 1998 and 1999. CPP floodplain sediments contained higher concentrations in the range of about 3-5 meq/100 g in 1998 and 1.5 to 3 meq/100 g in 1999.

CaCO₃ contents of flood sediments showed distinct differences between 1998 and 1999: active floodplains: contents in the range of 0.5 to 1 % and 3-4.5% in 1999. Contents for CPP floodplains were less homogeneous and ranged between 2 and 6% in 1998 and 3 to 5.5% in 1999. There is clear evidence that sediments within CPP floodplain contain material that is derived from both, river sediments plus eroded material from soils within the floodplain.

These sediment results were compared with water samples taken from different river sites, *khals* and floodplain locations at the soil sampling sites. There are distinct differences between the flood events in 1998 and 1999:

The total salinity (EC) of floodwater was considerably higher in 1998 than in 1999: 0.25 to 0.35 dS/m and 0.1 to 0.15 dS/m in 1999, respectively. Water in rivers and *khals* contain salts in similar ranges: about 0.30 to 0.35 dS/m. The variation in water salinity in CPP floodplain was slightly higher than in rivers and *khals*. In the flood 1999, variations were similar in floodplain, *khal* and river water.

Most soluble salts are transported as Ca-salts and measures in 1998 were in the range of some 0.7 meq/l in *khals* and rivers, compared to 0.3 meq/l in 1999.

Soluble Potassium also contributed to total salinity. Concentrations in *khal* and river water were observed at about 0.08 meq/l K in 1998 and 0.04 in 1999 floods. CPP floodplain water contained similar concentrations in 1998, but less in 1999 floods.



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Soluble Magnesium load in waters showed less evident changes between 1998 and 1999 and was observed in the range of 0.3 to 0.4 meq/l in rivers and khals and slightly higher values in CPP floodplains.

Phosphorus in rivers and *khals* were in the range of 0.2 to 0.3 meq/l KP in 1998 flood and in a similar range in CPP floodplain soils. In 1999, P-concentrations of floodwater were considerably higher in CPP floodplain water: 0.4 to 0.8 meq/l P in comparison with *khal* and river water: 0.3 to 0.4 meq/l.

In summary: the preliminary findings of two flood seasons provide information that floods have some positive impacts on the dynamics of soil development and the availability of nutrients. For example, soil reaction (p^H) can increase after floods, organic matter can slightly increase in topsoil and some nutrients can become easier available to plants. Some dissolved salts and sediments are added to the soils that have an positive impact: Ca- and P-salts and silty-clayey deposits. Organic matter depositions, however, are low in comparison to topsoil contents of arable soils. Generally, the fertility effects of new sediments deposited during the flood season are marginal in short-term agricultural perspectives, but are considerable in long-term (1000+ years). The impact of inundation during the monsoon season, however, is likely to be of importance for soil development and soil fertility, especially under continuous cropping. The CPP has, therefore, only marginal impacts on soil fertility, provided that seasonal flooding from river water is permitted at the levels of CPP operations in 1998 and 1999.

Impacts on Eco-Biological Resources

Wetland Resources

The 1st Wetland Study by NACOM in 1994 was performed on 11 *beels* in CPP area for a rapid assessment of the ecosystem's status "before CPP". Three *beels* (Atia, Baro and Jugini) were selected for an in-depth survey by using the standard RAMSAR Information Sheet for Wetland Sites with a description of the physical and ecological features and 29 other evaluation criteria. The overall finding was that all *beels* in CPP are heavily exploited by human interferences with many natural fauna and flora resources under threat. The threats are:

- *Beel* margins are converted into arable land;
- Intensive fishing throughout the year affects fish diversity and production;
- Construction of road embankments and water management interventions (before-CPP) affected the natural flood pattern.

Although the local people know about the value and importance of wetland resources,

no attempts had been taken in the past to improve the condition of wetland degradation. The resources utilized are mostly used by the poor people and the rich people (e.g. medium or large farmers, landowners, businessmen) who control most of the activities surrounding the wetlands do not bother about it. Wetland products are also often under valued or are not traded leaving a gap in their valuation.

The initiatives for community wetland management, proposed in this CPP study in 1996 failed from the very beginning. The existing land tenure and private ownership of most wetlands or government controlled khas land left no opportunities for community ownership and management. Even khas land is usually leased out by the Deputy Commissioner (Revenue) or Thana Fisheries Officer to private businessmen or local elite with no option for the declaration of government controlled wetland sanctuaries.

177 species including terrestrial angiosperms, pteridophyte, phytoplankton, zooplankton and aquatic macrophytes were identified at wetland Baro / Panchkahunia home-stead. Of these, 14 species were found as abundant, 99 species as common and 69 species as rare; 11 species were found to be medicinally important.

Types	Species no. Collected		Abundant		Common		Rare	
	Baro	Atia	Baro	Atia	Baro	Atia	Baro	Atia
Homestead species	91	65	61	3	3	65	27	27
Phytoplankton	30	30	7	2	1	30	22	18
Zooplankton	16	17	6	0	2	17	8	11
Aquatic macrophyte	40	31	25	3	8	31	7	17
Total	177	143	99	8	14	143	64	73
Table 13: Species abundance in two pilot beels in CPP area								

Baro beel/Panchkahunia homestead and Atiakumuria beel/Kumuria homestead

A total of 143 different species were identified at wetland Atia/ Kumuria homestead, of which 8 species were abundant, 59 species as common and 73 species as rare; 12 species were medicinally important table 2.

Noted that *Ceratophyllum demersum*, a submerged aquatic macrophyte, susceptible to flooding and an indicator of environmental changes is dominating at Atia while *Najas lacerata* in Baro beel. Water hyacinth is a dominant feature for both beels. The open water areas of Baro beel declined slightly until 1999: margins are continuously converted into agricultural land. Also Atia beel is facing some recent changes by fish pond developments across some stretches of the beel.

Birds and fishes are the most dominant components of the fauna. A marshland tree species *Barringtonia acutangula* (Hizol) and a herbaceous plant *Lasia heterophylla* were found to be threatened in Atiakumuria beel.

A common list of fauna observed at both villages and their ecological status shows:

Types of animals	No. of species collected	Abundant	Common	Rare
1. Amphibians	6	-	5	1
2. Reptiles	10	-	10	-
3. Birds	33	1	23	9
4. Mammals	8	-	5	3
5. Fish	33	-	27	6
Total	90	1	70	19
Table 14: Faunal species with ecological status of two villages				

Human aspects of bio-resources. The wetland and homesteads help meet the demand for livelihood of most villagers (farmer, fishermen, day labor, landless, children, etc.) as vegetables, fruit, timber, food, medicine, starchy grains, rhizomes, fruits of different aquatic plants, petioles of water lily, young shoots of aquatic herbs. About 40% of the families use medicinal plants from homesteads and beels. The wetland serves as fishing ground and water source for Baro cropping. Cow dung and wood are the principal sources of fuel for cooking and a significant portion is provided from the trees and wetlands.

Water hyacinth meets a significant portion of cattle feeding. In Atia, some 65% of villagers use some 400 kg/year in both dry and wet seasons. in Baro beel almost all villagers use about 400 kg in the wet season, but only 30% use some 300 kg in the dry season due to shortage of supply. In the wet season, also, Hygorhiza is used in Atia beel (20-50kg per family).

In Baro beel most villagers use the wetland for navigation in wet season while water is used in both seasons for domestic supply or irrigation (also supplementary irrigation). Some villagers used plants from Baro beel for herbal medicine and compost making. Only few villagers are aware of the ecological role of some animals such as frogs or birds for pest control. There is little awareness about nature conservation, although the problem of over-fishing is well acknowledged.

Year	Season	Food		Vegetable		Fodder		Fuel		Compost		Irrigation	
		%	Kg/y	%	Kg/y	%	Kg/y	%	Kg/y	%	Kg/y	%	L/y
Baro beel													
1999	Dry	25	1-5	50	1-10	17	370	Few	-	Few	-	10	6000
	Wet	84	1-2	2	½-5	88	400	Few	-	Few	-	-	-
1998	Dry	8	½-2	16	½-4	NA	-	Few	-	Few	-	?	-
	Wet	81	½-2	82	½-5	82	400	Few	-	Few	-	-	-
Atia beel													
1999	Dry	81	1-10	88	2-15	63	350	Few	-	Few	-	56	60,000
	Wet	94	1-2	100	1-3	71	400	6	10-99	Few	-	41	>60,000
1998	Dry	NA		-	-	-	-	-	-	-	-	-	-
	Wet	94	2-20	100	4-25	71	400	3	80	Few	-	38	100,000

Table 15: Utilization of different goods from wetlands in dry and wet seasons

Note:

% shows the number of families of the 100 persons interviewed in each village area at Baro and Atia beels. Yields are rough estimates. Irrigation in wet season 1999 due to water scarcity.

Seasonal dynamics of the indicator species. Most of the indicator species show poorabundance in dry while flourish well in wet season. Prolonged desiccation in dry period is one of the main reasons for the lower abundance of aquatic indicator species. Human interference in the wetland such as rice cultivation, fishing, jute retting and extraction of aquatic resources disturbs the habitats of the aquatic species. *Najas lacerata* (Jhanji) was common in Atiakumuria beel in 1998 but in 1999 it was rare. The abundant population of *Nymphaea nouchali* (Shapla) in 1998 dropped to the rank of

	Season	Vegetable	Fish	Fodder	Biomass	Compost	Medicine	Water use	Navigation	Hunting	Irrigation
Baro	Dry	83	100	50	13	29	4	4	12	0	4
	Wet	91	100	82	0	0	0	27	91	3	0
Atia	Dry	100	100	75	0	6	0	100	3	0	56
	Wet	85	97	68	0	0	0	91	6	0	41

Table 16: Use of different commodities from two beel areas in dry and wet season

common in the same beel in the wet season. A similar trend was also observed for *Dysophylla stellata* (Panikula). Population of *Pila globosa* (Baro Shamuk) was found common in 1999 but rare in 1998 at both sites. *Rana tigerina* (Kola Bang) was found

common in 1998 but rare in 1999 at Baro beel while in Atia beel it showed abundant to rare in 1999 to 1998 respectively. *Haliastur indus* (Shankha Chil) was observed 'abundant' in both the beels in 1998 but rare in Baro beel and common in Atiakumaria. The population of *Ardeola grayii* (Korchy Bok), which was common in both the seasons in both beel areas in 1998 but abundant in dry season in both the beels. High population of *Dendrocygna javanica* (Chhoto sharali) was found in both beels in dry and wet seasons in 1999 while common only in 1998 dry season at both beels. Out of 75 species of wetland macrophytes in Bangladesh 31 (41%) have been reported.

Indicator species			Baro beel				Atiakumaria beel			
Common Bangla name	Common English name	Scientific name	Dry seasons 1998 1999		Wet seasons 1998 1999		Dry seasons 1998 1999		Wet seasons 1998 1999	
Kata Jhanji	Coontail	<i>Ceratophyllum Demersum</i>	C	C	C	C	C	C	A	A
Kaowathukri	Arrowhead	<i>Sagittaria Guayanensis</i>	R	R	C	C	R	R	C	C
Chara Sheola	Stone wort	<i>Chara sp.</i>	R	R	R	R	R	R	A	A
Shapla	Water lily	<i>Nymphaea Nouchali</i>	R	R	C	C	R	R	A	C
Panikula		<i>Dysophylla Stellata</i>	R	R	A	C	R	R	C	C
Pani Shak	Stag-horn Fern	<i>Ceratopteris Thallictroides</i>	R	R	A	A	R	R	A	A
Baro Shamuk	Fresh water Snail	<i>Pila globosa</i>	R	C	C	C	R	C	C	C
Kola Bang	Indian bull Frog	<i>Rana tigerina</i>	R	R	C	R	R	R	A	R
Dhora shap	Checkered Keelback	<i>Xenochrophis Piscator</i>	R	R	C	C	R	C	C	C
Shankha Chil	Brahminy Kite	<i>Haliastur indus</i>	A	R	C	C	A	C	C	C
Dahuk	W. Breasted water hen	<i>Amauornis Phoenicurus</i>	R	R	R	R	R	R	R	R
Korchy Bok	Pond heron	<i>Ardeola grayii</i>	C	A	C	C	C	A	C	C
Choto sharali or Bali Hans	Lesser whistling teal	<i>Dendrocygna javanica</i>	C	A	R	A	C	A	R	A

Table 17: Occurrence of indicator species in Baro and Atia Beels

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Comparison of Biomonitoring in 1998/1999 with NACOM 1994 Survey

The occurrence of the starchy fruit *Trapa maximowiczii* (singara) was recorded in several beels in 1994, but not found any longer in 1998/1999 surveys. The threatened aquatic tree *Barringtonia acutangula* (Hizol) were observed in very few numbers (9) in 1999, but in larger numbers in 1994 (but without quantification). Many other species of amphibian, reptile, birds and mammals that had been recorded in 1992 and 1994 can also be found in 1999. There is no evidence that important species become extinct over the last ten years, although many are increasing pressure from over-exploitation. It appears that the flood of 1988 had an enormous impact on many terrestrial wildlife: Many elder villagers reported on wildlife resident in CPP area before the flood of 1988, but that had not been observed in the last decade.

Class	No. of species recorded* in the investigation 1998 and 1999	Survey 1994 (by NACOM 1996)	EIA Study 1992
Zooplankton	16	NA	
Amphibian	6	5	5
Reptiles	10	12	5 (A) + 12 (T)
Aves	33	30	56**
Mammals	8	6	11
Algae	30	NA	
Pteridophyta	5	4	
Aquatic angiosperm	26	42	
Homestead plants	90	NA	81

Table 18: Comparison of biodiversity faunistic and floristic list

**It appears that the survey in 1992 lists also fauna and flora that existed before the 1988 flood. The list in EIA 1992 is likely a list of all fauna (e.g. birds) that may existed in the greater region of Tangail and neighboring floodplains. A = aquatic; T = terrestrial

1999 survey	Scav.vulture		King vulture		Jungle cat		Wild boar	
Baro beel								
	% villagers	Number	% villagers	Number	% villagers	Number	% villagers	Number
Dry	46	5-20	8	rare	0	0	0	0
Wet	30	1-6	12	1	9	1-2	0	0
Atia beel								
Dry	31	1-2	6	1	18	1-2	0	0
Wet	80	2-7	0	0	0	0	0	0
Table 19: Information on the presence of endangered/threatened fauna and flora								

Quantification of economic value of common goods. The most common goods utilized in both the beel areas are petiole of water lily, rhizome of water lily, *Ipomoea* and other vegetables. The price of the petiole and the rhizome of water lily are higher in wet season and lower in dry season in both the beels. The price of *Ipomoea* (*Kalmi*) and other vegetables is higher in dry season compared with wet seasons. The price of petiole of water lily varies from 2-6 Tk/Kg in wet season whereas in dry season it is from 1-5 Tk/Kg and the price of the rhizome of water lily in wet season ranges from 22-35 Tk/Kg whereas in dry season it is 10-25 Tk/Kg. On the other hand, the price of *Ipomoea* and other vegetables in wet season ranges from 3-6 TK/Kg whereas in dry season it ranges from 2-4 Tk/Kg.

Among the plant species at least four are threatened in Bangladesh. These are *Hizol* (*Barringtonia acutangula*), Venus flytrap (*Aldrovanda vesiculosa*), Makhna (*Euryale ferox*) and Wild rose (*Rosa involucrata*) (Khan et al.1994). From these four species, *Hizol* plants are seen to survive in some parts of Atia beel. Most villagers have seen one to five *Hizol* trees during the last ten years in both the wetland areas. The two other important wetland inhabiting plants such as *Bonnya* and *Trewia* were seen to grow in the project area but disappearing from other parts of Bangladesh. In the last ten years King vultures were seen rarely in the project area. Nobody said that they traced wild boar in the last ten years in the project area. Some villagers have seen wild boar, jungle cat and monitor lizard once or twice before the disastrous flood in 1988.

Potential of Water Hyacinth. The most important wetland macrophyte having multifarious use is the water hyacinth (*Eichhornia*). It is used for preparing green manure, fodder and cattle feed. Almost 50% of interviewed villagers use *Eichhornia* to prepare manure in dry season at Baro beel while only 12% at Atia. The range on the quantity of compost varies from 20-10,000 kg/year. Very few of the villagers use the wetland macrophytes as fuel.

Fuel wood. The use of fuel wood from homestead and its trend of development over the last ten years was quantified as follows: Dried leaves, straw, dried herbs and shrubs, bamboo and other tree parts are the most commonly used fuel in the kitchens of the project area. The maximum present use is about 1,000 kg/year per family; while in the last ten years the amount was 1,400 kg/year/family. The rate of consumption of other biomass fuel after the tree parts are dried leaves (20-500 kg/year), straw (20-350 kg/year), dried herbs/shrubs (10-150 kg/year) and bamboos. No significant difference was observed in the trend of biomass fuel use in the last ten years.

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Quantification of logging and planting trees. Trends of cutting trees were low compared to planting at both sites. Hence, the number of trees increased.

Development of settlement area in the study sites. Little changes were observed in settlement pattern over the last ten years. Present average number of houses per family in Baro beel area is 3.2, while this number in Atiakumuria area is 2.4 houses. Poverty is the main reason for not building new houses.

Environmental Education and Dialogue Program. Environmental education, training and awareness concepts were tested in several meetings with villagers during the period 1995 to 1999. Despite some traditional knowledge, there are only few villagers fully aware of the intrinsic value of nature and natural resources, ethics of conservation and the ecological importance of key elements, such as frogs or earth worms. Knowledge about health and hygiene is sufficient but basic principles are rarely observed in daily life, although 90% claim to use kutchra toilet and almost all claim to wash their hands after toilet. Most diseases in the villages are infectious.

CPP conducted two environmental awareness campaigns in 1998 and 1999 by inviting different stakeholders of the wetland and circulating information leaflets that describe the effects of pollution with regard to agrochemicals and poor sanitation standards on bio-diversity. The campaigns covered plant species, birds, reptiles, mammals, fish and other aquatic organisms. Four village meetings and discussions in 1998 and 1999 were organized in cooperation with the WMC and some 450 people attended in total. The discussions focused on habitat and distribution of different plant species in homesteads and especially elder villagers contributed with their traditional knowledge.

The Homestead Plantation Program, originally initiated in 1994/95 in combination with the Embankment Plantation Program, aimed to improve species diversity and production in homesteads. About 1000 saplings of local varieties, selected by the Bio-diversity Team after consulting villagers, were purchased from local nurseries and NGOs and distributed with the assistance of the CPP women's section to female villagers. Some 200 school formal and non-formal teachers were trained on environmental knowledge.

The basic elements of flora and fauna and their functioning in terrestrial and wetland ecosystems were explained by the display of posters, photos and a video show.

Impacts on Fish and Fisheries Resources

The results of the fisheries program of CPP during the period 1992 to 1999 are reported in Annex F.

The fish catch monitoring results show an average of some 290 t/y, depending on the flood situation in the river and floodplain: the highest flood occurred in the monsoon season 1998/99 with most controlled flood infrastructure of CPP in place, whereas the river flood level and partly, also, rainfall in the previous years was below average, showing much less catches.. The final conclusion is

- There is no significant trend in the fish catch within the CPP area,
- There is, to date, no indication that CPP had a major impact on fisheries, and certainly much less impact than complete flood control.

Impacts on Resource Uses and Quality of Life Values

Flood disaster preparedness. The project provided evidences that extreme floods, like in 1998, can be managed, provided that embankment breaches are avoided.

Tangail Town. The urban areas with some 200,000 inhabitants in the year 2000 suffered from water congestion during the monsoon season which affected houses and infrastructure through frequent inundation. During the period 1995-1997, the urban main drainage channel from Lohajang River near Tangail Eidgah to Darun beel through the town and then onwards to Lohajang River at Nagar Jalfai was rehabilitated with technical assistance and financial support through CPP. In addition the town flood embankment/floodwall construction and flushing regulator and other minor drainage works

Agriculture. In areas where the cropping pattern involves primarily T-Aman as the monsoon crop, farmers in most years will be best served by a 'maximum drainage' scenario for water management. In some of the lower lying areas, however, farmers continue growing DW-Aman extensively and maximum drainage is not to their advantage. The CPP infrastructure should be operated in such a way that, while aiming at maximum drainage for most of the compartment in most years, the DW-Aman growing areas can obtain and hold sufficient water for this crop. Operational guidelines have been developed which specify ranges of target water levels for some of the major structures, rather than fixed levels. The guidelines need testing and revision through a number of years of learning by doing, assisted by computer modeling and monitoring of farmer assessment of water conditions in their *chawks*.

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Navigation. The CPP boat traffic survey in 1994 (an above average monsoon flood year) showed that boat traffic is carried out mainly in three months during mid July to mid September. Traffic in-/outbound of Tangail Town along the Lohajang River was most important for transporting cargo and passengers, whereas as other routes, e.g. via Sadulpur khal are of minor or local importance only. During the peak period, some 80 mechanized (~ 15 m long) and 15 "country" boats were daily counted, carrying some 750 passengers/day. Passengers were mostly male (87%) to transport of goods (e.g. fruit, fuel, paddy, jute, grocery items), market shopping, working, etc, while most female were traveling to visit relatives and Health Centers. Most boats traveled on a daily base (80%), indicating that professional boatmen are engaged. Other boat activities are related to fishing or farming. During the off-season, most boatmen return to agriculture or petty business, others as day laborer or rickshaw pullers.

The following mitigation measures were implemented:

- Vent size of main regulator is 3 m, wide enough for small boat traffic; the operation was successfully tested in the flood in 1995;
- Mooring places are constructed along the Lohajang River next to roads for loading and unloading of cargo for further transport along roads;
- Improvement of the road connecting Tangail Town and the main regulator at Jugini.

The CPP survey in 1996 on 135 boatmen within CPP area (11 villages with some 24,000 people) showed that only 9 claim themselves as "boatmen" (plus three fishing boatmen). However, none of them draws regular income from this activity because all of them have found already alternative employment, such as day laborer, cane and bamboo worker, farmer or fishermen. Boatmen claimed to use other means of transport, if conditions for navigation would deteriorate. Boatmen in CPP are not organized or member of an association.

Impact on Water-related Diseases. CPP collected information from the Department of Health, Tangail from hospitals and rural clinics on such diseases, which can be partially attributed to floodwater management in floodplains. These are:

Prevalence of vector borne diseases is rather at low stage. There are only few cases reported and there was no increase during the last ten years reported. Existing data on water-borne diseases indicate a decline in the three most important diseases that have a clear relationship with water, flood conditions and floodwater management (see also Siragjang Report 1993). Tentatively, it can be concluded from the data

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Type of disease	Possible positive impact of CPP	Possible negative impact of CPP
Water-borne, e.g. Diarrhea Hepatitis Dysentery Typhoid	In case of normal floods that can enter floodplains: Stagnant water becomes diluted with fresh river water. If CPP can manage extreme water level in the monsoon season, less hand pumps become inundated; better access to safe water during or after monsoon season due to partial control over water levels	In case of reduced river inflow: Prevalence of stagnant and polluted water used for bathing, washing act as catalytic agent. If there is no frequent flooding/flushing of such pool, diseases can increase
Vector-borne, e.g. Malaria Kal-a-zar	Improved drainage by CPP reduces the habitat (stagnant but clean water bodies) for many vectors, and hence may reduce vector abundance Regular flooding can minimize vector breeding	Clean water increase vector breeding

Table 20: Water-related diseases

Sources: EIA Study 1992*; CPP monitoring**

available that CPP interventions did not contributed to an increase of disease incidents. Whether CPP contributed to the substantial decrease in some diseases is beyond the scope of CPP monitoring. However, there is a clear link between (1) disease incidents and the monsoon season, and (2) the extent and duration of flood: high floods (1998) cause an increase compared to low floods (1999). It is recommended to conduct a rapid assessment of the important factors (1) community vulnerability, (2) environmental factors and (3) vector control to get an overall risk assessment, following the PEEM guidelines (WHO/FAO/UNEP 1989 and Birley 1993).

	Year	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sept-Oct	Nov-Dec
Diarrhea	1996	691	2354	1927	3130	3707	2442
	1997	1725	2614	2693	2894	3554	2593
	1998	2008	2035	2433	2605	4035	2504
	1999	853	987	1253	1389	1527	502
Hepatitis	1996	8	13	13	15	2	1
	1997	5	9	9	0	2	1
	1998	2	1	8	0	0	0
	1999	2	0	0	6	0	0
Dysentery	1996	NA	NA	NA	NA	NA	NA
	1997	2834	3544	2598	3285	2965	2370
	1998	2219	2163	2169	2920	3407	3121
	1999	1965	2158	2016	1592	1788	0

Table 21: Disease incidences in CPP and neighboring areas (number of clinical cases)

Summary of Impact Assessment

Table 22 presents a summary of assessment and scoring concerning the CPP interventions. This assessment does not compare all of the results of EIA Study 1992 with the impacts that had been monitored in the Environmental Management Plan since the implementation of CPP started in 1993. Some impacts are not yet evident, not measurable, or the data base used differs too much to allow meaningful comparisons. For example, for the predictions in land use changes by the use of inaccurate hydrological and GIS models in 1992, that had been revised in 1996/97.

Some of the changes predicted in 1992 were found to be valid. But many others not, probably due to the rather short observation time, since CPP is only for few years under full scale operation. Other relevant information had been collected and interpreted by other CPP sections, such as social and economic indicators, participation and institutional capacity building, and flood damage assessment.

The most important negative environmental impacts that are directly or partly caused by CPP are:

- Conversion of seasonal and perennial wetland into cropland and the associated losses in free access to wetland resources;
- Loss of navigation routes along the Lohajang River; the existing road network provides mitigation and alternative jobs;
- Fish species in capture fisheries are changing and species diversity is reduced
- The use of agro-chemical is increasing; and
- Groundwater abstraction increased thus increasing the risk for mining.

None of the negative impacts have a high magnitude and most changes can also be observed in neighboring areas or elsewhere in Bangladesh.

The most important positive impacts are:

- Settlements, homesteads and Tangail Town are less prone to disastrous floods;
- River bank erosion is controlled;
- Drainage congestion is considerably reduced in most CPP areas; and
- Crop intensity and crop yields increased.

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There are no substantial changes observed within the short monitoring period:

- Total capture fisheries production;
- Soil fertility;
- Sedimentation rates;
- Groundwater levels (but: the dry season lows are apparently changing);
- Status of endangered fauna and flora;
- Water related disease incidents;
- Water pollution status.

Impact Mitigation, Residual and Cumulative Impacts

Mitigation. The CPP has implemented several mitigation activities that are subject to other CPP reports. e.g. compensation of land acquisition for construction, fisheries, social impacts (women in development activities), navigation and programs that are aiming at sustainable agricultural development. Flood protection and regulation issues are also subject to separate CPP studies.

Impacts in bordering impacts. Impacts in bordering areas in the North and South of CPP area are likely to be less significant. The most important upstream impact is caused by a temporary rise of water level in the Lohajang River if the main Lohajang inlet is closed during the peak monsoon season. The impact had been assessed in special hydrological studies and was found to be marginal only. It affects the northern areas close to the CPP area by an maximum potential increase of some 20 cm in flood level for a few days.

Downstream impacts can also be attributed to an temporary increase in water levels if CPP area drains all floodwaters within a short period into the downstream reaches of the Lohajang River.

The impact of floodwater management on water quality further downstream of CPP had not been investigated. It is expected that the flushing of polluted surface water from CPP towards the southern reaches will adversely affect downstream water users. The additional impact by CPP is a matter of speculation because these processes occur also under natural flood conditions.

Environmental Component	Base Situation (EIA or CPP)	Prediction EIA 1992 w/o Project	CPP Monitoring 1999	Impact of CPP	Type of Impact*	Impact Magnitude	Impact Rating**
River flood inflow	NQ	No change	Slight Increase	NQ	S (Op)	Low	+ 0.5
River bank erosion	Threat	continued	Town is safe	controlled	S (Op)	High	+ 5.0
Land types, ha							
F0 0-0.3m flood	3,209	No change	5,178	+ 1,969	S (Op)	High	+ / -
F1 0.3-0.9m flood	3,819	"	3,232	- 587	S (Op)	Medium	+ / -
F2 0.9-1.8m flood	2,617	"	1,327	- 1,290	S (Op)	High	+ / -
F3 >1.8m flood	313	"	220	- 293	S (Op)	Minor	+ / -
Drainage congestion, ha	1,549 (EIA)	Increase	850	- 700	S (Op)	Medium	-
	4,276 (CPP)	"	850	- 3426	S (Op)	Medium	+ 2.5
Drainage Tangail Town, ha	228 (CPP)	No change	<10	- 220	S (Op)	High	+ 5.0
Homestead damage, %	20%	No change	<5%	- 15%	S (Op)	Medium	+2.5
Housing (rural areas), ha	1751	1926	Slight increase	<10% #	-	Minor	+ / -
Irrigated area (% of NCA)	43 %	Increase	83% #	Increase #	S	Low #	+ / -
Groundwater levels	Adequate	Decrease	Slight decrease	Slight decrease	R	Low #	- 0.5 #
Terrestrial Habitat, ha							
Pre-monsoon	12,976	No change	No change	No change	-	-	+ / -
Monsoon (F0 land)	4,139 (EIA)	No change	5,178	+ 1,157	SM	Medium	+ 1.5
Post-monsoon	6,005 (EIA)	No change	Increase	Increase	SM	Medium	+ 1.5
Aquatic Habitat, ha							
Pre-monsoon (F3-F4)	330 (EIA)	No change	220	- 110	S (Op)	High	- 2.5
Monsoon (F1-F4)	6,749 (CPP)	No change	4,779	- 1,970	RM	Medium	- 1.5
Post-monsoon (F1-F4)	7,300 (EIA)	No change	< 1,500	- 3,156	RM	High	- 2.5
Crop Production							
T.Aman HYV, ha	222 (CPP)	increase	2,462	x 10 #	S	High #	+ 2.5
Mustard, ha	1,267 (CPP)	increase	1,618	+ 27 % #	S	Medium #	+ 1.5
Monsoon Baro HYV, ha	3,557 (CPP)	increase	7,010	x 2 #	S	Medium #	+ 1.5
Total paddy, ha	8,225	increase	13,828	+ 5,603 #	S	Medium #	+ 1.5
Other main crops, ha	7,542	decrease	8,040	+ 498	S	Low	+ 0.5
Yields (all crops)	--	--	Baro increase	Increase #	S	Low #	+ 0.5
Cropping intensity %	181 (CPP)	214	215	+ 34 #	S	Medium #	+ 1.5
Pesticide application							
Total sales, t/a	2,409	Increase	3,734	+ 55% #	S	Low #	- 0.5
IPM instructions	very little	--	16 schools	IPM initiated	S	Medium	+ 1.5
Safety regulations compl.	very poor	--	very poor	little change	-	Marginal	+ / -
Ecosystem contamination	Prevalent	Increase	few evidences	little change	-	Marginal	+ / -
Fertilizer use							
Urea, S + P, Gypsum, Zn	3,128 (CPP)	Increase	>4,000	+ 28 % #	S	Low	+ 0.5 #
Organic fertilizer, manure	low	Decrease	very low	decrease	-	Marginal	+ / -
Ecosystem eutrophication	Prevalent	Increase	little evidence	slight increase	-	Marginal	- 0.5
Soil fertility status ##							
General status	Adequate	?	Adequate	Little change	-	Marginal	+ / -
Sedimentation rates	--	--	> 1 mm/a	Little change	-	Marginal	+ / -
Dynamics of floodplain	Pre-CPP	No change	Maintained	Little change	-	Marginal	+ / -
Fisheries production ##							
Capture, t/a	380, EIA	251	--	--	--	--	--
(but: change in species!)	96-336, CPP	--	301 to 642	no clear trend	S	Marginal	+ / -
Fish ponds (>0.04 ha), no	450 (EIA)	Increase	3,100	+2,650 #	S (Op)	Medium #	+ 1.5
Pond production (kg/ha)	910 (EIA)	1,625	--	--	--	--	--
	800 (CPP)	--	2,000	+ 175 % #	-	Medium #	+ 1.5
Fish species diversity	--	--	decline	NQ	S	Medium #	- 1.5
Wildlife ##							
Amphibians/ Reptiles	22 / 17 1	Decline	16	Common trend	S	Low #	-0.5
Birds	56 / 30	Decline	33	Common trend	S	Low #	-0.5
Mammals	11 / 6	Decline	8	Common trend	S	Low #	-0.5
Homestead plants	81 / -	Decline	90	Common trend	S	Low #	-0.5
Endanger/threat. species	17 / -	2 extinct	increase pressure	Common trend	S	Low #	-0.5
Wetland resources	Traditional	Decreasing	decreasing	Acceleration	S	Medium #	- 1.5
	open access	access	access	of common trend	--	--	--
Wetland exploitation	High	Increase	Increased	Common trend	S	Low #	- 0.5
Wetland conversion	Prevalent	Increase	Increased	Common trend	S	Medium #	- 1.5
Tree logging/plantations	--	--	planting > logging	campaigns	S	Low	+ 0.5
Fuelwood availability	Shortage	Increased sh.	Increased sh.	Common trend	S	Low	- 0.5
Water pollution ##							
Surface water	Contaminated	Deteriorates	No change	Common trend	-	Low	+ / -
Groundwater	Contaminated	Deteriorates	No change	Common trend	-	Low	+ / -
Constituents	High Fe	Deteriorates	No change	Common trend	-	Low	+ / -
Water related diseases	NQ	Increase	Decline	Common trend	-	Low #	+ 0.5
Road network, km	262	Increase	Improved	by DLGH	-	-	-
Navigation	2 waterways	Decrease	Decline	Common trend	S + M	Low	- 0.5
Flood free settlements	Prevalent	No change	<10% flooded	Increase	S	High	+ 2.5
Tangail Town flood hazard	High risk	No change	< 5% flooded	Decrease	S	High	+ 2.5

Table 22: Environmental Impact Matrix of Tangail CPP 1999

Note:

Many figures are indicative only and mostly they reflect trends rather than absolute numbers

S = Sustainable; R = Reversible; IR = Irreversible; Op = impact depends on maintenance and operation;

M = Mitigation measures are effective. NQ = not quantified; Common trend: similar changes occur elsewhere in Bangladesh

Significant changes were also observed outside of CPP area; the direct impact of CPP is not quantifiable

Some impacts can only be tentatively assessed under present state/data available: long-term changes may happen

1 = Fauna and flora surveys in 1992 / 1994

Impact rating follows the EIA Study 1992 methodology: ** Highest beneficial impact = + 5.0; Highest adverse impact = - 5.0

Sources: EIA Study 1992; CPP GIS Atlas 1996; CPP GIS Atlas 1999; CPP Tangail Field surveys 1993-94

Policy and Regulatory Compliance

In general, the compliance with environmental policy in CPP should be seen in the context of the overall environmental degradation in Bangladesh and the enormous pressure on land and water resources caused by the growing population. There is a need to balance enhancement for productivity and environmental performance.

In this context, CPP interventions comply with most policy goals, elaborated in the NEAP (1995) and the new NWMP (1999, draft versions of Topical Papers):

- **Flooding protection** is a major concern of the environmental policy in Bangladesh. CPP provided evidence that the general concept of partial flood control can be achieved with the participation of local people. It also provided evidence that the beneficial parts of a normal river flood should be maintained, i.e. allowing inflow through peripheral structures in embankments. The assessment of sustainability of participatory approaches (local water management committees) and the economic viability are subject to other CPP reports;
- **Urban flooding.** CPP interventions and associated works for Tangail Town aimed at improving flood proofing and protection. The flood event in 1998 provided evidence that CPP was successful to keep Tangail almost flood free (see CPP semi-annual report 1998);
- **Wetland conservation.** The national environmental and water policy demands that beels (wetlands) are preserved. CPP interventions, however, aim at providing more arable land by improving drainage congestions. Therefore, CPP interventions cannot directly contribute to the goal of wetland conservation. CPP environmental section, however, started a bio-diversity monitoring and conservation education and dialogue program that provided some insights in the potential to develop wetland conservation at local level. The CPP activities provided evidence that successful conservation at local level would require the formulation of procedures and methods for land use (natural resources) planning at both national and local level and a sound legal base for implementation: land policy, water policy, wetland policy etc. and corresponding laws and by-laws;
- **Controlling groundwater abstraction.** CPP has no direct impact on the development of irrigation facilities. However, CPP provided sufficient evidence that there is immediate action needed at both national and local level to formulate strategies for the control of groundwater abstraction and to provide capacity for enforcement at local level;

- **Changes in agro-chemical use:** The CPP initiated campaigns in cooperation with the DAE Tangail for Integrated Pest Management (IPM) and provided onfarm research opportunities to introduce or improve the use of organic fertilizers. Despite the fact that - at present - neither fertilizers nor pesticides are widespread and indiscriminately in use by farmers - compared to other areas in Bangladesh, there is potential for future deterioration and contamination of soils and ground- or surface waters with increased intensification of agriculture.

Compliance with the FAO Code of Conduct regarding the application and handling of agro-chemicals/pesticides. Action is required at all local levels to comply with the Code of Conduct: wholesalers, dealers, and farmers. CPP conducted surveys on agro-chemicals in Tangail in order to provide a database for further decision-making. Awareness creation campaigns and technical training should be the next steps that aim at DAE field and office staff, farmers, and dealers.

CPP is promoting safe uses of agro-chemicals and provides data for decision makers and thereby complies with national policy;

- **Faecal pollution** in open water bodies is widespread. Although CPP interventions are not the source of pollution, floodwater management in CPP area has some direct influence on the dispersion and dilution of polluted surface waters. Controlled floodwater management offers options for increasing the rate of both dispersion and dilution during the monsoon season, and thereby can have positive impacts, if properly designed and implemented in gate operations during the monsoon flood.

Other matters of concern that are beyond the scope of CPP interventions are:

- Cleaning of effluents from handloom factories in rural areas to reduce the pollution of open water and groundwater by hazardous chemicals;
- Provision of sanitation facilities in rural and urban areas is of outstanding importance in Tangail and elsewhere in Bangladesh.

In summary, CPP interventions comply with most environmental policy goals. Some other important environmental issues in rural areas need to be addressed by complementary projects:

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- Pollution of water sources, causing endemic diarrhea and other water-related diseases
 - Access to clean drinking water
 - Safe places for bathing, washing, swimming, etc.

Prolonged and high floods, like in 1988 and 1998 had disastrous effects and CPP could prove that conditions were better than in surrounding areas, providing that breaches can be avoided by improving design and construction standards.

Critical Evaluation of Achievements: EMP Implementation

CPP developed an environmental management plan (EMP 1994) that was based upon the findings of the EIA Study, undertaken by FAP 16/19 in 1992, and activities of the CPP environment section since its inception in mid 1993.

In summary, the CPP interventions comply with most environmental policy goals outlined or drafted by the National Environmental Action Plan and National Water Management Plan. To date - there is no evidence of significant and high magnitude adverse additional environmental impacts caused by the project. Other important environmental concerns are not directly related to flood hazards and had not been addressed by CPP interventions, such as water pollution control, sanitation, waste management in rural areas and urban centers, groundwater mining, environmentally friendly agricultural practices, etc. However, they need to be addressed to achieve sustainable development in Tangail floodplains.

It is also worthwhile to mention that apparently other development activities in Tangail area are conducted without in-depth consideration of possible environmental impacts, e.g. road and railway constructions, establishment of brick factories.

The project made it clear that existing conflicts between wetland conservation (beyond fish production) and agriculture and infrastructure developments (railway, roads, urbanization, etc.) cannot be solved at project level within the existing legal and socio-economic framework.

Environmental issues have a low profile in the institutions, the BWDB and WARPO. It is acknowledged that environmental issues are at the emerging stage if project planning and implementation is concerned, despite important policy statements and comments received from various individuals. Experiences gained in CPP should be used to

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- Strengthen efforts to institutionalize environmental issues in the implementing agencies in order to overcome the role of an externally imposed add-on activity;
 - Promote a comprehensive planning and multi-disciplinary team approach at an early project stage that also clearly sets regulations how to integrate environmental concerns in project design and implementation;
 - Admit that the integration of environmental issues in project planning and operation would require the assignment of very experienced national staff with a holistic environmental perspective and in-depth knowledge of both technical and ecological issues;
 - To promote the active role of national consultants or specialists within implementing agencies in conducting EIA and designing and implementing environmental management plans; the role of expatriate consultants should be confined to an advisory function.

In general, the principles of controlled (river) flooding and improved drainage are adequately achieved in CPP, and construction and operation of infrastructure were performed in close collaboration with local water management groups. Some activities and project achievements need to be maintained or continued after the project's lifetime, if the participatory compartmentalization concept will be sustainable:

- Continued monitoring of important long-term environmental impacts serve as tools for decision-making at local and to provide policy guidance at national level;
- Long-term soil fertility monitoring with the use of modern laboratory equipment
- Bio-diversity monitoring to comply with the Bio-diversity Convention
- Groundwater level monitoring to set regulations to avoid mining of groundwater
- Use and handling of agro-chemicals at national and *Thana* level
- Continuation and dissemination of environmental training and awareness programmes for rural population and farmers;
- Functioning of local participation in water management committees with the continued active involvement of major stakeholder groups; clear rules should be set to guide operation of peripheral and internal regulations that allow the beneficial part of the floodwater entering the floodplain and to maintain a

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water level in perennial *beels* that is sufficient to maintain the ecosystems functions;

- A regional committee is required to monitor and assess the upstream and downstream interlinkages and impacts in floodwater management.

The lack of capacity at local level and the rather poor performance of some governmental institutions at local level, partially caused by financial and staff constraints, may hamper the implementation some of these activities. It is also evident that there is no institution at local level that guides, coordinates or supervises environmental issues and activities. There is also shortage of capacity at national level to support local activities towards environmental management, e.g. research or other governmental institutions will only react if donor-driven activities will continue.

National decision makers should ensure an adequate level of institutional support to maintain the level of flood control intervention undertaken by CPP and to guide effective institutional collaboration at national and local level. Further support by institutions at national level would also be required to secure environmentally sound development in a complex project like CPP. If these conditions are met, the basic concept of controlled river flood management, in comparison with a full flood control, can contribute to environmentally sustainable resource uses in a floodplain ecosystem.

It is strongly recommended to develop a land use plan at regional level that considers also goals for nature conservation, especially to conserve wetland ecosystems as a common resource and to preserve bio-diversity assets.

Rules and regulations for environmentally sound resources utilization need to be developed at national level, based on a sound land policy that also considers aspects of social equity. Currently, it is unrealistic to plan for community or communal managed wetland conservation in the existing institutional, social and economic environment of the Tangail floodplains, or to enforce regulations to control the over-exploitation of wetland resources. Local decision makers or other local influential does not accept them.

It appears that one group of stakeholders benefits from CPP interventions: farmers and landowners, especially those who have land claims in lowland and medium highland. It would be essential to enforce their adequate contribution or share in construction and maintenance costs in order to ensure sustainability and to address social equity aspects.

