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 J-Monitoring and Evaluation
Annex K-Economic Analysis
Annex L-Modeling of Multi-compartments
Annex M-Guidelines

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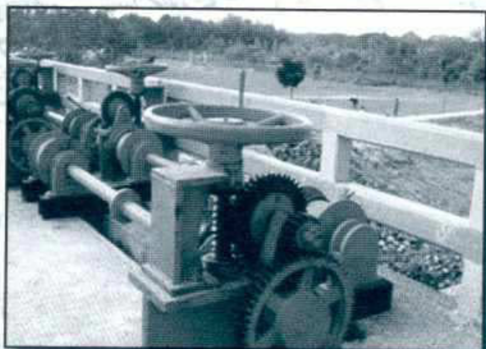

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Acronyms and Abbreviations

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

8

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 Onderzock 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

Aman	A group of photoperiod-sensitive rice planted in May-August and harvested in November-December.
Aus	Photoperiod-insensitive paddy varieties grown with irrigation from December -February
Baor	Oxbow lake, natural depression usually formed by the change of course of rivers
Bazar	Market place
Beel	Small lake, low-lying depression, a permanent body of water in a floodplain or a body of water created by rains or floods.
Bidi	Local Cigarette
Bigha	Unit of land (1/3 of an Acre)
Boro	A group of photoperiod-insensitive and fairly cold tolerant rice varieties transplanted in December-February and harvested in April-May.
Borrowpit	Excavated small and seasonal water bodies present mainly along the public roads.
Catch Assessmen	Determining the daily catch of the fishermen
Catch per unit	Quantity of fish caught by the fishermen in unit time and effort (Fishing equipment)
Chamara	Important deep water *Aman* variety
Chari in the *Bari*	A ditch on the homestead
Chawk	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.
Chula	Home made furnace
Cluster	A group of sub-compartments, which are merged together for management resons. Their hydrological features resemble an independent status.
Compartment	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.
Crore	100 lakh
Cusec	Discharge unit: 1 cusec equals 28 liters per second
Decimal	Unit of area measurement, 40 m^2
Deshi Jute	White jute (Corchorus capsularis) varieties, tolerant to standing water.
Dhaincha	An erect leguminous species (Sesbania sesban), used for green manure and fencing
Doon	Traditional water lifting device
Dopa	Lowest land type according to farmers' classification
DW *Aman*	Deep water Aman, a rice variety
Frame Survey	A survey for estimating the number of fishermen or gears.
Hat	Weekly market
Hijoldigha	Important deep water Aman variety
IPM	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.

20

Jalmahal	A leased water body or river stretch.
Khal	A natural channels.
Kharif	Crop season from March-October (Kharif-I: March-June, Kharif-II: July-October)
Khash land	Land owned by the government
Kutcha	Unlined earthen channel
Lakh	100.000
Madrasha	Islamic School
Mastan	Muscle man/thug
Mohalla	Urban village
Multi-criteria *analysis*	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.
Pagar	Small water body
Palam	Homestead land
Patchot	Intermediate land type according to farmers' classification
PA-Matrix	A relational matrix, depicting links between participants and activities in a certain process.
Parishad	Council
Perching	Placement of branched sticks (perches) in crop land as resting place for insect-eating birds.
Pourshava	Town council
Pucca	Lined earthen channel
Rabi	Crop season (November-February)
Rapid Rural *Appraisal*	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.
Retting	Bacterial processes of separating jute fiber in standing or slows running water.
Salish	Traditional informal village court which mitigate the disputes of the vilagers. The traditional village Matabbars (Chieftains) are the judges.
Sub-Compartment	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.
T. *Aman*	Transplanted Aman, a rice variety.
Tan	Highest land type according to farmers' classification.
Thana (previously Upazila)	Local administrative unit. Each Thana is composed of 10-15 Unions.
Tossa Jute	Jute (*Corchorus olitorius*) varities, grown in the highest land types, not tolerant to standing water.
Union	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 J
Monitoring and Evaluation

Table of Contents

2U

Tables

Appendix 3

Appendix 4

Figures

Introduction

Annex J covers the final report on the monitoring and evaluation (M & E) activities in CPP during the Final Phase of the project. It contains a presentation of the M & E concept used, what was achieved and what can be concluded from the analysis of collected indicators as to sustainable, replicable and viable water management options. Moreover, this annex provides an evaluation of the lessons learned from the way M & E was implemented in CPP, and concludes with recommendations for the period after June 2000.

M & E's Objectives

The objectives of monitoring and evaluation in the CPP were first, to assess whether project objectives are achieved. Secondly, M & E aimed to show whether activities were implemented in accordance with planned targets. Thirdly, M & E was meant to assist project management to recognize and identify implementation problems so that remedial actions could be taken.

M & E During First and Final Phases of CPP

When looking at the objectives and the resulting monitoring and evaluation activities during the entire project period from 1991 until mid-2000, there is a distinct difference between the First and Final Phases on how monitoring and evaluation activities were implemented.

During the First Phase the responsibility for monitoring and evaluation activities was placed mainly with the technical sections, and as it seemed, the sections monitored what they found useful.

In the Final Phase, more emphasis was placed on centralization of monitoring and evaluation, leading to the creation of a separate M & E Section.

Achievements of M & E during First Phase of the project are summarized in the project completion report of September 1996. With respect to monitoring policies in the project, the document mentioned that a baseline survey was executed and an outline and comprehensive work plan for M & E were published. Although a list of indicators was selected and discussions between the consultants of the various groups and sections in the project took place, the project completion report concluded that no consensus could be reached and as such the document on indicators remained incomplete.

During the Final Phase of the project, and in accordance with the ToR, the responsibility for monitoring and evaluation was given to a separate section in CPP, which not only coordinated and supervised the activities, but also selected the indicators, processed them and analyzed the results. The achievements with respect to M & E during this phase of the CPP form the content of this annex, what is given below is a summary:

- The selection of indicators to monitor and evaluate project performance was based on the project's logical framework,
- A total of 47 indicators were selected and collected on a regular basis by staff of the technical sections and personnel of the M & E Section,
- All field information was entered and stored in a computerized database system for further processing and analysis, and
- Analysis of water management, agricultural production, construction activities in CPP, population trends, farm economics and disease incidences was done and published in separate documents (named M & E Analytical Notes),

Staffing

During First Phase of CPP, staffing in the MEU consisted of:

- National Consultant as head of the MEU, employed on a temporarily basis from 1993 to mid-1996.
- International Experts, various experts on short term mission (2 months).
- Supporting staff: Junior Agricultural Engineer (1) employed on a permanent basis from 1995 to mid-1996

At the start of Final Phase, when the M & E Section was created, more staff was appointed, reflecting the change in scope of monitoring and evaluation:

- National Consultant heading the M & E Section, employed on a permanent basis from mid-1996 to mid-2000.
- International Expert, on short term missions, 16 months in total over the period from mid-1996 to mid-2000.
- Supporting staff: Data Entry and Processing Assistant (1) employed on a permanent basis from mid-1996 to mid-2000,

  Field Enumerator (1) employed from April 1998 to mid-2000,

  Librarian-cum-Researcher (1) employed from April 1999 to mid-2000.

Objectives and Activities of CPP

This chapter will present the objectives of the project based on ToR of Final Phase. These objectives form the basis of the logical framework, which is used as a tool to select appropriate indicators, and will be discussed in more detail in the next chapter. Also discussed in this chapter are the project activities.

CPP's Objectives

The overall objective of CPP, states the national goals of water resources development in Bangladesh in general terms:

> *"Enhance economic production, improve environmental security and reduce poverty in the floodplains of Bangladesh"*

Within the scope of this overall objective CPP's specific purposes were formulated:

> *"Provide viable, sustainable and replicable approaches to compartmentalization,*
>
> *Give integrated water management options for different sections of the population,*
>
> *Develop policies and guidelines for integrated water resources management."*

The overall objectives and the specific purposes of CPP indicated that the core activity was water management while the project did, to a limited extent, aim to increase agricultural production. However, it did not directly aim to increase fishery production. Water management was the critical issue in CPP and this meant that it was also the central theme around which monitoring and evaluation should center, while changes in production, or in environmental conditions had to be seen as resulting from it.

Being focused on water management led to the definitions of a number of project goals:

- Test the practicability of compartmentalization,
- Establish water management systems,
- Prevent environmental degradation,
- Enhance the environment,
- Develop guidelines,
- Improve drainage of Tangail Town,
- Enhance economic production, and
- Reduce poverty.

20

Project Activities

In order to achieve the projects goals through the creation of a compartment in Tangail with established water management systems, CPP concentrated on a number of activities in the field of construction of infrastructures, water management, economic production activities, environmental monitoring and social economic improvements. Project activities during Final Phase of CPP comprised:

Construction Activities

The activities concerning the construction of water management infrastructures continued during Final Phase of the project. Moreover, a special activity was added, notably drainage of Tangail Town. The latter has nothing to do with water management in the compartment, but was included as one of CPP's activities during the reformulation of the project in 1996.

Water Management

There were two aspects related to water management, first a technical component comprising of the rules and guidelines for the operation of water management structures to regulate the flow of water in the compartment. Secondly, there was the need for an institutional component, enabling the organization and proper execution of structure operations.

The activities for technical water management consisted of an operational model for controlled flooding and improved drainage based on mathematical simulations executed by the Surface Water Modeling Center (SWMC).

Creation of an institutional base through people's participation in water management, and testing this institutional framework in 4 pilot *Chawks* were the activities connected to organizing water management in the compartment.

Boundary Activities

In order to conceptualize and visualize the physical conditions in the compartment as well as the achievements of CPP, a GIS system was set-up during First Phase. In Final Phase, this activity continued.

Agricultural Production

The activities for the agricultural program of CPP consisted, first of a survey program that covered land use and irrigation surveys. Secondly, a monitoring program that covered farming systems and a sample of cultivated plots to record input use and yields. Thirdly, the OFTD program was undertaken, consisting of crop demonstration plots for improvement of paddy and vegetable cultivation.

Fishery and Aquaculture

The fishery program aimed at monitoring catches in the waters of the compartment through catch assessments and "frame" surveys in various habitats, like floodplain, *Beels*, open water and *Khals*. Activities related to aquaculture consisted of training fishpond owners, giving extension and monitoring the results.

Environmental Monitoring

Activities related to environmental monitoring concerned soil fertility, changes in biodiversity, social forestry extension, agricultural chemical use, monitoring ground water levels and water quality analysis. Moreover, CPP undertook an environmental awareness-raising program.

Social Economic Improvements

In trying to improve the social economic situation of women and landless people, CPP increased empowerment of women through participation in water management, gender training and awareness raising. Also the project was involved in monitoring and coordinating activities related to employment generation amongst women organized in Embankment Maintenance Groups (EMG). Although CPP was not directly involved in coordination, monitoring or administration of work executed by Labor Contracting Societies (LCS), project funds were used to pay them.

Selection of Indicators

This chapter addresses the underlying concepts and approaches for M & E in CPP giving selection criteria for indicators. For the sake of any more appropriate analytical tool, CPP used the logical framework approach to define monitoring and evaluation indicators.

Logical Framework

The choice of an analytical model to define an effective set of performance indicators was a critical one. During the First Phase of the project, an attempt to reach agreement on a set of M & E indicators failed. The selection of indicators had not been structured and seemed to be the sum of on-going monitoring activities already executed by the various sections. In Final Phase, CPP opted for an approach that provided a clear insight in the relationships between activities and achievements. The logical framework is such an approach, providing this type of integrated reflection on project objectives and activities.

A logical framework provides in a nutshell the relationships between project objectives, activities and the underlying assumptions, risks and conditions. CPP's logical framework lists for each objective of the project and the activities it executed the means of verification and the source of verification. These means of verification were taken as the starting point for the selection of performance indicators.

The system of indicators developed for CPP did not monitor achievements towards the overall objective of the project. The reason being that it was not possible to prove that changes in national indicators (like per capita GDP, total cultivated areas, literacy rate, total flood damage in the country) were due to CPP's activities. However, this is not the case with the indicators related to the specific project purpose and those of CPP's purpose, because they form the performance indicators by which it can be proven whether CPP was able to achieve its objectives (see Figure 1 for details).

The logical framework for CPP also contained assumptions, conditions and risks for the objectives and activities. The M & E system did not develop any indicator to assess whether assumptions, conditions or risks influenced the execution of the activities of the project, principally because CPP has no influence over these assumptions, conditions and risks.

Figure 1 provides a summarized logical framework of CPP, a more detailed one figures can be found in Appendix 1.

Intervention logic	Objectively verifiable indicators	Sources of verification	Assumptions, conditions and risks
Overall Objective: To enhance economic production, improve environmental security and reduce poverty in the floodplains of Bangladesh.	**Indicators:** National indicators, like per capita GDP, cultivated area, literacy rate, flood damage, etc.	**Sources:** National statistics (BBS), publications Planning Commission.	Agreement between the GOB and the donors to fulfill their plight
Specific Purpose: Provide viable, sustainable and replicable approaches to compartmentalization, Give integrated water management options for different sections of the population, Develop policies and guidelines for integrated water resources management.	**Indicators:** > Economic viability assessment, > Model results, water management scenarios, > Institutional parameters and operational guidelines.	**Sources:** Reports of evaluation missions, as wells as modeling output, economic analysis, environmental assessment.	Letter of intention between the GOB and the GON and KfW to implement CPP
CPP Output: Test the practicability of compartmentalization, Establish water management systems, Prevent environmental degradation, Enhance the environment, Develop guidelines, Improve drainage of Tangail Town, Enhance economic production, and Reduce poverty.	**Indicators:** > Modeling results (output), water management scenarios > Constructions and operational guidelines, > Water quality and biodiversity monitoring, > Publications, > Drainage infrastructure, flood damage, > IRR, NPV, B/C, > Employment generation, income distribution.	**Sources:** M & E indicators and multi-criteria analysis.	Acceptance by the GOB and the donors of the TAPP. Acceptance of CPP by the local population.
Project Activities: Construction and maintenance of infrastructure, Water management, Institutional development, Agricultural extension and support, Gender related actions, Fish-culture promotion and extension and catch monitoring, Environmental monitoring and support, Supporting activities: GIS, surveys, M & E.	**Means:** Land acquisition, Construction and O&M, Technical assistance, Program costs: agriculture, fishery, Institutions, WID, M & E, etc., Surveys, Equipment.	**Costs:** Contributions: GOB: \$ 3.9 M GON: \$ 8.9 M KfW: \$ 8.1 M (actual expenditure, converted to dollars based on rate of 50 Tk/\$)	Availability of funds. Active participation of the BWDB in implementing CPP. Acceptance and contribution by the local population. Land acquisition by the GOB, infrastructure by KfW and TA by GON.
			Pre-condition: GOB must provide the legislative and administrative structure for sustainable improved water management.

Figure 1: Summarized logical framework for CPP

28

Indicators

In view of the main emphasis of CPP, notably water management, it seemed logical to make this issue the central issue in the definition of performance indicators. Water management concerns a number of building blocks that are needed to make it successful, notably the proper infrastructure, an institutional framework, the good functioning of the institutions and the proper operation of structures. On the one hand, water management needs finances to construct structures and to establish the institutional framework and make it work, while on the other hand, water management impacts on agricultural production, fisheries, the environment, the social economy of the region, etc.

Given the situation in the compartment before starting the project and the resources made available, CPP's impact could only be limited. The prevailing physical, climatic and to a large degree, the social economic environment wherein the project took place, defined by and large what was possible, and to what extent it could be replicated. These formed the boundary conditions wherein CPP operated. These given conditions thus form the "mirror" against which CPP should be measured, as the project could be expected to influence the physical or climatic environment and possibly only to some extent the social economic situation in the compartment.

The fixed boundary conditions included hydrology (type, discharge), topography (slopes, natural drainage system), soil quality (potential cropping intensities and yields), population densities, distribution and number of urban agglomerations, water borne activities (transport), and limiting factors such as protected areas and wetlands. However, CPP could have had some impact on the regional economy through its agricultural and fishery activities.

Project Costs Indicators

Contributions from GoB and Donors

The rationale for recommending an indicator with regard to the contributions made by the GoB and the donors towards program and project support was to know how much was spent and how expenses were distributed. Project costs formed one of the main elements to judge the economic feasibility of CPP and as such were an important indicator.

Costs of Construction Activities

The indicators dealing with monitoring what the project spent on construction activities, concentrated on recording expenses for land acquisition, construction works, maintenance costs, minor works costs and income generation activities. These expenses permitted to calculate parameters like investments per ha, operational costs per ha and so on. Moreover, the indicator gave insight in the distribution of expenses over the project implementation period, which is an element needed for the calculation of the economic feasibility of CPP.

Land Acquisition

The GoB paid for all land acquisition costs in CPP, which concerned land needed for structures and for excavation of *Khals*. Land acquisition was a critical issue in the implementation of CPP's infrastructure works, and as such a valid indicator to define the opportunities for duplication of the concept. Given that the project was able to secure the approbation of the landowners to take land into possession within a reasonable time frame, data, nevertheless, showed that full payment lagged behind. Sometimes one or two landowners were able to hold up the excavation of a *Khal*, thus jeopardizing drainage of a large area.

Construction Costs

The indicator monitoring construction costs provided insight in the cost per ha of structures that the project has constructed for the compartmentalization approach in Tangail. Collected were data on construction price, starting and completion dates, details of the implementation process (mode of execution, e.g. contractor or labor contract), etc. The viability of the compartmentalization approach depended largely on capital infrastructure put into place. Not only for the technical feasibility of the concept this indicator was important, but also for the economic performance of compartmentalization, as it was one of the important elements in the cost-benefit analysis.

Maintenance Costs

Directly related to the indicator explained above are the costs of operating and maintaining infrastructures. As an indicator, the costs for maintenance served two purposes, notably it was one of the important cost elements in the cost-benefit analysis, whereas it indicates to the GoB how much is needed in the future for maintaining the infrastructure in order to sustain water management operation.

Mitigation

Mitigation costs were required either to prevent potential detrimental impacts of project activities or to alleviate negative effects that may not be avoided. However, no separate data collection took place as to the cost of mitigation. Where CPP

20

installed fish friendly gates, the incremental costs were part of the construction price and monitored consequently. A separate investigation in the costs of mitigation was thus not considered appropriate.

Employment Generation

Construction activities in the compartment have certainly contributed to extra employment opportunities as much of the earth moving work is by manual labor. However, it was not possible to monitor the employment of unskilled labor in the construction contracts handed out for infrastructure and excavation works. The whole process around construction contracts was not transparent, and it proved impossible within this situation to obtain details about the employment of unskilled labor by contractors.

Nevertheless, CPP was able to monitor the activities of the LCS and the work done by the EMG (see below under the social-economic indicators), although their impact was not very important. Moreover, it appeared that the LCS concept was not working and during 1998, the project did not issue new LCS contracts. After the floods of 1998, the EMG program stopped because, virtually, all embankments required resectioning by contractors. WID activities recommended in 2000.

Minor Works

Minor works were small construction works, like culverts, constructed by the water management committees themselves. These minor works made only a small contribution to improving water management, but the fact that the water management committees were engaged in their construction bears probably some importance. M & E recorded expenses made towards minor works, but did not attempt to monitor any improvement in the commitment of towards water management directly; the qualitative survey of water management committees, executed in 1997 by COMMUNICA[1] addressed this issue already.

Support Costs

For the sake of completeness, the M & E system also recorded support costs, which were needed for the implementation of the program. They covered repair costs for transport and equipment of the BWDB, training expenses for LCS groups, etc.

[1] COMMUNICA, March 1997, The study on appraisal of water management organizations in CPP and gender impact of project activities (Final Report)

Water Management Indicators

Technical

Water management consisted, on the one hand, of a technical or hydraulic part and on the other hand, of institutional components. The technical side of water management was monitored, since the monsoon of 1998, by means of what happened to water levels and flows at selected key structures. The process covered records of water levels, the listing of changes in gate settings, together with where the instruction came from and what the expected and actual results were. Although monitoring activities only started late in the Final Phase, the indicator proved valid in monitoring two monsoon seasons.

Institutional

With respect to the institutional side of water management, CPP monitored closely the nomination and election process of water management committees. Within a very short time, CPP created over one hundred Chawk Water Management Committees (ChWMC) and fifteen Sub-compartment Water Management Committees (SCWMC). Monitoring concerned the nomination and election process of committee members. Also, it covered additional information on aspects that could play a role in the functioning of the committees, like the residence of the committee member, his or her experience with management, etc.

Boundary Indicators

Population

One important boundary indicator for CPP is population. Although the project has no influence over population trends, or the place where people chose to live, it should be recognized that project interventions were people oriented. The project tried to improve water management to safeguard the well being of persons, so population and its location over the compartment were important indicators to monitor. However, population data were scant and did not cover much more than those of the 1991 population census. Estimates for later years were based on birth and death records of the Thanas and the health centers in the compartment.

Strongly related to population was migration. CPP carried out an assessment to obtain insight into the number of persons inmigrating into the compartment and leaving the compartment, from information collected with the SCWMC. Although, not perfect, this assessment gave some indication of migration flows.

2X

Rainfall

CPP recorded rainfall data as it formed an important boundary indicator.

Prices

In general market prices reflect the scarcity of a commodity; if a certain good is in short supply or high demand its market price tends to increase in an open economy. CPP monitored market prices of inputs and commodities in the compartment as to be able to use real local prices in the feasibility study of the project.

Flood Damage

An important indicator, which could prove whether flood protection is achieved, was the assessment of flood damage. Based on District and Thana statistics, CPP was able to monitor flood damage to properties, infrastructure and agriculture.

Agricultural Indicators

Cultivated Areas

Improvements in water management in the compartment should be reflected in changes of the area under modern high yielding rice varieties (HYV) as farmers gain confidence and are prepared to cultivate crops needing more capital and thus involving a higher risk. Moreover, any changes in water management could lead to higher cropping intensities and another mix of crops and varieties. These changes would be reflected in the crop mix and areas under cultivation. As such, cropping pattern and land use, which were monitored by the Agricultural Section, provided a good indicator of the changes taking place in cultivated areas, in particular of those under HYV rice.

Yields

To some extent crop yields reflected water management, but there were so many outside factors also playing a role, that it would be difficult to prove a direct cause-effect relationship. Factors like climate, irrigation or extension, not forming part of any CPP program could have influenced yields. Monitoring yields in the compartment and the areas outside served to be able to calculate the total agricultural production and later the value of agricultural cropping in the compartment. Moreover, yield data from the DAE cover many years and were thus a good source to show the difference between the pre-project situation and the project situation.

Input-Output Data

The results of monitoring farm management activities, served principally for the collection of farm economic data to calculate agricultural income and value added. Income and value added provided, to some extent, a reflection of the impact compartmentalization had on economic activities in the agricultural sector. It certainly showed the dynamics of the sector. Changes in agricultural income and value added were used for the economic feasibility of CPP. Moreover, details of farm management practices served to check and crosscheck other information.

Irrigation

Every two years the project carried out an irrigation survey in order to monitor changes in irrigated areas and any increase in the use of equipment. In 1993, 1995, 1997 and 1999, the Agricultural Section carried out surveys, and although the base was not always the same, it gave a good picture of what happened. Survey results were used as an indicator for irrigation in CPP.

Crop Demonstrations

Monitoring the activities related to crop demonstrations served to follow the activities of the Agricultural Section and gave a good indication of the level of participation by other sections in CPP's activities. The indicator recorded dates of field visits, the crops in the demonstration field and the involvement of other technical staff other than those from the Agricultural Section (of the WID and Institutions Sections, BARI, BWDB, etc.) in the program.

Fishery Indicators

Catch Assessment

When CPP started there was a feeling that water management could have an adverse impact on fish production and consequently on catches. CPP recorded, since 1992, catches in a number of habitats in the compartment. These recordings proved to be a good basis for time series on the catch per unit area and the catch per unit effort.

Aquaculture Training and Monitoring

Training in aquaculture opened opportunities for persons to cultivate fish in dug ponds following the reduction in flooding, likely making investments worthwhile, because there would be less risk of losing the pond when the land is flooded. However, it seems that the land owing part of the rural society benefited from the program as fishpond culture required land, while 70% of the rural population do not have land.

Promotion of Catfish Cultivation

In 1999 CPP started a catfish program, helping households in the compartment in growing catfish in their yards in small basins. The project monitored the program accordingly.

Environmental Indicators

CPP monitored a large number of environmental issues over a long period, sometimes not without difficulty and setbacks.

Soil Fertility

There was been much discussion about the possible impact of the compartmentalization approach on soil fertility. First, there would be the possible reduction of silt deposits on plots, which could affect soil fertility. Then, one expected that changes in hydrology would also lead to other cropping patterns and crop choices, which could also, influence soil fertility. Hence, the importance of an indicator to verify the prediction of possible long-term impacts on soil fertility. The collection of information on soil fertility started very late, and as a result the value of the indicator was small.

Bio-Diversity

The collection of data on bio-diversity started late and the results of the survey contract to Dhaka University were not well suited to use in an analysis of water management and bio-diversity changes. Much of the data form this survey consisted of the recording of plant and animal species living in the compartment. However, a good and useful analysis was done on aquatic bio-diversity (see the Annex on Fishery). Apart from the fishery data, there was little quantitative information to use in combination with other activities of CPP, like water management, population increase, agricultural production, etc.

Agro-chemical Use

In 1997, CPP surveyed a limited number of wholesalers, retailers and farmers in order to estimate the sale and use of fertilizers and chemicals, but unfortunately CPP staff did not repeat the survey. However, since 1999 Dhaka University surveyed the use of agro-chemical in the compartment.

Ground Water Levels

Ground water use by irrigation was expected to be high during the *Rabi* season, and hence it became rather important to prove whether there is a relationship between water management and the recharge of ground water. Since 1989, CPP collected data on ground water and analyzed these together with the results of the irrigation surveys.

Water Quality

There could be an effect of changes and intensification of agriculture cropping on water quality in the *Beels, Khals* and rivers in the compartment. However, it could also be more than likely that much of degradation in water quality had a non-project source. Industrial economic activities (for instance the handloom weaving industry) in the compartment and the number of persons living there were an important source of pollution. CPP started a water-quality monitoring program during the First Phase, but stopped it early in the Final Phase. However, since 1999, a revised water quality monitoring program, collecting relevant parameters on likely impacts by intensified agriculture, started.

Public Health

Changes in the compartment's flood regime could impact on public health. CPP started early in the Final Phase a survey of clinic visits in nine rural clinics and Tangail General Hospital, to monitor health incidences. However, the fact that income had probably a much larger impact on clinic visits, than changes in the compartment's flood regime, influenced the interpretation of public health data.

Social Forestry

Since 1998, the project carried out a tree plantation program around homesteads. CPP monitored the distribution of saplings, their survival as well as the involvement of other project staff in the activity.

Awareness Raising

The project started a program of environmental awareness raising, which was monitored.

Social Economy Indicators

Indicators that fall outside the activities of project activities came from secondary sources, e.g. statistics on market prices for inputs and produce (agriculture, fishery, livestock), data on processing agricultural products, figures on flood damage. The collection of these base statistics was necessary for the economic analysis of the compartmentalization approach. However, it became clear during data collection that there were hardly any relevant statistics at the Thana and District level available.

Pre-project Situation

The pre-project situation formed the basis against which progress was evaluated. As such it was important that there was a full consensus on these data, otherwise, they were useless for evaluation later. The main source of information consisted of existing statistical publications, project documents and supplementary information collected at the Thana and DAE levels. In particular, the economic analysis needed such a picture of the pre-project situation.

Women Participation in Decision Making

Empowerment of women was an important issue the project addressed. It seemed clear that without any women involvement in the water management committees a larger influence of women would never be achieved. As indicator to measure the influence of women in the water management committees, the number of women holding a function in the water management committees was used.

Collection of Performance Indicators

General

A full list of the indicators collected by CPP is presented in Appendix 2 to the annex. The organization of the indicators in this list is according to the section that was the source of the indicator. The name of the indicator and the number of the questionnaire refer to those used internally in CPP.

The collection of M & E indicators was based on an analysis of CPP's logical framework. However, in the execution of the program compromises had to be made, as M & E had to rely on data collection by the various sections of CPP for the simple reason that there were not enough field workers to collect field data. As much as possible, the monitoring programs of the various sections were left unchanged, because it concerned often ongoing activities, and where possible M & E indicators were extracted from this ongoing monitoring. In a small number of cases, ongoing monitoring programs were modified or new programs introduced, as to ensure that specific indicators were collected.

Apart from indicators collected through CPP sections, there were also a number of indicators that had to be collected separately, because they were not covered by the sectional monitoring programs. This concerned data from BWDB, LGED, District statistics, *Thana* offices, or public heath clinics in the compartment, covering labor contracts by LCS, commodity market prices, flood damage, disease incidences, etc.

The following paragraphs indicate where the indicators came from, and achievements in collecting the data from the sections or from sources outside the project.

Project Costs

The indicator reflecting project costs came from various sources. The contributions made by the GoB and the KfW to CPP originated from the XEN's Office. All contributions made as technical assistance from the Netherlands were supplied by CPP's own administration. CPP's Quality Control Section provided all details on construction and maintenance activities and their costs. Details concerning employment generation by LCS came from the XEN's Office, while similar information for EMG women came from the WID Section of CPP.

It was not always possible to complete data series for each indicator for the entire project period from 1992 to 2000. In particular, the records from the First Phase of the project concerning the GoB contributions and the assistance from the Netherlands could not be completed. Almost all other indicators relating to project costs were collected for the entire project period.

No.	Indicator	Collection frequency	Data source	Achievement
1.3	Contributions made by the donors towards the project	Half-yearly	CPP's semi annual reports	Since 1992 complete
2.1	Constructions costs for infrastructures and excavation	Monthly	Quality Control Section	Since 1992 complete
2.2	Land acquisition costs	Monthly	Quality Control Section	Since 1992 complete
2.3/5.2B	Details about the contracts given to LCS	Monthly	Quality Control Section/XEN's Office	Complete, since 1998 no contracts
5.2A	Details of the EMG contracts	Monthly	WID Section	Complete, since 1998 no contracts
2.4	Supplementary costs	Monthly	Quality Control Section	Complete

Table 1: Details of the collection process for the project costs indicators

Water Management

The indicators concerning water management were collected from CPP's Water Management and the Institutional Development Sections. In particular, the technical side of water management operations, covering information on key structures, gauge reading and details of structure operations originated from the first section. All data that had to do with the organization of water management and the functioning of water management committees came from the second section.

No.	Indicator	Collection frequency	Data source	Achievement
9.1	Properties of key structures for water management		Water Management Section	Carried out in 1998
9.2	Target water levels of the key structures	Annual	Water Management Section	Record complete up to 1995
9.3	Details of structure operations	Annual	Water Management Section	Complete for 1998 monsoon
9.4	Rainfall data	Monthly	Water Management Section	Since 1991
9.5	Gauge reading of the key structures (August - October)	Annual	Water Management Section	Record complete up to 1995
3.1	Monitoring of the election process of water management committees	Annual	Institutional Development Section	Complete for 1998 re-formulation process
3.2	Monitoring of the effectiveness of committees to manage structures	Annual	Institutional Development Section	Complete for 1998 monsoon
3.3	Follow-up monitoring of the functioning of water management committees	During monsoon	Institutional Development Section	Planned for 1999 monsoon
3.4	Monitoring of training activities in water management	Monthly	Institutional Development Section	Complete for Final Phase

Table 2: Details of the collection process for water management indicators

The achievements in collecting water management indicators were good; since the reformulation process of committees in 1998, a complete record of institutional activities was provided. With respect to technical water management, data series were as complete as possible; record keeping on gauge readings started in 1995 and 1996, while those on structure operations dated back to 1998, when the new water (reformulated) management committees became operational.
Table 2 provides the details.

Boundary Conditions

Data that reflect boundary conditions for CPP came from various sources. Market prices were made available by the German funded LGED road project, while flood damages came from the District Office in Tangail and the various Thanas. The population and migration flows originated from the SCWMC and were collected by CPP's Institutional Development Section. CPP's Water Management Section provided details of rainfall in the compartment. The sub-compartment areas were taken from the GIS Atlas of CPP.

Data collection for these indicators was almost complete, as showed in Table 3.

No.	Indicator	Collection frequency	Data source	Achievement
8.1	Statistics of market prices	Monthly	From LGED	Complete since August 1993
8.3	Flood damage assessments	After monsoon	M & E Section from District and *Thana* offices	1988 and 1998 available
8.5	Population and migration flows		Institutional Development Section	Covering entire project period
	Conversion rates (Tk/DFL and TK/DM)		Quality Control Section	Complete since 1992
	Gross and net areas in the compartment		GIS Atlas	Complete

Table 3: Details of the collection process for boundary indicators

Agriculture

Almost all indicators covering agricultural production and extensions came from CPP's Agricultural Section, with the exception of data collection on the input-output analysis of agricultural cropping, for which CPP's M & E Section was responsible.

Some of the monitoring surveys in agriculture are not complete because no data collection took place; as such there are gaps in the land use surveys, and was the irrigation survey only carried out every two years. Data collection on the inputs and outputs of agricultural cropping started only in 1997 and the OFTD program was monitored from 1998, when it started (see Table 4).

No.	Indicator	Collection frequency	Data source	Achievement
4.1A	Land use in the compartment and adjacent areas	Seasonally	Agricultural Section	Before 1997 not complete, from 1997 complete
4.1B	Land use changes from one year to the next	Seasonally	Agricultural Section	From 1995 complete
4.2	Cropping pattern based on 250 + 40 monitoring plots	Seasonally	Agricultural Section	Complete from pre-project period
4.3	OFTD training program	Monthly	Agricultural Section	Started in 1998
8.4	Input-output survey of agricultural cropping in 125 monitoring plots	Daily	M & E Section	Since Rabi 1997 season
	Irrigation survey results	Bi-annually	Agricultural Section	Completed for 1993, 1995, 1997 and 1999

Table 4: Details of the collection process for agricultural indicators

Fishery

All data concerning fishery and aquaculture originated from CPP's Fishery Section. Table 5 gives details.

Since the start of the project, the section monitored fish catches and a complete record of these was available. The recording of inputs and outputs in pond fishery covered only the years 1995 to 1997, while the aquaculture extension program for catfish started in 1999 and was monitored subsequently. A survey of fishponds took place in 1999 and was included in the M & E program.

No.	Indicator	Collection frequency	Data source	Achievement
6.1A	Open water catches, details per habitat	Monthly	Fishery Section	Since 1992 complete
6.1B	Open water catches, details per gear type	Monthly	Fishery Section	Since 1992 complete
6.4	Input-output analysis aqua-culture	Annually	Fishery Section	1995, 1996 and 1997 only
6.5	Aquaculture program (extension activities)	Monthly	Fishery Section	Since 1999
6.6	Survey of fishponds		Fishery Section	1999 only

Table 5: Details of the collection process for fishery and aquaculture indicators

[2] Within the compartment CPP's Agricultural Sections monitors 250 plots, in the adjacent areas monitoring covers only 40 plots.

Environment

CPP's Environmental Section provided all except one indicator to indicate the possible impacts on the natural environment. CPP's M & E Section collected data on waterborne diseases.

Unfortunately, there were gaps in data series concerning environmental indicators; some series such as groundwater monitoring datas back to 1987, while other programs started only in 1998 and were monitored from that date. Table 6 provides details.

No.	Indicator	Collection frequency	Data source	Achievement
7.1	Monitoring program for soil fertility and river borne sedimentation	Annually	Contracted out	1998 monsoon
7.2	Bio-diversity monitoring	Annually	Contracted out	1998
7.3	Monitoring agro-chemical use	Annually	Environmental Section	Data collection incomplete
7.4	Ground water level monitoring	Monthly	Environmental Section	Since 1987
7.5	Water quality monitoring	Monthly	Environmental Section	Since 1995, but incomplete data set
7.6	Monitoring (water borne) diseases in 13 clinics and in Tangail Hospital	Monthly	M & E Section	Since 1996
7.7	Monitoring tree plantation around homes	Monthly	Environmental Section	Since 1998

Table 6: Details of the collection process for environmental indicators

Social Economy

An important part of the indicators for the social economy of the compartment came from CPP's WID Section, especially those covering details of activities targeting the position of women. Cultivated areas coming from DAE were provided through CPP's Agricultural Section, while all secondary data needed for the evaluation of the performance of CPP, were collected or taken from library reports by CPP's M & E Section. These data cover by and large the pre-project situation.

The achievements on data collection can be found in Table 7. Data collection on the involvement of women started after the reformulation process of the water management committees in.

No.	Indicator	Collection frequency	Data source	Achievement
5.1A	Women involvement in ChWMC nominations		WID Section	Completed for 1998 reformulation process
5.1B	Women involvement in ChWMC elections		WID Section	Completed for 1998 reformulation process
5.1C	Women involvement in ChWMC elections		WID Section	Completed for 1998 reformulation process
5.3	Monitoring WID training, meetings and workshops	Monthly	WID Section	Since 1998
8.2	Cultivated areas and crop production from DAE	Annually	Agricultural Section	Since 1997
NA	Secondary data on social economy		M & E Section	

Table 7: Details of the collection process for social economy indicators

Results

This chapter of the annex contains the output of data stored in the M & E database that was collected by CPP to monitor and evaluate project performance. Detailed tables can be found in APPENDIX 3. Results of indicators collected for M & E are structured as follows:

- Results are organized per calendar year. This means that there could be some variation with data provided by some of CPP's sections, which refer to fiscal year, as is the case with project costs, or to hydrological year, as is the case with data from fisheries.
- Results are organized per sub-compartment if applicable, which is the smallest spatial unit used in the M & E system.

Summary of Project Costs

The following tables provide a summary of the project costs. First the contributions to the project are presented, giving the annual total for the GoB contributions, the financial (FA) and the technical assistance (TA) to CPP. Data included in the table came from the quarterly (during the First Phase) and semi-annual reports (during the Final Phase) of CPP.

It is noted that the project also received help from the World Food Program (WFP) through Work for Food aid. The value of the provided grain was converted to Tk in order to estimate its value

Source of funds	Total	Aug '91/ Dec '92	Jan/Dec '93	Jan/Dec '94	1994/ 1995	1995/ 1996	1996/ 1997	1997/ 1998	1998/ 1999	1999/ 2000
GOB	**193.72**	5.79	9.62	19.22	25.24	68.14	55.85	8.83	-4.40	5.43
FA	**442.49**	1.57	17.95	87.99	113.02	64.25	70.90	42.82	39.57	4.42
TA	**410.30**	68.50	55.89	31.10	50.66	55.72	31.33	33.58	61.39	22.13
WFP	**3.75**							3.75		
Total	1 050.26	**75.86**	**83.46**	**138.31**	**188.92**	**188.11**	**158.08**	**88.98**	**96.56**	**31.98**

Table 8: Details of contributions made to CPP (million Tk)

Notes:

No breakdown can be provided for the period Aug '91/Dec '92 and the years 1993 and 1994

The negative value in the GoB contribution of 1998/1999 results from a refund of advanced land acquisition money

The table below summarizes the cost made for the construction of infrastructure. However, it should be noted that the following assumptions were made:

- The costs of land acquisition refer to the estimated purchase price and the year refers to the year the procedure to aquire the land started,
- The reference year for the construction expenditure refers to the reimbursement year,
- For constructions which have not yet been commenced at 1 January 2000 the remainder of the contract price was used to define the costs, and
- Mitigation measures are those construction activities which CPP identified as such, like Tangail Drain, roads, bridges, etc.

Supplementary costs cover such items as training, repair works during construction, etc. Details are provided in Table A3. 7 in APPENDIX 3.

Item	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total (KTk)
Landacquisition	2 771	14 266	15 698	24 479	3 104		1 118			61 436
Construction		10 957	21 398	132 384	72 076	25 919	12 128	31 270	26 818	332 950
Mitigation measures				1 753	2 491	37 729	7 347	4 077	3 251	56 648
Supplementary costs		3 196	4 775	7 315	8 674	7 887	5 884	2 630	2 300	42 662
Total	2 771	28 419	41 871	165 931	86 345	71 535	26 477	37 977	32 369	493 695

Table 9: Details of infrastructure, O&M and supplementary costs ('000 Tk)

Notes:
Details of the different items can be found in APPENDIX 3
Total equals US$ 9.9 million

Results of Monitoring Water Management

The results of water management monitoring are given in APPENDIX 3. The technical side of water management is shown in the two tables below. It has been evaluated in the following way:

- Only the selected key structures (27 in total), for which water levels were recorded, were considered in the presented results,
- The set target water levels CPP should be considered as the maximum water levels allowable,
- Whenever the recorded water level at a structure was lower than the CPP

target water level, it was considered as a operational success,

- Whenever the recorded water level at a structure exceeded the CPP target water level, it was considered as a operational fault, and
- The sum of operational successes divided by the total number of recorded readings defined the success rate of water management operations: a rate exceeding 80% was considered acceptable.

The first table summarizes the results per months for all structures combined. The second table gives a summary per structure for all the months combined.

Month	1995	1996	1997	1998	1999
July	11%	55%	65%	21%	72%
August	56%	35%	65%	13%	72%
September	89%	70%	60%	21%	38%
October	89%	95%	100%	100%	92%

Table 10: Monthly effectiveness of water management operations

Notes:
Details can be found in APPENDIX 3

Table 10 indicates that the success rate of water management operations tended to exceed 80% at the end of the monsoon season. In particular, at the start of the season the rate was very low. However, it should also be noted that in 1999 performance at the beginning of the season was much better than in the years before.

Type of structure	1995	1996	1997	1998	1999
WCS	63%	69%	67%	13%	61%
Outlet	75%	79%	79%	36%	89%
Inlet	50%	71%	56%	17%	55%

Table 11: Effectiveness of water management operations by structure type

Notes:
Details can be found in APPENDIX 3

Table 11 shows that the effectiveness of water management operations was very good in almost every year for outlets. It is also apparent from the table that operations

82

failed completely in 1998 for every structure. However, it should be stressed that the situation in 1998 was exceptional and structures and embankments were not designed to cope with a situation where backwater aggravated flooding.

The organization aspects of water management are shown in the tables below and the tables in the appendix, which refer to the election process of the water management committees in 1998. The tables reveal that participation of stakeholders in the ChWMC was 37%, and that 32% of those voting for SCWMC members participated in the election process. Moreover, it seemed that 71% of the ChWMC committee members lived in the Chawk they represent and that 80% of the SCWMC members, lived in the sub-compartment where they are elected. Of the ChWMC committee members 17% had previous experience in water management. For the SCWMC members this was 25%.

From the table below, which gives details of the operation of gates at the selected key structures, it could be concluded that gate operations in 1998 did not draw many complaints. However, of the 49 cases where the gate was operated, it seems that in 15 cases operations was on instruction of someone not being made responsible by the

Instruction to operate the gate were given by	Cases	Complaints	Complaints
Gate not operated	13	1	8%
Responsible office bearer	32	4	13%
Gate operator	2		0%
Another committee member	4		0%
Union Parishad office bearer	1		0%
Other person	9	1	11%
CPP staff	1		0%
Total	**62**	**6**	**0%**

Table 12: Evaluation of gate operations during the 1998 monsoon

Notes:
Records concern 1998 monsoon
Cases refers to the number of times gate operations were monitored
"Gate not operated" refers to those structures, which were not operated at all in the 1998 monsoon, so 13 of the key structures were not operated at all in the 1998 monsoon

water management committee, although this did not draw many complaints (1 case only). Unfortunately, the monitoring activity was not repeated during the 1999 monsoon season.

Data on Boundary Conditions

The results of the boundary monitoring actions comprised data on population, agricultural and gross areas per compartment, market prices, rainfall and flood damages. All collected data, except the rainfall records, which already formed part of the annex on water management, are presented in APPENDIX 3.

Flood damage information came from District and *Thana* statistics. Data from the *Thanas* served to make estimates for the compartment by taking the percentage the compartment takes in the total *Thana* area as an estimator for damage done to property and crops in the compartment.

Agriculture Production and Extension

To understand agriculture in Bangladesh, it is important to know about the three seasons and their specific cultures. *Kharif* 1 concerns the pre-monsoon seasons going from March to June, with *Aus* paddy varieties in combination with jute and sugarcane. *Kharif* 2 ranges from June to October and is the season for the *Aman* paddy varieties. The *Rabi* season goes from November to February and is the cool season for *Boro* paddy (irrigated) varieties and also wheat, vegetables, oilseeds, etc.

Monitoring results in the domain of agricultural production covered land use, cropping pattern, yields from the DAE, input-output analysis of agricultural cropping and the outcome from the various irrigation surveys. Agricultural extension activities were monitored through the crop demonstration activities undertaken by CPP.

CPP carried out a land use survey, covering the entire compartment and the adjacent areas, and also monitored cropping patterns in 250 plots in the compartment and 40 plots outside it. The results of the cropping pattern sample served also to make an estimate of cropped areas in the compartment. In APPENDIX 3 both outcomes are given, the estimated areas based on the land use survey (Table A3. 19) as well as the estimated areas based on cropping pattern monitoring (Table A3. 20).

The extension activities for agriculture centered on the OFTD program and addressed on-farm trials and demonstrations. APPENDIX 3 presents the details.

Fishery Production and Extension

The annex dealing with the activities on fishery reported extensively on the catches in the compartment. Nevertheless, two tables concerning total fish production in the compartment were retained for publication in this annex. Details can be found in APPENDIX 3.

The extension program for catfish introduction in the compartment was monitored closely. Details can be found in APPENDIX 3.

Results Environmental Monitoring

The results of the environmental monitoring activities concern only data on ground water monitoring, water quality analysis and the disease incidences at Tangail Hospital and 13 clinics in the region. APPENDIX 3 gives the relevant tables.

Also published in the appendix are data on the tree planting activities around the homesteads in the compartment.

Results Social Economy Data Collection

Social economic data collection concentrated on registering employment generation through LCS and EMG activities. Moreover, data collection also addressed activities aiming at the reinforcement of the social position of women, notably through training, awareness raising and workshops. Detail can be found in APPENDIX 3.

Analysis

Population Estimates for 2000

In 1991, a population census took place in Bangladesh. Based on the results of the 1991 population census, the sub-compartment population was estimated and the total population for the compartment derived. In 1991, there were 263,268 persons living in the compartment, distributed over 48,111 households. Details of the population distribution over the compartment in 1991 can be found in APPENDIX 4,

To estimate the population of the compartment for the year 2000, data on growth rate and migration into and from the compartment were collected. The growth rate of the population was estimated from figures provided by the Thana Health Center and the Thana Family Planning Office. On the basis of this analysis it seemed that an annual population growth rate of 1% would apply to the compartment. The analysis can be found in APPENDIX 4,

An analysis of migration trends per sub-compartment indicated for 9 sub-compartments that the total inflow of persons over the period 1991 to 1999 was 2,490 persons, while the recorded outflow was 1,461 persons.

SC	Popul. 1991	1% growth per year	Perm. in-migrat.	Perm. out-migrat.	Popul. 2000
1	6 060	567	18	60	6 585
2	16 867	1 580	155	5	18 597
3	14 136	1 324			15 460
4	17 331	1 623			18 954
5	12 723	1 191	54	11	13 957
6	12 921	1 210	344	114	14 361
7	10 148	950	117	193	11 022
8	11 509	1 078	27	22	12 592
9	5 440	509	761	259	6 451
10	12 146	1 137	96	180	13 199
11	24 501	2 295	71	194	26 673
12	14 825	1 388	598	77	16 734
13	6 031	565	138	120	6 614
14	20 935	1 961	66	166	22 796
15	15 570	1 458	45	60	17 013
16	42 744	4 004			46 748
LFP	19 381	1 815			21 196
Total	**263 268**	**24 655**	**2 490**	**1 461**	**288 952**
As % of 1991		9%	0.9%	0.6%	110%

Table 13: Population estimates for the year 2000

Table 13 gives the results of the analysis. The total compartment population will be 288,952 persons in 2000, an increase of 10% over the 1991 population.

Water Management Performance

The analysis of water management was confined to an evaluation of structure operation, crop losses to flooding, cropping pattern changes and related institutional aspects. Structure operations concerned the analysis of water levels and the achievement of target water levels per type of structure. The evaluation of crop losses is based on the record given by Tangail Sadar Thana and makes a comparison with the harvested areas in the compartment. Cropping pattern changes could result from water management and would be reflected in the percentage of HYV of paddy as compared to long-stem paddy varieties. The results of this analysis are summarized in Table 14.

Institutional aspects of water management addressed, first, the election process of ChWMCs and SCWMCs. Secondly, an evaluation was made of gate operations during the 1998 monsoon and who gave the instruction for opening or closing the gates. Results are summarized in Table 16.

Achievement of Target Water Levels

The evaluation of the water management operations in order to achieve target water levels was based on a further analysis of the results of Table 10 and Table A3. 9. From the analysis of both tables, it seems that for all structures target water levels were achieved in at most two out of the four months when gauge readings took place.

When looking at the individual structures, it seems that management of the main inlet functioned reasonably well in 1995 and 1997: the success rate set for water management was achieved in at least three out of four months during the monsoon. However, in 1996 and 1998, management was less successful in achieving target water levels. Monitoring in 1999 covered two months and the success rate was achieved in one of the two months during that year.

Management of water control structures (WCS) and inlets was not achieving the same success rate as management of the outlets.

It is acceptable to conclude that management of some of the peripheral structures like the inlets was reasonable to good. In three out of six years, the target water levels were achieved in at least three out of four months in the monsoon. Management performance at inlets was less good. Internal water management, through WCSs was also less perfect as shown the table. Here the conclusion would be that management of water outlets is good, while managing water inlets is not achieving a similar high rate of success. The latter could also stem from construction defaults: for instance sill levels may be above normal water levels outside the copmpartment during the monsoon, which makes it impossible to let water in and to achieve target water levels.

Flood Damage

The analysis of flood damage to agricultural crops was based on data from Tangail Sadar only. As the compartment only covers 40% of the *Thana* a factor of 0.4 was applied to estimate the damage to areas in the compartment. The estimation was based on Table A3. 18.

Moreover, the cropped area should also be adjusted, as to represent only that part of the compartment covered by Tangail Sadar *Thana*. A factor of 0.825 was applied to the cropped areas of Table A3. 20, as the *Thana* covers 82.5% of the area of the compartment.

Designation	1995	1996	1997	1998	1999
Number of months when water management was acceptable (max. no. can be 4):					
All structures together	2	1	1	1	0
WCS	2	2	2	0	2
Outlet	2	3	3	1	3
Inlet	2	1	1	1	1
% of area lost due to flooding:					
Paddy	11%	2%	2%	27%	NA
Jute	7%	3%	0%	10%	NA
Sugarcane	0%	0%	0%	23%	NA
Analysis of cultivated areas (Kharif 2):					
HYV area as % of longstem area	16%	20%	55%	45%	60%
HYV area as % of paddy area	14%	17%	36%	31%	37%
Longstem as % of paddy area	86%	83%	64%	69%	63%

Table 14: Analysis of water management operations

Notes:

The maximum number of months monitored is 4

In 1999 only the first two months of the monsoon season were monitored

The analysis of areas lost due to flooding is based on data from Tangail Sadar only

The analysis of the areas concerns "sown/transplanted" area and is based on the results of the cropping pattern monitoring program

8

Table 14 indicates that cropped area damage of more than 20% took place in two out of four years for paddy and vegetables, one out of four years for jute, sugarcane and other crops (mainly summer *till*). The figure for vegetables should be treated carefully, as most vegetable production takes place during the Rabi season, and little is cultivated in *Kharif* 2. The used cultivated area represented the total vegetable area, including what was cultivated in the *Rabi* season. So the damage percentage could be biased and would probably be somewhat higher, because of a smaller area in *Kharif* 2.

Based on the damage to cultivated areas, it seems correct to conclude that water management was not perfect over the five years.

Use of Modern HYV Paddy

The cultivation of HYV paddy could give an indication of the faith farmers have in water management operations in the compartment. The analysis used data from Table A3. 20 to compare the cultivated areas for HYV and long-stem (LS) paddy. From it appears that HYV area remained below the area with long-stem paddy in the *Kharif* 2 season.

The 1998 figure should be treated with care, as large areas where usually LS paddy was planted were probably not used in that year due to high water levels in the compartment. It seems reasonable to assume that areas where normally long-stem paddy was cultivated lie lower and were thus more affected, than land for HYV. So the figure of 60% representing the 1998 cultivated area of HYV over long-stem paddy was not reflecting water management achievements, but it merely indicated common sense by the farmers. However, in the year 1999 HYV paddy increased even further.

The analysis of the cultivated areas and the total cultivated paddy area during *Kharif* 2 over the period 1995 - 1998 also shows a steady increase of HYV and a decrease of long-stem paddy (the statistically significant change is 6% per year) in the total paddy area during *Kharif* 2. It cannot be concluded that farmers have shifted massively to HYV away from long-stem paddy (because long-stem still exceeded HYV paddy at the end of the project); it seems as if they have been cautious in judging water management performance and then made the change.

Perception of Risks

The analysis of land use changes also gave insight in the perception of risks by farmers. The following table was the result of a four years monitoring process of land use changes in the compartment.

The table shows that the perception of risk changed dramatically between 1996 - 1997 and 1998 - 1999. The area changes with an upgrade of paddy varieties (e.g. from long-stem to transplanted paddy or from water body to long-stem paddy) reduced considerably from 44% of the total *Kharif* 2 area under cultivation to 11%. At the same time, the area where the crop variety was downgraded (from transplanted to deep water paddy) increased between 1996 - 1997 and 1998 - 1999, from 8% of the *Kharif* 2 area to 57%. Finally, it was clear that between 1997 and 1998 a very large part of the changes (the equivalent of 91% of the cultivated *Kharif* 2 area) was the result of keeping the land fallow (probably because it was flooded) or of crop losses.

The conclusion seems to be that over the years farmers gained faith in water management, but that lately they have lost it again, which probably indicates that water management did not give them what they expected. Although the 1998 situation was exceptional and structures and embankments were not designed to cope with a situation where backwater aggravated flooding, the table shows that in 1999 even more land was planted with deep-water paddy varieties.

Transfer	from 1994 to 1995	from 1995 to 1996	from 1996 to 1997	from 1997 to 1998	from 1998 to 1999	Possible reason
(L) var. to (MV) var.	4%	12%	22%	7%	20%	Intensification
T. *Aman* to D.W.*Aman*			8%	18%	57%	Perception of higher risk
D.W. *Aman* to T. *Aman*	4%	44%	57%	3%	11%	Perception of lower risk
Water b. to D.W. *Aman*			18%	1%		Perception of lower risk
In/out of fallow	5%	22%	13%	99%	21%	Normal rotation/lost
D.W. Aman to Water b.				40%		Flooding
(unclear)			3%	8%	21%	Unclear why changed

Table 15: Land use changes in the compartment as % of cultivated area in *Kharif 2*

Institutional Base

The analysis of the institutional base for water management was based on an analysis of Table A3. 10, Table A3. 11 and Table 12. When observing the election of ChWMCs, it appeared that stakeholder participation was 41%, which is reasonable. However, the average size of the committee, 11 members to manage a limited number of structures is large. The fact that 71% of the committee members lived in the is another good thing.

The same conclusion applies to SCWMCs: participation in the election of committee, members was also 41%, while the size of the executive committee remained large.

In 1998, monitoring of gate operations took place and showed that in 26% of the cases reviewed the instructions for gate operation did not come from the responsible office bearer in the water management committee. Moreover, it was shown that in 21% of the cases, the gate was not operated. Some gates did not need to be operated, others were broken down. However, in over 50% of the cases the right person issued the orders.

The general conclusion would be that the institutional base for water management is acceptable, but that the management itself, e.g. giving the instruction, doing the work, etc. could improve. A larger share of the instructions should come from the right person. Table 16 gives the details.

Designation	Result
ChWMC election process:	
Participation of stakeholders in election process	37%
Committee size (office bearers)	11
Office bearers living in the Chawk	71%
SCWMC election process:	
Participation of those who have the right to vote	32%
Executive Committee size (members)	8
Gate operations in 1998:	
Instructions came from the right persons	53%
Gate operator took actions	3%
Others gave the instructions	23%
Gate not operated	21%

Table 16: Appraisal of the institutional side of water management

Agricultural Employment

From an analysis of the cropping pattern in the compartment and the labor days recorded in the inputs-output survey of agricultural cropping, it was possible to make an estimate of changes in labor use in crop production. Table A3. 20 provided details of the cropping pattern during the project period, while the results of hired and family labor employed in cropping are published in the first column of Table A4. 5.

Evaluation

The question that needs to be answered: "Did the collected indicators reflect the performance and the achievements of the project objectives rightly and do the indicators prove the sustainability, replicability and viability of water management options". A multi-criteria analysis was done in order to be able to give an answer to this question.

The basis for the multi-criteria analysis is provided by data presented in the chapters giving the results of collection efforts and the one on the analysis of collected indicators.

Data on the gross area of the compartment and the net cultivable area came from the first GIS Atlas.

The costs per unit area were calculated as to the net cultivable area. Details were presented in APPENDIX 3.

The analysis of water management in formed the basis for the data published in the multi-criteria analysis.

The criteria presented for agriculture refer to annual growth rate from 1991 onwards. They are based on a linear regression of monitored data. Hence, during the project implementation period, cropping intensity improved on the average by 4% per year.

The evaluation of the environment was confined in this analysis to the changes in ground water levels in the compartment and outside it. It seemed from the monitoring data the levels hardly changed in the compartment, while outside the compartment a lowering of the water table of 28 cm per year was recorded.

Employment generation data were not covering all possible source of employment generated by the project. For instance, labor days used for construction activities were excluded, as was explained before. In total over the project period, LCS and EMG required over 200,000 labor days. Also agricultural cropping used more days at the end of the project then at its start; between 1992 and 1999, about 973,000 labor days were needed more in agriculture, this is approximately 140,000 per year.

Criteria	Details	Evaluation
POPULATION	1991	263 268
	2000	288 952
AREAS		
Gross area	ha	13 200
Net cultivable area (NCA)	ha	9 764
CONTRIBUTIONS		
Government of Bangladesh	MTk	193.72
Financial Assistance (KfW and GON)	MTk	442.49
Technical Assistance (GON)	MTk	410.29
World Food Program (Food for Work)	MTk	3.75
Total	MTk	1 050.25
COSTS PER HA NCA		
Land acquisition	Tk/ha	6 292
Construction	Tk/ha	34 100
Mitigation measures	Tk/ha	5 802
Supplementary costs	Tk/ha	4 369
Total	Tk/ha	50 563
WATER MANAGEMENT		
Degree of achieving target water levels (peripheral structures)	1995-1999	Reasonable
Degree of achieving target water levels (internal structures)	1995-1999	Reasonable
Degree of achieving a reduction in flood damage to cropping	1995-1998	Reasonable
Increase in use of HYV over long-stem paddy (Kharif 2)	1992-1999	Significant
Farmers perception of risk of crop loss due to flooding	1994-1999	Decreased risk
Institutional base for water management		Reasonable
AGRICULTURE		
Annual growth in cropping intensity	1992 -1999	4%
Cultivated area annual growth rate	1992-1999	2%
Paddy production annual growth rate	1992-1999	11%
FISHERY		
Annual increase in open water fish production in CPP (tonnes/year)	1993-1995	-81
Annual increase in open water fish production in CPP (tonnes/year)	1995-1998	215
ENVIRONMENT		
Annual changes in groundwater levels during project period (April-May) in SC 16 (m)	1992 -1999	-0.19
Annual changes in groundwater levels during project period (April-May) West of CPP (m)	1992 -1999	-0.20
EMPLOYMENT GENERATION		
Through LCS (total days)	1993-1997	140 592
Through EMG (total days)	1995-1998	72 852
Growth of agricultural labor days (total days)	1992-1999	973 161

Table 17: Results multi-criteria analysis

The conclusions as to the viability, sustainability and replicability of the project are discussed next.

Viability

The viability criterion of CPP is expressed by the economic indicators, which will be published in the economic and financial analysis annex.

Sustainability

The supplementary costs of the constructions, including operation and maintenance costs of structures and embankments were of the order of Tk 6,094,547 or US$ 122,000 over the entire project period. Of these supplementary cost, about 26% was used so far for the repair and maintenance of the infrastructure during construction. This would mean that on the average Tk 1,607,878 per year could be needed for the entire compartment or Tk 165 per ha per year, including embankment maintenance by EMGs. However, when looking at the maintenance plan for CPP, it appeared that the estimated maintenance costs were of the order of Tk 9,865,400 (US$ 197,300) per year for the entire compartment. This would mean Tk 1,000 on the average per ha, or US$ 20. This amount is equal to 2% of the construction costs. Here the conclusion would be that the BWDB could probably not sustain this amount on the future.

Management of the peripheral and internal structures is reasonable, which is a positive aspect to prove the sustainability. The institutional base was considered reasonable, also giving some weight to a sustainable development.

Cropping intensity, cultivated area and paddy production was on the increase during the project period. There was a small but significant change towards HYV paddy during the *Kharif* 2 season, of the order of 283 ha per year since 1992. This increase was probably affected by the expansion of *Boro* (MV) cultivation. The steady growing importance of *Boro* in the compartment could be have affected paddy cultivation during the *Kharif* 2 season, as farmers with irrigation prefer to cultivate *Boro* instead of the riskier HYV *Aman*. As such it could reflect a lack of confidence in water management.

Lessons Learned and Proposed Changes

Preamble

The general conclusion is that M & E was done during the Final Phase of CPP, despite a number of problems encountered.

The use of the logical framework as the tool for the identification of indicators was a blessing. Given that these frameworks put into perspective project objectives, goals, activities and the boundary conditions for their success, make them highly suitable to define performance indicators. It should be one of the major lessons learned from this project.

Lessons Learned

One important lesson learned from the First Phase of the project, and fortunately not repeated in the Final Phase, concerns the scope of monitoring. Technical sections most often monitored their activities well, although in isolation. Little or no integration took place, not to say that there was no "cross pollination" at all between monitoring done by the technical sections. Often, one was simply not aware of what happened in other sections, because they did not work together. The fact that only late during the First Phase an attempt was made to structure the selection of indicators was an important reason behind this situation.

Integrated M & E proved possible, as was shown during the Final Phase of CPP. However, all integrated future M & E activities should combine a number of critical issues.

First, there is the need for a wise selection of indicators. In this respect CPP proposed and used the logical framework.

Secondly, data collection should be a combined effort of all those involved in a project. It is impossible to create monitoring and evaluation units that function on their own, simply because resources will never be made available. Therefore, M & E efforts should be carried out in part by those implementing project activities.

Thirdly, in addition to regular quantitative data collection, there should be scope for qualitative surveys. The baseline survey at the beginning of the First Phase of CPP was a good initiative, and repeated towards the end of the project.

Fourthly, data analysis should not suffer from the lack of secondary data, and it should be realized that collection and search of secondary data is a major task. Secondary data form an important source of information to help M & E. The vast amount of research findings, reports and publications in Bangladesh should be researched well at the beginning of the M & E activities, in order to use scarce resources wisely.

Fifthly, it should be realized that data processing should start at a very early stage, meaning a balance between collection and analysis.

Proposed Concepts and Approaches

It is firmly believed that any project impacting on the regional social economy should investigate the pre-project situation well. A baseline survey of households is not enough to capture the pre-project situation, it should be complemented by a baseline survey of regional economic activities. Given that most water management project focus on agricultural production, it is rural households that normally receive attention, while economic activities hardly receive any. Consequently, the first recommendation is to survey the pre-project situation through a well-designed baseline survey covering households and economic activities.

No change seems needed in the mechanism for the selection of indicators. The approach followed in CPP, based on the logical framework works well. This leads to the second recommendation, notably that the logical framework approach should become the tool for the selection of performance indicators.

Given that CPP's core activity relates to water management, M & E activities should center on it as well. Moreover, M & E have to look at the social economic conditions and at the physical environment. Together with the logical framework analysis, the above conclusions leads to the recommendation that M & E in water management projects comprises the following four major components:

- Water management: monitoring investments, operations, maintenance and institutions,
- Physical environment: collection data on climate, water/flood levels, ground water, public health, etc.,
- Social environment: monitoring population, migration, households characteristics such as their income and expenditure, employment, gender issues, and any other issues related to water management,
- Economic environment: investigating such aspects as input-output characteristics of farming, fishery, livestock, formal and informal industrial sectors, transport, etc.

The implementation of such a system cannot be the task of an M & E Section alone, unless it has a large number of field staff to carry out surveys and data collection. Therefore, it is believe that the compromise reached in CPP whereby technical sections contribute in data collection, is a good and cost effective solution. Hence, the conclusion that to large extent technical sections should assist in data collection, while what is not collected becomes the task of M & E staff.

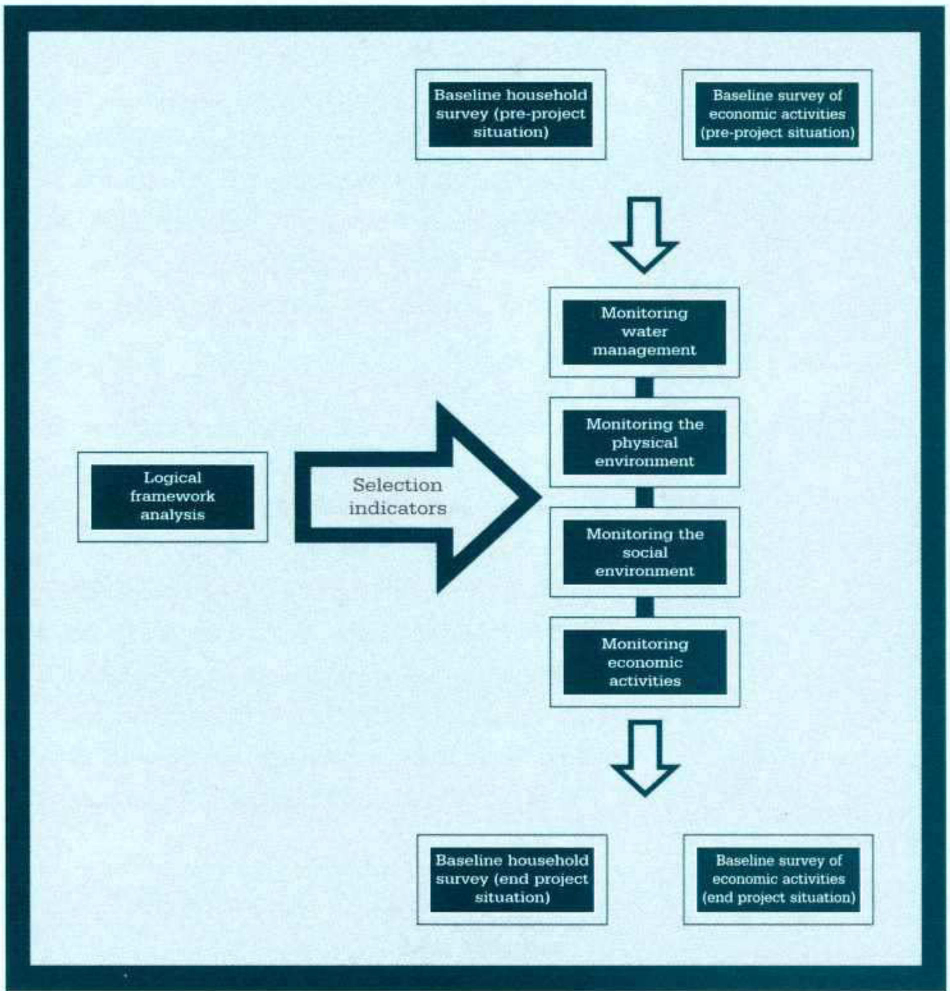

Figure 2: Flow chart for M & E activities in a water management project

No specific change should be envisaged as to data entry and processing. The programs used in CPP are suitable

At the end of a project like CPP, there is the need to repeat a survey covering households and economic activities. For M & E purposes it seems important to show

Monitoring and Evaluation After The Year 2000

During the Final Phase, many data were collected and stored in a large database. This database covers now a wide range of indicators about the compartment. Much effort went into the regular update of indicators and into making data series complete. As such, the database could serve as a starting point for monitoring process in the compartment. The collected time series would provide, when they are continued, a good opportunity to judge the impact of CPP on the future of the compartment. They would give a very good insight into the sustainability of developing and managing the waters of protective areas in flood plains.

M & E should at least continue for a period of five years after the completion of the Final Phase of CPP under the responsibility of the BWDB. In this respect, a proposal has been prepared outlining the responsibilities, duties and the performance indicators that would be needed to monitor the sustainability of the concept.

At the time of Donor Review Mission, August 16-24, 1999, a Memorandum of Understanding (MoU) was signed where the Mission and the BWDB on behalf of GoB agreed upon an independent Monitoring and Evaluation Unit (MEU) that will be created in Tangail. The MEU will report directly to the Evaluation Directorate of BWDB.

The MEU will maintain working relationships with relevant institutions like BARI and SWMC. The MoU suggested formalizing working relationships with these organizations. The experiences obtained by the MEU will be reported to WARPO, BWDB and the MoWR and its relevance will be reviewed regularly for national water management planning.

The proposed set up of the MEU has given below:

Director, Planning General
BWDB

↓

Monitoring & Evaluation Specialist

↓

Data entry operator	2
Date collector/enumerator	4
Driver	1
MLSS	2

what changes have taken place during the project period. This ex-post survey will allow for a comparison with the surveys covering the pre-project period. Both surveys indicate what has changed, the M & E activities during the project implementation period merely show the process: what happened when and how did it happen.

Appendix 1

Intervention logic	Objectively verifiable indicators	Sources of verification	Assumptions,conditions and risks
Overall Objective: To enhance economic production, improve environmental security and reduce poverty in the floodplains of Bangladesh.	**Indicators:** National indicators, like per capita GDP, culti-vated area, literacy rate, flood damage, etc.	**Sources:** National statistics (BBS), publications Planning Commission.	Agreement between the GOB and the donors to fulfill their plight
Specific Purpose: Provide viable, sustainable and replicable approaches to compart-mentalization, Give integrated water management options for different sections of the population, Develop policies and guidelines for integrated water resources man-agement.	**Indicators:** Economic viability assessment, Model results, water management scenarios, Institutional parameters and operational guide-lines.	**Sources:** Reports of evaluation missions, as wells as modeling output, economic analysis, environmental assessment.	Letter of intention between the GOB and the GON and KfW to implement CPP
CPP Output: Test the practicability of compartmentalization, Establish water management systems, Prevent environmental degradation, Enhance the environment, Develop guidelines, Improve drainage of Tangail Town, Enhance economic production, and Reduce poverty.	**Indicators:** Modeling results (output), water management scenarios Constructions and operational guidelines, Water quality and bio-diversity monitoring, Publications, Drainage infrastructure, flood damage, IRR, NPV, B/C, Employment generation, income distribution.	**Sources:** M & E publications and analysis cov-ering: Project costs, water management, agricultural production, fishery, environment; flood damage, social econ-omy, etc. Multi-criteria analysis.	Acceptance by the GOB and the donors of the TAPP. Acceptance of CPP by the local popula-tion.
This appendix presents the logical framework for CPP			

Project Activities:	Direct effects	Costs	Assumptions, conditions and risks
Fishery and aquaculture: Monitoring catches assessment and frame survey in various habitats, like floodplain, Beels, open water and Khals. Aquaculture: training, extension and monitoring.	"Chari in the Bari" program, as a means of pov-erty alleviation.	TA Fisheries Section: $ 118,500	**Assumption:** need for income generation. **Risk:** fishery activities (catches) might be affected negatively by CPP constructions. **Condition:** Fishery Section in CPP, as Department of Fishery is not doing this monitoring.
Environmental monitoring: Soil fertility monitoring program. Bio-diversity monitoring and social forestry pro-gram. Agro-chemicals monitoring program. Ground water levels monitoring. Monitoring of water quality. Environmental awareness raising.	Plantation of tress in villages.	TA Environmental Section: $ 106,700	**Assumption:** CPP's water management would impact on crop intensity and use of agro-chemicals, **Risk:** water management leads to a reduc-tion in sedimentation and soil fertility, leads to a reduction in bio-diversity. **Condition:** CPP has possibilities to improve environmental awareness.
Social economy: Empowerment of women through participation in water management, gender training and aware-ness raising. Employment generation through LCS and EMG.	Employment generation through LCS and EMG work contracting, estimated over the period 1992 - 2000 at $ 255,000	TA WID Section: $ 156,200	**Assumption:** need for income generation, determination among women to get a greater say in water management. **Risk:** effects of employment generation are negative (pro-gram not cost effective). **Condition:** financial support, involvement, active participation and technical supervision by CPP are needed.
Support activities: M & E Information Dissemination Center	M & E System. IDS Center operational.	TA M & E Section: $ 292,500 IDS Program: 47,900	

This appendix presents the logical framework for CPP

y2

Project Activities:	Direct effects	Costs	Assumptions, conditions and risks
Construction activities: Termination of construction works and maintenance of infrastructures. Drainage of Tangail Town	Regulation of drainage and irrigation through the operation of regulators and sluices.	GOB land acquisition: $ 1,976,000 TA Quality Control: $ 72,600 FA construction: $ 7,915,000	**Assumptions:** structure designs are acceptable. **Risks:** bad quality of construction works, problems with land acquisition.
Water management: Operational model for controlled flooding and improved drainage based on mathematical simulations by the SWMC. Creation of an institutional base through people's participation in water management, and testing in 4 pilot Chawks.	A set of operational rules and guidelines that are a tested and accepted for use as water management tool in the compartment.	TA Institutional Development: $ 294,300 TA Water Management: $ 223,600	**Assumption:** water management has a positive impact on crop damage reduction; with large people's involvement there is a better understanding of why gates are opened or closed. **Risk:** no institutional structure to execute water management. **Condition:** operational rules and guidelines can be tested through the SWMC mathematical model.
Boundary conditions: GIS system to present the physical and boundary conditions in the compartment.	GIS atlas. WEB side. Program costs: $ 11,400		
Agricultural production: **Survey program:** land use survey and irrigation survey (DTW, STW, and surface water irrigation, done every 2 years). Monitoring program Farming Systems, and a sample of plots for input (250) use and yields (30). **OFTD:** Crop demonstration plots (paddy and vegetables).		TA Agricultural Section: $ 176,900	**Assumption:** better water management is sought by farmers, need for crop diversification and intensification exists **Risk:** compartmentalization may not have a positive impact on farm income **Condition:** survey program gives representative results, demonstration program is representative

This appendix presents the logical framework for CPP

Appendix 2

CPP COMPARTMENTALIZATION PILOT PROJECT
MONITORING & EVALUATION INDICATORS

Section	Questionnaire No.	Name of Indicator
Project Management	1.3A	Donor contribution
Quality Control Section	2.1	Costs for infrastructure
	2.2	Details information about land acquisition
	2.3	LCS contracts
	2.4	Support costs
Institutional Development Section	3.1	Election process for ChWMC and SCWMC
	3.2	Effectiveness of the elected WMCs in managing structures
	3.3	Follow-up of functioning of WMCs
	3.4	IDS training, meetings and workshops
Agricultural Section	4.1A	Land use survey per SC and adjacent area
	4.1B	Land use change
	4.2	Cropping pattern in monitoring plots
	4.3	OFTD training program
WID Section	5.1A	ChWMC Nomination meeting monitoring
	5.1B	ChWMC Election meeting
	5.1C	SCWMC Election meeting
	5.2A	Contract issued to EMG: duration, Taka paid etc.
	5.2B	Contract issued to LCS and details
	5.3	WID training, meetings and workshops
Fishery Section	6.1A	Open water catches, details per habitat
	6.1B	Open water catches, details per habitat, details per gear-type
	6.4	Monitoring of inputs and outputs parameters of pond fisheries
	6.5	Aqua-culture program (extension activities)
	6.6	Survey of fish ponds

This appendix gives a listing of all the indicators collected by CPP.

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CPP COMPARTMENTALIZATION PILOT PROJECT
MONITORING & EVALUATION INDICATORS

Section	Questionnaire No.	Name of Indicator
Environment Section	7.1	River borne sedimentation and soil fertility monitoring
	7.2	Bio-diversity monitoring
	7.3	Agro-chemicals monitoring program
	7.4	Ground water availability monitoring program
	7.5	Water pollution monitoring program
	7.6	Disease incidences and record of infant mortality
	7.7	Social forestry program at the homestead
Economics Section	8.1	Market prices statistics
	8.2	Cultivated areas and crop production (DAE)
	8.3	Crop damage, damage to public and private property
	8.4	Input-output survey of agricultural crops
	8.5	Population and migration flows
	8.6	Irrigation survey
Water Management Section	9.1	List of key structures in water management operation
	9.2	Target levels (key structures)
	9.3	Details of structure operations
	9.4	Rain fall data
	9.5	Gauge readings (key structures)

This appendix gives a listing of all the indicators collected by CPP.

Appendix 3

A3.1 Project costs indicators

Table A3. 1 to Table A3. 3 provide details of the contributions made to CPP by the GoB and donors. Data covering the GoB contribution, financial and technical assistance to the project covered the entire project period, including the First Phase.

Item	Total	Aug'91/Dec'92	Jan/Dec '93	Jan/Dec '94	1994/1995	1995/1996	1996/1997	1997/1998	1998/1999	1999/2000
Land acquisition	132.47		3.81	8.99	13.94	58.00	47.37		0.12	0.25
GoB Establishment	71.35	5.79	5.81	8.87	11.30	10.14	8.48	8.83	8.25	3.87
Taxes	1.35			1.35						
O&M during construction	9.56								8.25	1.31
Unspent land acquisition	-21.02								-21.02	
Total	193.72	5.79	9.62	19.22	25.24	68.14	55.85	8.83	-4.40	5.43

Table A3.1: GoB contributions towards CPP (million Tk)

Item	Total	Aug'91/Dec'92	Jan/Dec '93	Jan/Dec '94	1994/1995	1995/1996	1996/1997	1997/1998	1998/1999	1999/2000
Surveys and studies	27.11	0.45	4.38	7.52	4.06	3.72	4.04	1.50	1.10	0.35
Equipment	4.22			3.46		0.38	0.39			
Construction	421.00	1.12	11.12	68.67	106.64	58.18	62.83	40.83	36.05	35.56
Augmentation PT	6.52				2.31	1.97	1.02		0.68	0.54
Unforeseen costs	16.42		2.45	8.34	0.01		2.62	0.50	1.74	0.76
Total	475.27	1.57	17.95	87.99	113.02	64.25	70.90	42.82	39.57	37.20

Table A3.2: Financial assistance to CPP activities (million Tk)

The following table only gives the technical assistance provided by the Netherlands for the project.

Item	Total	Aug'91/Dec'92	Jan/Dec '93	Jan/Dec '94	1994/1995	1995/1996	1996/1997	1997/1998	1998/1999	1999/2000
Contract staff costs	332.77	57.25	47.48	23.40	37.69	42.73	35.41	23.02	34.57	31.22
Reporting	0.32				0.07	0.25				
Investment/purchase	17.24	6.68	1.34	1.36	0.97	0.58	0.85	0.48	4.02	0.97
Operational costs	37.35	2.41	5.13	2.79	3.90	5.47	3.57	4.14	6.20	3.74
Training and courses	54.78	0.15	1.94	3.55	7.68	6.75	3.54	4.71	13.17	13.28
Transferred funds	0.28				0.34	-0.07				
Contingencies	11.16	2.00					0.73	1.23	3.43	3.77
Total	453.90	68.50	55.89	31.10	50.66	55.72	44.10	33.58	61.39	52.97

Table A3.3: Technical assistance to CPP (million Tk)

The following three tables give details of land acquisition, construction, expenses made towards supplementary costs. It is noted that the costs for the years up to 2000 represent the reimbursed amounts, while costs in 2000 are estimates based on expected reimbursements. The costs per ha are calculated on the basis of the compartment's gross area of 13,200 ha.

SC	Nmb. contr.	Needed (ha)	Total (KTk)	1992	1993	1994	1995	1996	1997	1998
1	8	7	6 045			528	5 518			
2	9	13	7 525	1 668	1 931	87	3 839	-		
3	11	18	4 592		2 901	226	1 465			
4	12	12	1 910		1 044	388	477			
5	3	2	918		187		732			
6	10	21	13 363	339	3 598	625	8 139	662		-
7	8	3	500	118	132	250	-			
8	7	17	10 111	523		9 346	242			
9	8	8	3 633		778	237	176	2 442		
10	9	7	2 635	106	795	615				1 118
11	13	11	7 067		1 705	3 033	2 329	-		
12	11	11	1 910		826	50	1 035	-	-	
13	12	5	678	17	247	313	101			
14	8	9	220				220	-		
15	4	1	329		122		207			
Total	**133**	**144**	**61 436**	**2 771**	**14 266**	**15 698**	**24 479**	**3 104**	-	**1 118**

Table A3.4: Number of contracts and cost of land acquisition per sub-compartment('000 Tk)

Notes:
Presented costs represent the actual purchase price in '000 Tk.
The years refer to the period when the land was obtained by CPP

SC	Nmb. works	Total (KTk)	1993	1994	1995	1996	1997	1998	1999	2000	Tk./ha
1	6	7 765			6 051	1 030			683		588
2	10	11 136			7 845	819	11		1 297	1 164	844
3	16	23 138		4 866	13 371	3 446	647		288	520	1 753
4	9	18 384		2 495	9 438	3 172	442	928	702	1 207	1 393
5	3	11 451		6 870	3 524	909	148				868
6	11	15 390	128		6 072	5 164	1 378	1 518	85	1 044	1 166
7	13	20 408			16 145	2 491	351	231	1 090	100	1 546
8	13	17 535	779	5 563	6 391	2 606	28	778	462	928	1 328
9	14	37 403	3 712	453	22 313	9 794	378	337	237	178	2 834
10	16	18 365			14 674	1 658	466	374	614	579	1 391
11	30	37 521	2 907	1 150	19 694	8 937	2 892	587	1 304	50	2 842
12	16	10 355	43		2 391	2 237	3 174	707	1 523	280	785
13	14	17 225	923		2 996	4 748	3 410	2 956	1 650	542	1 305
14	2	5 985				806	4 790	239	150		453
15	5	14 632				8 857	2 714	30	396	2 635	1 108
16	4	3 885	2 464		201		1	855	25	339	294
LFP	1	9 440				9 349	91				715
E2	3	993							62	931	75
1-4	3	9 543			1 278	6 053	2 210	3			723
CPP	8	42 395					2 786	2 585	20 703	16 322	3 212
Total	**197**	**332 950**	**10 957**	**21 398**	**132 384**	**72 076**	**25 919**	**12 128**	**31 270**	**26 818**	**34 100**

Table A3.5: Number of works and construction costs per sub-compartment ('000 Tk)

Notes:
The table gives the reimbursed amount for finished constructions.
The years refer to the reimbursement date

SC	Nmb. works	Total (KTk)	1995	1996	1997	1998	1999	2000	Tk/ha
4	1	485				209	276		37
7	1	4 244	1 753	2 491					322
16	1	37 779			30 115	4 379	3 285		2 862
E2	6	3 455			1 501	1 423	290	242	262
E3	4	3 522			1 311	585	171	1 455	267
E4	8	7 163			4 803	751	55	1 554	543
Total	**21**	**56 648**	**1 753**	**2 491**	**37 729**	**7 347**	**4 077**	**3 251**	**5 802**

Table A3.6: Number of contracts and mitigation costs per sub-compartment ('000 Tk)

Notes:
Mitigation costs are for works labelled as mitigation measure by CPP
Tangail Drain, certain bridges, re-excavation of Khals, road resectioning, etc.

Item	Total (KTk)	1993	1994	1995	1996	1997	1998	1999	2000
Purchase equip./vehicles	1 982	403	589	65	773	152			
Repair equip./vehicles	35				9	26			
Quality control	244				208		4	33	
LCS training advance	621					311	311		
Miscellaneous costs	531			10	285	221	16		
Wages of WC staff	5 424	38		565	2 494	1 796	475	58	
Surveys and investigations	14 773	2 756	4 186	4 041	1 567	1 346	641	37	200
Environmental management	1 109			254	559	254	42		
Augmentation of project team	6 655			2 314	1 365	566	923	1 087	400
Steel gate for Panch Kahania	31				31				
EMG costs	4 019				521	890	1 100	1 008	500
Petty repair works (O&M)	7 236			66	862	2 326	2 374	408	1 200
Total	**42 662**	**3 196**	**4 775**	**7 315**	**8 674**	**7 887**	**5 884**	**2 630**	**2 300**

Table A3.7: Supplementary costs ('000 Tk)

Note:

Supplementary costs are paid by CPP from the FA and served to finance non-constructions or O&M items

Item	1993	1994	1995	1996	1997	1998	1999	2000	Total (KTk)
CONSTRUCTION									
Main regulator			19 832	3 802			237	178	24 049
Embankment	576		8 930	16 779	5 527	1 221	1 795	4 719	39 547
Protective works	3 199	6 870	1 267	5 654	378	855	20 520	3 470	42 214
Elangani loop cut				3 360	748	61			4 169
Khals/canals	1 951	58	4 730	10 822	3 031	3 223	2 605	2 373	28 793
GPI							2 301		2 301
Inlet	2 534		15 670	2 731	1 343	231	340		22 850
Outlet	1 916	12 913	16 848	17 277	7 764	323	1 553	2 184	60 779
WCS		396	43 145	5 649	3 665	3 223	711		56 789
Minor works					2 786	2 585	952		6 322
Roads	779	12	5 492	197	21			431	6 932
Bridge			5 083	3 921		281			9 285
Tangail drain								339	339
Others		1 150	11 388	1 884	657	125	255	13 123	28 581
Sub-total	10 957	21 398	132 384	72 076	25 919	12 128	31 270	26 818	332 950
MITIGATION									
Khals/canals							29		29
Roads					4 247	1 220	171	3 251	8 889
Bridge			1 753	2 491	3 367	1 538	316		9 465
Tangail drain					30 115	4 588	3 561		38 264
Sub-total			1 753	2 491	37 729	7 347	4 077	3 251	56 648
SUPPL. COSTS	3 196	4 775	7 315	8 674	7 887	5 884	2 630	2 300	42 662
GRAND TOTAL	**14 153**	**26 173**	**141 452**	**83 242**	**71 535**	**25 358**	**37 977**	**32 369**	**432 260**

Table A3.8: Summary of construction costs by item ('000 Tk)

A3.2 Water Management Indicators

The technical side of water management is presented in the following table, which gives a full record of water management operations for every type of structure. The record evaluates the achievement of target water levels as compared to the recorded water levels. If the recorded level stayed below the target level it was considered an operational success, did it exceed the target level, then there was a failure. The percentage of successes was recorded and can be found in the table.

Only the selected key structures (27 in total) for which water levels recording was done, were considered in the presented results.

Type of structure	Month	1995	1996	1997	1998	1999
WCS	July	0%	75%	75%	40%	80%
WCS	August	50%	25%	75%	0%	60%
WCS	September	100%	75%	50%	0%	25%
WCS	October	100%	100%			75%
Outlet	July	33%	83%	83%	38%	100%
Outlet	August	67%	33%	83%	25%	100%
Outlet	September	100%	100%	67%	38%	56%
Outlet	October	100%	100%	100%	100%	100%
Inlet	July	0%	30%	50%	0%	45%
Inlet	August	50%	40%	50%	9%	55%
Inlet	September	75%	50%	60%	18%	27%
Inlet	October	75%	89%	100%	100%	91%

Table A3.9: Success rate of water management operations

The organization aspects of water management are reflected in the following two tables, which address the election process of the ChWMC and the SCWMC. The importance of the tables is their indication of the enthusiasm (participation of stakeholders), the fact whether water management committee members live in the *Chawk* of sub-compartment and the experience they have gained previously.

SC	House-holds	Meetings	Attend.	Elected number	Stakeh. partic.	Living Chawk	Expe-rience
1	141	4	151	44	54%	75%	27%
2	986	8	584	88	30%	70%	16%
3	488	8	380	92	39%	55%	12%
4	371	7	319	79	43%	68%	19%
5	72	2	60	24	42%	58%	13%
6	315	6	254	68	40%	62%	15%
7	609	8	446	90	37%	67%	11%
8	491	8	342	90	35%	67%	7%
9	228	6	198	69	43%	91%	17%
10	317	8	304	88	48%	94%	14%
11	828	14	529	159	32%	84%	22%
12	436	7	258	80	30%	79%	15%
13	96	4	90	44	47%	34%	20%
14	839	13	571	146	34%	56%	24%
15	291	7	187	79	32%	76%	22%
Total	**6 508**	**110**	**4 673**	**1 240**	**37%**	**71%**	**17%**

Table A3.10: Details of the elections of ChWMC (1998)

Notes:
Households refers to the number of stakeholder households.
Meetings refers to the number of election meetings held.
Attendance gives the number of persons present at the meetings.
Stakeholder participation refers to the attendance, living *Chawk* and experience both refer to the elected office bearers

SC	Elected in ChWMC	Attend.	Elected number	Participation	Living SC	Experience
1	44	16	7	36%	71%	29%
2	88	26	8	30%	88%	25%
3	92	30	8	33%	100%	38%
4	79	26	8	33%	63%	0%
5	24	11	6	46%	83%	17%
6	68	23	8	34%	75%	38%
7	90	28	7	31%	43%	29%
8	90	27	7	30%	86%	14%
9	69	23	8	33%	88%	38%
10	88	28	8	32%	75%	13%
11	159	47	11	30%	100%	0%
12	80	25	7	31%	100%	43%
13	44	15	7	34%	71%	14%
14	146	44	9	30%	56%	44%
15	79	23	8	29%	100%	38%
Total	**1 240**	**392**	**117**	**32%**	**80%**	**25%**

Table A3.11: Details of the elections of SCWMC (1998)

Notes:
Elected in ChWMC refers to the number of ChWMC committee membersable to take part in the election process for the SCWMC committee.
Attendance gives the number of persons present at the meetings.
Participation refers to the attendance, living SC and experience both refer to the elected SCWMC office bearers

A3.3 Boundary Indicators

The tables under this section concern data on population, gross and net cultivable area (NCA), rainfall records, the conversion rates used in this study, and registered market prices of the major agricultural commodities and fresh fish.

SC	Households	Population	Avg. per housh.	Avg. per km^2
1	941	6 060	6.44	2 453
2	2 988	16 867	5.64	3 101
3	2 269	14 136	6.23	1 267
4	3 365	17 331	5.15	2 156
5	2 228	12 723	5.71	3 448
6	2 334	12 921	5.54	1 931
7	1 852	10 148	5.48	1 275
8	2 089	11 509	5.51	1 479
9	1 002	5 440	5.43	1 353
10	2 306	12 146	5.27	1 387
11	4 460	24 501	5.49	2 099
12	2 746	14 825	5.40	1 430
13	989	6 031	6.10	1 320
14	4 009	20 935	5.22	1 765
15	2 920	15 570	5.33	2 030
16	8 105	42 744	5.27	6 905
LFP	3 508	19 381	5.52	1 419
Total	**48 111**	**263 268**	**5.47**	**1 994**

Table A3.12: Population per sub-compartment (1991)

SC	Part of	Net cult. area	Gross area	Cultiv.
1	CPP	191	247	77%
2	CPP	439	544	81%
3	CPP	931	1 116	83%
4	CPP	578	804	72%
5	CPP	262	369	71%
6	CPP	523	669	78%
7	CPP	670	796	84%
8	CPP	641	778	82%
9	CPP	288	402	72%
10	CPP	682	876	78%
11	CPP	830	1 167	71%
12	CPP	815	1 037	79%
13	CPP	332	457	73%
14	CPP	863	1 186	73%
15	CPP	550	767	72%
16	CPP	156	619	25%
LFP	CPP	1 013	1 366	74%
E2	Adjacent	121	525	23%
E3	Adjacent	497	678	73%
E4	Adjacent	712	889	80%
E6	Adjacent	1 280	1 700	75%
E7	Adjacent	1 650	2 250	73%
CPP		9 764	13 200	

Table A3.13: Details of areas per sub-compartment (ha)

Month	1991	1992	1993	1994	1995	1996	1997	1998	1999
January	14		7	28	7				
February	16	65	7	49	54	59	38		
March	80		44	79	9	2	25	8	
April	53	2	192	235	34	177	199	112	5
May	437	188	357	333	218	216	163	397	214
June	366	392	527	334	319	214	312	178	212
July	428	317	487	285	368	118	507	481	347
August	170	299	297	205	353	263	469	413	177
September	732	501	425	141	245	166	266	271	267
October	315	54	233	122	129	226	12	49	191
November		5		20	79		2	61	38
December	93				1		28		
Total	**2 704**	**1 823**	**2 576**	**1 831**	**1 816**	**1 441**	**2 021**	**1 969**	**1 450**
Year	Wet(P=0.05)	Wet(P=0.20)	Wet(P=0.05)	Wet(P=0.20)	Wet(P=0.20)	Average	Wet(P=0.10)	Wet(P=0.10)	Average

Table A3.14: Rainfall data

Note:
Wet(P=0.05) indicates a 1:20 wet year; Wet(P=0.10) indicates a 1:10 wet year; and Wet(P=0.20) indicates a 1:5 wet year. Dry(P=0.05) indicates a 1:20 dry year; Dry(P=0.10) indicates a 1:10 dry year; and Dry(P=0.20) indicates a 1:5 dry year. Data are bassed on Attia and BMD data series

Year	Tk per DFL	Tk per DM
1992	21.00	23.50
1993	21.28	23.73
1994	21.94	24.57
1995	25.11	28.12
1996	24.81	27.77
1997	24.84	27.93
1998	22.72	25.61
1999	25.94	27.20
2000	23.68	24.83

Table A3.15: Currency conversion rates used

Item	Unit	1993	1994	1995	1996	1997	1998	1999
AGRICULTURE:								
Rice	kg	10.38	12.54	14.39	12.88	12.43	16.24	15.90
Paddy	kg	5.49	7.16	8.71	6.98	6.62	9.66	8.14
Soybean oil	kg	42.59	50.20	50.05	47.72	48.38	54.74	43.22
Mustard oil	kg	58.12	56.28	55.38	57.12	57.53	61.82	56.67
Garlic	kg	35.34	41.00	40.23	25.10	28.25	45.33	47.11
Chilli	kg	58.82	56.62	106.62	76.83	43.47	84.17	73.75
Ginger	kg	21.37	32.27	37.34	26.78	18.29	23.31	40.75
Potato	kg	11.08	7.93	7.77	9.20	6.93	8.35	9.46
Onion	kg	18.00	11.65	14.58	12.55	11.07	27.58	25.07
Urea	kg	5.10	5.13	5.65	5.29	5.57	5.86	5.95
Phosphate	kg	9.11	8.91	10.49	10.56	10.33	13.01	12.92
Potash	kg	8.33	7.88	7.57	8.15	7.67	9.03	10.04
FISHERY:								
Rui	kg	Market prices fish are only collected since January 1999						126
Catla	kg							110
Shrimp (small)	kg							77
Koi	kg							141
Magur (local)	kg							156
Singh	kg							131
Tengra	kg							73
Puti (local)	kg							61

Table A3.16: Market prices of agricultural commodities and fish (Tk per unit) ay

Details of flood damage refer only to Tangail Sadar Thana, is for 82.5% in the CPP area. No data were available for the other *Thanas* that are also part of the compartment: Delduar Thana (14.0%), Basail Thana (3.0%) and Kalihati Thana (0.5%).

Moreover, it should be known that CPP covers 34.3% of the area of Tangail Sadar, 10.5% of the area of Delduar, 2.2% of the area of Basail and 0.2% of the area of Kalihati Thanas. The tables below have not been adjusted; they present total for Tangail Sadar Thana.

Degree	Item	1988	1998
Fully	Bridges	1	2
	Embankment (km)	5	
	Homes	3 132	2 117
	Road (km)	52	
	Social buildings	1	18
Partly	Bridges	5	8
	Embankment (km)	37	288
	Homes	59 525	20 624
	Road (km)	363	
	Social buildings	18	13

Table A3.17: Damage done by floods to housing and infrastructure in Tangail Sadar

Crop	1988	1995	1996	1997	1998
Paddy (ha)	12 146	5 276	957	875	8 541
Jute (ha)	83	704	413	40	1 530
Sugarcane (ha)					835
Vegetables (ha)			110		355
Seedlings (ha)	60		480		128
Other crops (ha)	152	926		131	84
Total	**12 440**	**6 906**	**1 960**	**1 046**	**11 473**

Table A3.18: Damage done by floods to agricultural cropping in TangailSadar (ha)

A3.4 Agricultural Production and Extension Indicators

It is noted that data concerning crop areas are published by calendar year. The agricultural cropping year starts with the *Rabi* season and ends with the *Kharif* 2 season in the year thereafter, whereby the harvesting date of the crop is indicative for the cropping year. Hence, areas of *Boro* transplanted in for instance December 1994 and harvested in March/April 1995 are considered as 1995 *Rabi* season areas.

Season	Crop	1993	1996	1997	1998	1999
Rabi	*Boro* (MV)	This season was not monitored before 1998			5 310	6 444
	Maize				8	
	Oilseeds				2 251	2 631
	Potato				141	204
	Pulses				921	730
	Spices				55	81
	Veges/minor crops				164	336
	Wheat				1 516	1 155
Kharif 1	B. *Aus*			249	173	185
	Jute			3 440	2 443	1 486
	Sugarcane	756	692	672	573	462
	Summer Till				84	82
Kharif 2	D.W. *Aman*	2 980	1 852	1 712	1 028	2 993
	T. *Aman* (L)	1 982	2 649	2 852	634	1 965
	T. *Aman* (MV)	587	1 319	2 891	1 538	2 607
Total		**6 305**	**6 512**	**11 816**	**16 839**	**21 361**

Table A3.19: Results land use surveys (ha)

Season	Crop	1992	1993	1994	1995	1996	1997	1998	1999
Rabi	*Boro* (L)	431	Details are not available						
	Boro (MV)	3 390		6 430	6 464	6 458	6 682	6 774	6 623
	Oilseeds	1 277		1 297	2 239	1 431	1 505	1 967	3 487
	Potato	138			108	121	185	116	49
	Pulses	733		724	645	335	611	592	421
	Veges/minor crops	135		68	25	111	106	306	168
	Wheat	1 963		972	1 152	1 205	1 053	1 133	1 742
Kharif 1	*Aus* (MV)	726	83						
	B. *Aus*	2664	473	477	605	359	347	232	163
	Jute	1 614	1 385	1 623	1 403	1 998	2 106	2 082	1 541
	Sugarcane	691	968	1 250	1 156	740	518	519	547
Kharif 2	D.W. *Aman*		3 515	1 057	2 089	1 335	1 798	1 277	1 703
	D.W.B. *Aman*	1464							
	D.W.T. *Aman*	2 254		1 266	1 355	1 291	1 402	613	840
	T. *Aman* (L)	848	2 309	2 201	2 141	2 172	1 759	1 172	1 650
	T. *Aman* (MV)	222	716	371	696	1 446	1 440	1 129	2 462
	Others	60				53	122	12	
Total		**18618**	**9 449**	**17 736**	**20 141**	**19 084**	**19 722**	**17 949**	**21 396**

Table A3.20: Results of cropping pattern surveys (ha)

Crop yields were calculated form data provided by DAE for the four *Thanas*, which form part of the compartment. The average yield was calculated as the weighted average using the following weighting factors:

- CPP covers 34.3% in Tangail Sadar Thana,
- It also covers 10.5% in Delduar Thana,
- 2.2% of Basail,
- and 0.2% of Kalihati Thana.

Season	Crop	1994	1995	1996	1997	1998	1999
Rabi	Wheat		2.096	2.049	1.752	2.107	1.730
	Pulses		1.628	1.615	1.624	1.172	1.143
	Oilseeds		1.395	1.210	1.121	1.114	1.131
	Potato		13.436	12.283	12.894	12.626	9.466
	Boro (L)		1.474	1.740	1.701	1.894	3.096
	Boro (MV)		3.437	3.402	3.913	4.929	6.723
	Veges/minor crops		17.967	18.007	18.124	17.958	18.018
	Spices		3.319	3.321	14.673	3.304	3.301
Kharif 1	B. *Aus*	1.010	1.124	0.913	0.821	0.754	1.294
	Aus (MV)	1.879	2.253	2.050	1.905	1.957	2.262
	Jute	2.142	1.279	2.143	1.279	1.174	1.799
	Sugarcane	49.934	48.778	52.457	51.340	51.723	50.813
	Summer Till	0.720	0.759	0.829	0.768	0.755	0.782
Kharif 2	T. *Aman* (L)	1.412	1.771	1.919	1.555	1.396	2.281
	T. *Aman* (MV)	1.470	2.705	2.555	2.479	2.148	3.594
	D.W.B. *Aman*	0.553	1.317	1.139	1.069	0.889	1.990
	D.W.T. *Aman*	2.194	2.029	1.253	1.180	1.091	1.856

Table A3.21: Crop yields in the compartment (kg/ha)

Notes:
Data give the average yield based on DAE figures in tonne/ha

Year	Crop		OUTPUT		CASH EXPENSES				GROSS MARGIN	Family labour	RETURNS TO LAND	RETURNS TO LABOUR	VALUE ADDED
			Main product	Gross return	Inputs	Hired labour		Total					
			Kg/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/day	Tk/ha
1998	*Boro* (MV)	All farms	5 180	38 869	21 580	182	10 626	32 206	6 663	93	2 007	72	17 289
		Marginal farms	5 054	37 758	17 300	150	9 059	26 359	11 399	100	6 396	114	20 458
		Small farms	5 146	38 444	19 525	184	10 695	30 220	8 224	92	3 622	89	18 919
		Medium farms	5 287	40 283	28 591	164	9 687	38 278	2 005	90	-2 485	22	11 692
		Large farms	4 907	36 736	18 515	157	9 458	27 973	8 763	57	5 905	153	18 221
	T. *Aman* (MV)	All farms	2 460	30 703	8 814	168	10 068	18 882	11 821	123	5 691	96	21 889
		Marginal farms	2 512	34 780	7 609	180	10 774	18 384	16 396	22	15 274	730	27 170
		Small farms	2 896	35 143	8 556	141	8 446	17 002	18 142	33	16 489	549	26 587
		Medium farms	2 873	34 597	7 846	177	10 617	18 463	16 134	63	12 974	255	26 751
		Large farms	1 645	19 750	6 797	159	9 524	16 321	3 429	-	3 429	-	12 953
	T. *Aman* (L)	All farms	1 314	19 096	7 470	172	9 873	17 344	1 752	128	-4 656	14	11 625
		Marginal farms	767	11 313	5 975	-	-	5 975	5 337	115	-424	46	5 337
		Small farms	1 372	19 780	7 516	161	9 271	16 786	2 994	134	-3 730	22	12 265
		Medium farms	1 210	19 565	6 807	144	8 599	15 406	4 159	41	2 126	102	12 758
		Large farms	1 340	18 413	7 075	149	8 700	15 775	2 638	14	1 961	195	11 338
	D.W.B. *Aman*	All farms	1 072	13 262	4 832	134	7 838	12 670	592	90	-3 903	7	8 430
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	1 178	14 493	5 414	111	6 661	12 075	2 418	47	56	51	9 080
		Medium farms	1 018	12 423	3 741	92	5 159	8 900	3 523	33	1 855	106	8 682
		Large farms	1 114	13 691	4 936	80	4 792	9 729	3 963	7	3 634	603	8 755
	D.W.T. *Aman*	All farms	1 161	14 045	6 730	113	6 134	12 864	1 181	70	-2 336	17	7 315
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	1 068	13 323	6 172	115	5 998	12 170	1 153	31	-378	38	7 151
		Medium farms	1 385	16 525	7 034	135	7 530	14 563	1 962	9	1 503	214	9 492
		Large farms	-	-	-	-	-	-	-	-	-	-	-
	B. *Aus*	All farms	747	7 916	5 250	117	6 568	11 818	-3 902	28	-5 304	-139	2 666
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	921	9 564	3 020	105	5 892	8 912	652	25	-582	26	6 544
		Medium farms	689	7 366	3 908	108	6 035	9 943	-2 577	24	-3 788	-106	3 458
		Large farms	-	-	4 115	62	3 395	7 510	-7 510	10	-8 025	-730	-4 115
	Jute	All farms	1 505	22 356	4 708	171	9 188	13 896	8 461	124	2 248	68	17 648
		Marginal farms	1 688	16 833	4 067	152	8 449	12 516	4 317	120	-1 681	36	12 766
		Small farms	1 479	15 067	3 981	154	8 473	12 454	2 613	99	-2 342	26	11 086
		Medium farms	1 715	20 985	5 514	183	9 886	15 400	5 585	64	2 388	87	15 471
		Large farms	1 669	19 347	6 188	208	10 924	17 112	2 235	21	1 169	105	13 159

Continued

Year	Crop		OUTPUT		CASH EXPENSES				GROSS MARGIN	Family labour	RETURNS TO LAND	RETURNS TO LABOUR	VALUE ADDED
			Main product	Gross return	Inputs	Hired labour		Total					
			Kg/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/day	Tk/ha
1998	Potato	All farms	8 228	57 620	20 799	151	7 633	28 431	29 189	183	20 037	159	36 822
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	-	-	-	-	-	-	-	-	-	-	-
		Medium farms	7 409	49 426	23 197	55	2 743	25 940	23 486	186	14 186	126	26 229
		Large farms	9 868	74 008	12 676	168	8 466	21 142	52 866	26	51 543	1 998	61 332
	Wheat	All farms	2 303	21 252	8 734	108	5 178	13 912	7 340	95	2 586	77	12 518
		Marginal farms	2 333	21 212	6 653	69	3 827	10 481	10 731	49	8 262	217	14 559
		Small farms	2 240	21 480	9 124	114	5 819	14 943	6 538	105	1 285	62	12 357
		Medium farms	2 486	22 214	5 993	98	4 624	10 617	11 597	106	6 301	109	16 221
		Large farms	2 348	21 899	5 758	105	4 362	10 120	11 779	95	7 052	125	16 141
	Oilseeds	All farms	611	11 107	3 856	77	3 982	7 838	3 269	65	3	50	7 251
		Marginal farms	150	2 955	2 971	30	1 496	4 468	-1 512	15	-2 260	-101	-16
		Small farms	597	10 427	3 593	70	3 592	7 185	3 242	54	565	61	6 834
		Medium farms	564	10 754	4 438	74	4 087	8 525	2 229	78	-1 682	28	6 316
		Large farms	777	14 401	3 599	79	3 960	7 559	6 842	22	5 723	306	10 802
	Pulses	All farms	714	14 781	3 533	83	4 356	7 889	6 892	97	2 034	71	11 248
		Marginal farms	767	17 286	2 279	144	7 202	9 480	7 805	41	5 748	190	15 007
		Small farms	550	12 360	3 287	57	3 086	6 374	5 987	20	4 982	298	9 073
		Medium farms	735	16 576	4 011	99	4 889	8 899	7 677	19	6 726	404	12 565
		Large farms	890	12 714	482	76	4 690	5 172	7 542	33	5 905	230	12 233
	Veges/ minor crops	All farms	-	92 181	9 309	33	1 646	10 955	81 226	403	61 062	201	82 872
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	-	92 181	9 309	33	1 646	10 955	81 226	403	61 062	201	82 872
		Medium farms	-	-	-	-	-	-	-	-	-	-	-
		Large farms	-	-	-	-	-	-	-	-	-	-	-
	Sugarcane (see notes)	All farms	-	57 849	9 120	254	13 809	22 929	34 919	85	30 678	412	48 728
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	-	59 534	8 617	252	12 593	21 209	38 324	9	37 867	4 191	50 917
		Medium farms	-	-	-	-	-	-	-	-	-	-	-
		Large farms	-	59 858	9 728	241	14 478	24 207	35 651	-	35 651	-	50 129

Table A3.22: Results input-output analysis agricultural cropping in the CPP area (1998)

Notes:

Data for all farms include results taken from landless farmers, those having less than 0.5 acre or 0.08 ha of land Family labour is valued at Tk 50 per day. The figure concerning sugarcane for all farms is influenced downwards by landless farmers (less than 0.5 acre or 0.08 ha of land) who cultivate sugarcane

Year	Crop		OUTPUT		CASH EXPENSES				GROSS MARGIN	Family labour	RETURNS TO LAND	RETURNS TO LABOUR	VALUE ADDED
			Main product	Gross return	Inputs	Hired labour		Total					
			Kg/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/day	Tk/ha
1999	*Boro* (MV)	All farms	6 162	55 465	23 040	169	12 023	35 063	20 402	101	15 352	202	32 425
		Marginal farms	6 271	57 086	20 967	-	-	20 967	36 118	123	29 968	294	36 118
		Small farms	6 130	55 233	22 750	168	12 020	34 770	20 463	71	16 892	287	32 483
		Medium farms	6 220	56 130	22 353	168	12 301	34 653	21 477	72	17 859	297	33 777
		Large farms	6 105	54 142	21 879	175	12 597	34 476	19 667	54	16 984	367	32 264
	T. *Aman* (MV)	All farms	3 350	26 999	7 770	151	9 077	16 847	10 152	129	3 678	78	19 229
		Marginal farms	2 582	20 663	7 643	180	10 774	18 418	2 245	78	-1 636	29	13 020
		Small farms	3 642	29 392	7 347	146	8 788	16 135	13 256	46	10 980	291	22 044
		Medium farms	3 099	24 592	7 851	157	9 427	17 279	7 313	154	-364	48	16 741
		Large farms	3 783	31 213	6 252	167	10 009	16 261	14 952	10	14 475	1 565	24 961
	T. *Aman* (L)	All farms	2 234	19 400	7 116	133	7 971	15 087	4 313	119	-1 652	36	12 284
		Marginal farms	1 876	16 205	6 161	-	-	6 161	10 044	134	3 340	75	10 044
		Small farms	2 516	21 810	6 709	128	7 678	14 387	7 424	81	3 386	92	15 102
		Medium farms	2 283	20 449	6 416	139	8 321	14 737	5 713	45	3 487	128	14 034
		Large farms	2 093	17 776	6 570	149	8 938	15 508	2 267	8	1 873	287	11 205
	D.W.B. *Aman*	All farms	1 962	14 629	4 044	77	4 623	8 667	5 962	84	1 780	71	10 585
		Marginal farms	1 916	14 552	2 595	-	-	2 595	11 956	88	7 571	136	11 956
		Small farms	1 962	14 666	4 159	72	4 339	8 498	6 168	52	3 574	119	10 507
		Medium farms	1 907	14 189	3 519	87	5 195	8 715	5 474	100	461	55	10 670
		Large farms	2 039	14 983	3 623	91	5 447	9 070	5 914	19	4 962	311	11 361
	D.W.T. *Aman*	All farms	2 072	15 347	7 194	125	7 489	14 683	664	37	-1 205	18	8 153
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	2 089	15 477	7 248	101	6 078	13 326	2 151	39	194	55	8 229
		Medium farms	2 050	15 173	6 103	129	7 731	13 834	1 339	16	540	84	9 070
		Large farms	-	-	-	-	-	-	-	-	-	-	-
	B. *Aus*	All farms	1 316	12 876	3 616	-	-	3 616	9 260	119	3 308	78	9 260
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	-	-	-	-	-	-	-	-	-	-	-
		Medium farms	-	-	-	-	-	-	-	-	-	-	-
		Large farms	-	-	-	-	-	-	-	-	-	-	-
	Jute	All farms	1 623	25 333	6 310	186	10 753	17 064	8 269	145	1 021	57	19 023
		Marginal farms	1 705	22 738	4 638	-	-	4 638	18 100	157	10 264	115	18 100
		Small farms	1 567	24 213	4 421	172	9 863	14 285	9 929	134	3 229	74	19 792
		Medium farms	1 640	26 860	5 438	186	11 438	16 876	9 984	51	7 438	196	21 422
		Large farms	1 756	29 265	6 051	216	12 209	18 259	11 006	45	8 742	243	23 214

Continued

Year	Crop		OUTPUT		CASH EXPENSES				GROSS MARGIN	Family labour	RETURNS TO LAND	RETURNS TO LABOUR	VALUE ADDED
			Main product	Gross return	Inputs	Hired labour		Total					
			Kg/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/day	Tk/ha
1999	Potato	All farms	9 990	62 214	15 775	133	6 653	22 428	39 786	204	29 567	195	46 439
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	10 123	67 827	16 123	136	6 790	22 914	44 914	74	41 210	606	51 704
		Medium farms	10 974	64 746	16 653	-	-	16 653	48 093	233	36 433	206	48 093
		Large farms	-	-	-	-	-	-	-	-	-	-	-
	Wheat	All farms	1 899	17 500	6 145	110	5 392	11 537	5 963	114	272	52	11 355
		Marginal farms	1 949	18 084	5 529	41	2 469	7 998	10 086	108	4 695	94	12 555
		Small farms	1 789	16 871	6 095	102	5 057	11 152	5 719	84	1 497	68	10 776
		Medium farms	2 091	18 788	5 920	113	5 404	11 324	7 463	76	3 672	98	12 868
		Large farms	1 772	16 352	6 090	123	5 989	12 079	4 273	52	1 656	82	10 262
	Oilseeds	All farms	825	13 812	4 427	84	4 196	8 623	5 189	96	402	54	9 385
		Marginal farms	713	12 116	4 316	-	-	4 316	7 800	68	4 383	114	7 800
		Small farms	883	14 837	4 035	59	2 939	6 975	7 862	108	2 473	73	10 802
		Medium farms	764	13 009	4 189	40	1 984	6 173	6 837	88	2 427	78	8 821
		Large farms	932	15 067	4 368	78	3 917	8 285	6 781	-	6 781	-	10 698
	Pulses	All farms	703	13 527	4 915	94	4 680	9 596	3 931	105	-1 318	37	8 611
		Marginal farms	823	17 490	3 210	103	5 144	8 354	9 136	41	7 078	222	14 280
		Small farms	654	12 266	2 951	57	2 861	5 812	6 454	111	915	58	9 315
		Medium farms	763	14 374	2 885	99	4 827	7 711	6 663	49	4 209	136	11 490
		Large farms	748	14 665	1 025	60	2 993	4 018	10 647	7	10 273	1 423	13 640
	Veges/ minor crops	All farms	-	62 779	12 223	45	2 245	14 468	48 311	322	32 206	150	50 556
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	-	98 765	15 572	-	-	15 572	83 193	449	60 765	185	83 193
		Medium farms	-	-	-	-	-	-	-	-	-	-	-
		Large farms	-	-	-	-	-	-	-	-	-	-	-
	Sugarcane (see notes)	All farms	-	59 742	13 416	199	11 715	25 132	34 611	122	28 496	283	46 326
		Marginal farms	-	-	-	-	-	-	-	-	-	-	-
		Small farms	-	57 979	6 246	237	14 200	20 446	37 533	67	34 167	558	51 733
		Medium farms	-	52 376	13 633	127	6 360	19 993	32 383	64	29 203	509	38 743
		Large farms	-	74 822	6 966	296	17 733	24 699	50 123	-	50 123	-	67 856

Table A3.23 Results input-output analysis agricultural cropping in the CPP area (1999)

Notes:

Data for all farms include results taken from landless farmers, those having less than 0.5 acre or 0.08 ha of land Family labour is valued at Tk 50 per day. The figure concerning sugarcane for all farms is influenced downwards by landless farmers (less than 0.5 acre or 0.08 ha of land) who cultivate sugarcane

Year	Crop	OUTPUT		CASH EXPENSES				GROSS MARGIN	Family labour	RETURNS TO LAND	RETURNS TO LABOUR	VALUE ADDED
		Main product	Gross return	Inputs	Hired labour		Total					
		Kg/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/ha	Tk/ha	days/ha	Tk/ha	Tk/day	Tk/ha
1999	*Boro* (MV)	4 868	40 997	17 858	158	9 690	27 548	13 449	130	6 952	104	23 139
	T. *Aman* (MV)	2 860	23 549	5 467	136	7 469	12 936	10 614	106	5 293	100	18 082
	T. *Aman* (L)	2 188	20 721	4 336	127	7 273	11 609	9 112	95	4 387	96	16 385
	D.W.B. *Aman*	1 546	12 367	3 544	63	3 762	7 305	5 062	67	1 734	76	8 823
	D.W.T. *Aman*	1 991	16 063	3 849	86	5 000	8 849	7 214	100	2 199	72	12 214
	B. *Aus*	-	-	-	-	-	-	-	-	-	-	-
	Jute	1 574	21 158	5 157	120	6 623	11 781	9 377	152	1 787	62	16 001
	Potato	-	-	-	-	-	-	-	-	-	-	-
	Wheat	1 771	15 048	7 331	92	5 151	12 482	2 566	92	-2 036	28	7 717
	Oilseeds	777	13 082	5 314	83	4 552	9 866	3 216	92	-1 406	35	7 768
	Pulses	679	12 840	2 099	62	3 704	5 802	7 037	28	5 648	253	10 741
	Veges/minor crops	-	-	-	-	-	-	-	-	-	-	-
	Sugarcane	-	-	-	-	-	-	-	-	-	-	-

Table A3.24 Results input-output analysis agricultural cropping in the adjacent areas(1999)

Notes:
Family labour is valued at Tk 50 per day

Year	STW number	LLP number	DTW number	Traditional number	Total number	Irrigated area ha	% NCA
1993	774	3	78	450	1 305	4 384	45%
1995	619	4	85	550	1 258	4 218	43%
1997	881	2	81	33	997	4 781	49%
1999	1 441	3	70	54	1 568	6 141	63%

Table A3.25 Number of irrigation pumps and irrigated areas by year (ha)

Year	STW Irr.Area ha	LLP Irr.Area ha	DTW Irr.Area ha	Traditional Irr.Area ha	Total Irr.Area ha	Total number	% NCA
1993	2 819	45	1 438	82	4 384	1 309	45%
1995	2 236	47	1 835	100	4 218	1 258	43%
1997	2 960	19	1 796	6	4 781	997	49%
1999	4 640	16	1 476	9	6 141	1 568	63%

Table A3.26 Irrigated area by type of pump by year (ha)

The following tables provide insight in the activities of CPP as to the OFTD program, indicating what crops were selected for the program, the participation of farmers and which CPP staff participated in the activities.

Year	Month	Crop demonstrated	Attending men	Attending women	Total
1998	January	Jute	145	60	205
	January	Veges/minor crops	455	180	635
	March	Jute	59	21	80
	March	Veges/minor crops	177	63	240
	April	Jute	5	2	7
	April	T. *Aman* (MV)	223	52	275
	April	Veges/minor crops	15	6	21
	June	T. *Aman* (MV)	177	46	223
	July	T. *Aman* (MV)	15	5	20
	October	*Boro* (MV)	25	7	32
	October	Veges/minor crops	57	9	66
	November	*Boro* (MV)	14	2	16
	December	*Boro* (MV)	40	5	45
1999	January	Veges/minor crops	35	1	36
	February	*Boro* (MV)	75	43	118
	February	Veges/minor crops	8	5	13
	March	Compost making	94	51	145
	April	Compost making	7	5	12
	April	IPM Training	236	52	288
	April	Veges/minor crops	76	60	136
	May	Compost making	9	4	13
	May	IPM Training	137	33	170
	June	Compost making	57	41	98
	June	T. *Aman* (MV)	61	42	103
	June	Veges/minor crops	141	47	188
	July	Compost making	150	72	222
	July	T. *Aman* (MV)	115	32	147
	August	Compost making	198	146	344
	August	IPM Training	36	22	58
	August	Khejur seedling	31	17	48
	September	Compost making	32	28	60
	September	T. *Aman* (MV)	44	16	60
	October	Compost making	78	65	143
	October	T. *Aman* (MV)	54	25	79
	October	Veges/minor crops	76	38	114
	October	Veges/minor crops	54	35	89
	November	Veges/minor crops	85	54	139
	December	Veges/minor crops	25	18	43

Table A3.27 Details of activities related to the OFTD program

Year	Month	Staff Agric. Section	Staff WID Section	Staff DAE	Staff BARI	Staff BWDB	Staff Inst. Section	Others
1998	January	3	2	1	1	1	1	
	March	3	1	1	1			
	April	3	1		1	1		
	June	3	1	1	1	1		
	July	2	1					
	October	3	1		1	2		
	November	3	1		1	2		
	December	3	1		1	2		
1999	January	2	1		1	2		
	February	2	1		1	2	1	
	March	4	1		1	2	1	
	April	4	1	3	1	2		3
	May	6	1	2	1	2		2
	June	2	1		1	1		1
	July	2	1		1	1		1
	August	2	1	1	1	1		1
	September	2	1		1	1	1	
	October	2	1		1	1		
	October	2	1		1	1		
	November	2	1		1			
	December	2	1		1	1		

Table A3.28: Participation of CPP staff and others in the OFTD program

A3.5 Fishery Extension Indicators

Details of fish catches were extensively reported on the in annex on fisheries. This section of the M & E results presents two tables on fish catches in the compartment as well as details of the extension activities in relation to the promotion of catfish cultivation (*Chari* in the *Bari*).

Habitat	1992	1993	1994	1995	1996	1997	1998	1999
F_1 (30-90 cm)	4.72	32.80	15.81	12.36	39.51	38.29	119.12	11.88
F_2 (90-180 cm)	40.37	172.10	162.93	91.57	222.54	284.27	602.61	85.00
F_3 (>180 cm)	32.03	71.04	50.00	42.92	29.03	71.27	77.46	72.88
Khal	1.50	29.27			9.08	8.62	24.72	5.27
Lohajang	0.88	2.73			3.68	1.14	7.99	4.29
Total	79.50	307.94	228.75	146.85	303.85	403.58	831.89	179.32

Table A3.29: Annual catches of fish per habitat (tons)

Notes: 1992 data only cover 8 months (May-December); 1999 data cover 4 months only (January-April) F1, F2 and F3 refers to land types: F1 concerns land with a flood depth of 30-90 cm for rainfall and flooding return periods of 1 in 5 years. F2 applies to flood depths of 90-180 cm and F3 to >180 cm flood depth.

Habitat	Avg. Annual prod.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F_1 (30-90 cm)	39.21	0.11	0.05	0.00	0.00	0.00	0.27	3.63	7.81	12.71	6.60	2.70	0.43
F_2 (90-180 cm)	237.34	1.68	0.60	0.03	0.02	0.03	3.15	19.17	40.16	61.46	52.85	23.03	5.79
F_3 (>180 cm)	63.80	2.77	4.02	3.60	1.11	2.43	3.94	1.60	2.68	7.70	18.00	5.83	3.16
Khal	11.21	0.00					0.04	0.52	1.26	2.70	3.29	1.82	0.17
Lohajang	2.96						0.05	0.19	0.38	1.47	0.42	0.05	0.03
Total	354.53	4.56	4.67	3.63	1.13	2.46	7.45	25.13	52.30	86.04	81.16	33.42	9.58

Table A3.30: Average monthly catches of fish per habitat (tons)

Notes: Covering the years 1992-1999: 1992 data only cover 8 months (May-December); 1999 data cover 4 months only (January-April, F1, F2 and F3 refers to land types: F1 concerns land with a flood depth of 30-90 cm for rainfall and flooding return periods of 1 in 5 years. F2 applies to flood depths of 90-180 cm and F3 to >180 cm flood depth.

The total weight of the fish monitored in the catfish extension program and the number of persons participating in cultivation are given in the next table. The table there-after gives the involvement of CPP staff in the program.

Year	Month	Regist. weight fish (kg)	Men partic.	Women partic.	Children partic.	Total
1999	May	110	23	30	3	56
	June	236	17	116	6	139
	July	1 350	20	101	5	126
	August	2 546	23	139	7	169
	September	2 707	16	102	6	124
	October	3 683	5	17	2	24

Table A3.31: Details of the catfish extension program

A3.6 Environmental Indicators

The environmental monitoring results comprise data on groundwater level monitoring, results from the water quality monitoring program, disease incidences and the activities in the field of social forestry. Groundwater level monitoring was confined to a number of tube wells for drinking water, which were distributed over an area covering the compartment as well as adjacent areas.

Location well SC	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1			9.03	8.20	8.29	7.78	8.17	7.81	7.76	7.79	8.26	7.88	7.50
3					4.90	4.65	6.17	6.91	6.89	5.95	5.92	5.90	5.90
5					5.90	5.65	6.71	7.20	7.12	7.05	6.97	6.95	6.92
7	7.99	7.45	7.43	8.32	7.20	6.95	7.68	8.14	8.07	7.53	7.53	7.51	7.48
9	8.28	7.67	7.37	8.38	7.77	7.37	7.26	7.52	7.47	7.39	7.37	7.37	7.34
10	8.68	8.87	8.39	8.90	9.03	8.19	8.60	8.27	8.39	8.27	9.02	8.00	8.36
12			6.47	7.15	6.77	6.62	6.77	6.93	6.91	6.78	6.87	6.85	6.85
16	8.67	8.97	8.43	8.85	9.05	9.24	9.29	9.09	8.41	8.69	8.33	8.40	7.93
E6											6.86	7.46	6.55
E7											5.18	5.66	4.80
99E										8.35	7.88	8.12	7.51
99W	8.12	7.94	7.36	8.33	7.74	7.69	7.74	7.69	7.67	7.46	6.39	6.38	6.38
99N													7.80
99S										7.84	7.51	7.93	7.15

Table A3.32: Groundwater levels in CPP, annual averages in April/May (m+PWD)

Notes:

99N, 99E, 99S and 99W refer to wells located outside the compartment, respectively North, East, South and West of CPP

Location well SC	Starting year monitor.	Ending year monitor.	Apr	May
1	1989	1999	6.12	6.61
3	1991	1999	5.90	5.91
5	1991	1999	6.92	6.69
7	1987	1999	7.48	7.65
9	1987	1999	7.34	7.61
10	1987	1999	7.17	7.46
12	1989	1999	6.85	6.81
16	1987	1999	7.16	7.59
E6	1997	1999	6.55	7.16
E7	1997	1999	4.80	5.42
99E	1996	1999	5.97	6.49
99W	1987	1999	6.38	7.25
99N	1999	1999	7.80	
99S	1996	1999	6.00	6.21

Table A3.33: Groundwater levels in CPP, monthly averages (m+ PWD)

Notes:
99N, 99E, 99S and 99W refer to wells located outside the compartment, respectively North, East, South and West of CPP

Water monitoring covered a number of aspects of which the most important are the pollution levels in Chemical Oxygen Demand (COD), the acidity level (p^H) of the water and the load of ammonia in the water. The third could provide some indication of the leaching of nitrogen from fertilizers like Urea, Sulfate of Ammonia or NPK. The monthly averages are only given for the months of April to May, when concentration of pollutants were likely to be high because it concerned the end of the dry season.

SC	Indicator	Unit	1995	1996	1997	1999
3	Ammonia	mg/l				2.4
4	Ammonia	mg/l	0.5	0.7	1.2	1.3
5	Ammonia	mg/l				0.7
6	Ammonia	mg/l				2.0
7	Ammonia	mg/l	-	1.0	5.1	1.7
9	Ammonia	mg/l	7.2	3.8	3.8	1.9
10	Ammonia	mg/l	1.2	2.2	5.7	1.4
11	Ammonia	mg/l	0.2	5.1	5.6	1.4
13	Ammonia	mg/l		6.7	19.6	3.2
14	Ammonia	mg/l	0.5	0.6	1.1	1.2
16	Ammonia	mg/l	7.1	10.8		27.4
LFP	Ammonia	mg/l	1.3	3.3	5.5	1.1
E4	Ammonia	mg/l				1.6
3	COD	mg/l	10.0	29.0		10.2
4	COD	mg/l	29.0	39.0	17.6	3.6
5	COD	mg/l				10.2
6	COD	mg/l				30.6
7	COD	mg/l	20.0	24.5	36.2	20.4
9	COD	mg/l				25.5
10	COD	mg/l	15.0	3.0	4.0	23.0
11	COD	mg/l		10.0	37.0	30.6
13	COD	mg/l		74.0	133.5	71.4
14	COD	mg/l	60.0	15.0	25.0	27.2
16	COD	mg/l	150.0	20.0		30.6
LFP	COD	mg/l	22.0	22.0	7.0	15.3
3	Faecal Coliform	c.f.u/100 ml				2.0
4	Faecal Coliform	c.f.u/100 ml	1.0	4.0	2.5	10.5
5	Faecal Coliform	c.f.u/100 ml				1.0
6	Faecal Coliform	c.f.u/100 ml				313.5
7	Faecal Coliform	c.f.u/100 ml		10.5	12.4	48.5
9	Faecal Coliform	c.f.u/100 ml				26.5
10	Faecal Coliform	c.f.u/100 ml				37.1
11	Faecal Coliform	c.f.u/100 ml		14.0	16.5	1.0
13	Faecal Coliform	c.f.u/100 ml		40.0	82.0	400.5
14	Faecal Coliform	c.f.u/100 ml		2.7	12.3	121.3
16	Faecal Coliform	c.f.u/100 ml	25.0	65.0		348.0
LFP	Faecal Coliform	c.f.u/100 ml	28.0	35.0	8.2	75.5
E4	Faecal Coliform	c.f.u/100 ml				115.0
3	pH	-	7.2	7.6	7.2	6.8
4	pH	-	7.7	8.3	7.5	7.5
5	pH	-				6.8
6	pH	-				7.5
7	pH	-	7.3	8.1	7.6	7.4
9	pH	-	8.0	9.4	9.2	7.4
10	pH	-	6.8	7.3	7.0	7.1
11	pH	-	8.3	8.4	8.5	8.1
13	pH	-		8.7	8.4	7.4
14	pH	-	7.5	8.1	7.0	7.0
16	pH	-	8.4	8.2		7.4
LFP	pH	-	7.6	7.6	7.3	7.2
E4	pH	-				8.6

Table A3.34: Results water quality analysis, annual averages

SC	Indicator	Unit	Mar	Apr
3	Ammonia	mg/l	2.0	2.7
4	Ammonia	mg/l	1.3	0.9
5	Ammonia	mg/l	0.8	0.7
6	Ammonia	mg/l	2.0	2.1
7	Ammonia	mg/l	3.6	1.8
9	Ammonia	mg/l	2.1	4.0
10	Ammonia	mg/l	2.7	2.3
11	Ammonia	mg/l	4.7	3.6
13	Ammonia	mg/l	15.3	7.3
14	Ammonia	mg/l	1.4	0.9
16	Ammonia	mg/l	24.1	22.7
LFP	Ammonia	mg/l	2.9	2.9
E4	Ammonia	mg/l	1.6	1.5
3	COD	mg/l	10.2	19.5
4	COD	mg/l	14.2	26.1
5	COD	mg/l	10.2	
6	COD	mg/l	30.6	
7	COD	mg/l	29.7	23.3
9	COD	mg/l	25.5	
10	COD	mg/l	19.2	9.0
11	COD	mg/l	31.7	25.6
13	COD	mg/l	99.6	106.6
14	COD	mg/l	25.7	34.6
16	COD	mg/l	30.6	85.0
LFP	COD	mg/l	11.6	16.7
3	Faecal Coliform	c.f.u/100 ml	2.0	2.0
4	Faecal Coliform	c.f.u/100 ml	10.2	2.7
5	Faecal Coliform	c.f.u/100 ml	1.0	1.0
6	Faecal Coliform	c.f.u/100 ml	500.0	127.0
7	Faecal Coliform	c.f.u/100 ml	26.3	37.6
9	Faecal Coliform	c.f.u/100 ml	36.5	16.5
10	Faecal Coliform	c.f.u/100 ml	45.8	28.5
11	Faecal Coliform	c.f.u/100 ml	3.0	14.3
13	Faecal Coliform	c.f.u/100 ml	423.5	52.7
14	Faecal Coliform	c.f.u/100 ml	31.9	124.8
16	Faecal Coliform	c.f.u/100 ml	389.0	194.0
LFP	Faecal Coliform	c.f.u/100 ml	50.8	45.8
E4	Faecal Coliform	c.f.u/100 ml	110.0	120.0
3	pH	-	7.0	7.2
4	pH	-	7.4	7.8
5	pH	-	6.8	6.8
6	pH	-	8.0	6.9
7	pH	-	7.6	7.6
9	pH	-	8.0	8.3
10	pH	-	7.2	7.0
11	pH	-	8.4	8.3
13	pH	-	7.9	8.1
14	pH	-	7.0	7.2
16	pH	-	7.5	7.7
LFP	pH	-	7.1	7.5
E4	pH	-	8.6	8.6

Table A3.35: Results water quality analysis, averages April to May

The tables giving the results of waterborne diseases incidence covered the following diseases: diarrhoea, hepatitis, dysentery and typhoid.

SC	Number of sick persons	1996	1997	1998	1999
2	10 064	1 889	3 029	2 777	2 369
5	7 024		3 043	2 749	1 232
7	6 324		2 746	2 837	741
8	11 197	4 564	3 641	2 290	702
10	10 730		4 653	4 031	2 046
11	6 742	1 817	1 942	2 207	776
12	5 292		1 781	1 745	1 766
14	5 689		2 515	1 770	1 404
15	5 345		2 663	1 500	1 182
16	7 011	1 322	2 424	2 098	1 167
E2	5 907	1 820	1 517	1 810	760
E4	15 265	2 891	3 746	5 816	2 812

Table A3.36: Number of persons treated for waterborne diseases, annual averages

Notes:
As waterborne diseases were taken: diarrhoea, hepatitis, dysentery and typhoid

SC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	95	123	146	141	200	210	209	213	178	214	162	246
5	111	182	139	144	127	139	224	169	192	130	179	213
7	125	104	177	101	105	130	193	136	130	141	170	149
8	134	98	260	188	120	216	186	184	276	235	280	209
10	341	251	188	216	222	328	260	184	209	203	200	242
11	73	68	143	136	95	130	166	208	268	167	131	85
12	122	153	75	107	87	119	88	115	108	97	110	72
14	178	100	155	179	140	135	149	142	153	142	129	108
15	124	77	121	125	95	114	167	115	149	108	105	115
16	55	53	66	64	71	61	65	87	81	94	94	98
E2	40	60	51	71	54	94	101	92	214	185	172	110
E4	118	125	160	162	184	255	332	294	444	572	381	270

Table A3.37: Number of persons treated for waterborne diseases, monthlyaverages

Notes:
As waterborne diseases were taken: diarrhoea, hepatitis, dysentery and typhoid

The extension activities for environmental protection and awareness raising comprised the distribution of saplings to farming households and the activities in relation to awareness raising among primary school children. Details of the first activity were monitored and published in the following tables.

Year	Month	Distributed surviving saplings	Attending men	Attending women	Total
1998	July	500	64	36	100
	August	373	64	36	100
	September	289	64	36	100
	October	289	64	36	100
	November	289	64	36	100
	December	255	53	47	100
1999	January	251	50	50	100
	February	248	50	50	100

Table A3.38: Details of the social forestry activities

Year	Month	Staff Env. Section	Staff WID Section	Staff Inst. Dev. Section	Others
1998	July	1	2		1
	August	1	1		
	September	1	1		
	October	1	1		
	November	1		1	
	December	1			
1999	January	1			
	February	1			

Table A3.39: Details of the social forestry activities

A3.5 Social Economy Indicators

Results of the social economic monitoring program concerned, firstly, the effects on employment generated through the construction and O&M activities that CPP undertook. LCS contracts were issued for the excavation of Khals, while employment generated among women in the EMG comprises the maintenance of embankments. The following tables provide details.

SC	Paid (Tk)	Total pers. Days	1993	1994	1995	1996	1997
2	293 286	5 866			5 866		
5	53 060	1 061	1 061				
6	242 919	4 858					4 858
7	508 047	10 161		5 688	4 473		
8	392 800	7 856		2 555	5 301		
9	366 411	7 328		7 328			
10	439 641	8 793		8 793			
11	1 001 413	20 028	11 745	2 805	5 478		
12	664 370	13 287			11 263		2 025
13	555 529	11 111			7 187		3 924
14	224 169	4 483					4 483
E3	1 141 336	22 827					22 827
E4	1 146 617	22 932					22 932

Table A3.40: Details of employment generation through LCS contracts

Notes:
Person days were valued at Tk 50 After 1997 no contracts were issued to LCS by the XEN's Office

SC	Paid (Tk)	Total pers. Days	1995	1996	1997	1998
1	278 500	6 189			3 333	2 856
2	224 145	4 981			2 727	2 254
4	6 480	144				144
5	17 775	395				395
5-6	153 090	3 402			1 818	1 584
6	402 615	8 947			4 623	4 324
7	107 420	2 394			810	1 584
7-8	145 040	3 222			8 818	1 404
9	279 630	6 252			3 333	2 919
10	255 150	5 670			3 030	2 640
11	93 600	2 080			1 515	565
11-12	155 475	3 455			1 515	1 940
12-13	127 575	2 835			1 515	1 320
13	255 150	5 670			3 030	2 640
CPP	700 574	17 216	2 967	14 250		

Table A3.41 Details of employment generation through EMG contracts

Note:
Person days were valued at the on-going annual rate (incl. savings) After 1998 no contracts were issued to LCS by the XEN's Office For 1995 and 1996 no break-down per sub-compartment could be given

Appendix 4

A4.1 Estimation of the Population In 2000

This part of the annex provides details of the tables having served to make an estimation of the compartment population in 2000. The compartment population in 1991 was estimated from the national population census and the Thana population.

SC	Male poul.	Female popul.	Total	House-holds	Pers per h.h.
1	3 080	2 980	6 060	941	6.44
2	8 873	7 994	16 867	2 988	5.64
3	7 223	6 913	14 136	2 269	6.23
4	9 075	8 256	17 331	3 365	5.15
5	6 723	6 000	12 723	2 228	5.71
6	6 752	6 169	12 921	2 334	5.54
7	5 170	4 978	10 148	1 852	5.48
8	5 881	5 628	11 509	2 089	5.51
9	2 789	2 651	5 440	1 002	5.43
10	6 160	5 986	12 146	2 306	5.27
11	12 526	11 975	24 501	4 460	5.49
12	7 452	7 373	14 825	2 746	5.40
13	3 079	2 952	6 031	989	6.10
14	10 724	10 211	20 935	4 009	5.22
15	8 053	7 517	15 570	2 920	5.33
16	22 309	20 435	42 744	8 105	5.27
LFP	9 964	9 417	19 381	3 508	5.52
Total	**135 833**	**127 435**	**263 268**	**48 111**	**5.47**

Table A4.1: Compartment population in 1991

The estimation of the annual growth rate in the compartment was based on an analysis of Thana population indicators. Data series were not complete and there was also some discrepancy between data coming from the health center and the family planning office. Moreover, the estimated growth rate from the Bangladesh Bureau of Statistics (BBS) was somewhat higher. Hence, it was assumed that a rate of 1%, being between the extremes, would be a good estimator for the population growth rate in the compartment. The table below gives details.

Thana	Data source	Growth rate	Period for which data exist	
Tangail Sadar	Family Planning Office	0.9%	1992	1998
Tangail Sadar	Thana Health Centre	1.3%	1995	1999
Delduar	Family Planning Office	0.9%	1995	1998
Delduar	Thana Health Centre	0.5%	1992	1999
National	BBS	1.7%	1993	1998

Table A4.2: Analysis of *Thana* population indicators

The number of persons migrating into or from the compartment was enumerated through the SCWMCs. The results are given in the two tables below.

SC	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
1	6						6		6	18
2					5			150		155
5				5	22	11	16			54
6		38	27	33	110	65	44	27		344
7		54	5	16	5	32	5			117
8								27		27
9		5	5		10			736	5	761
10	5	5	5		10		41	30		96
11		5		5		20	31	10		71
12	26	5	26	26	41	53	31	295	95	598
13	42	6		12	18	18	30	6	6	138
14								56	10	66
15	5			5	10		5	10	10	45
Total	**84**	**118**	**68**	**102**	**231**	**199**	**209**	**1 347**	**132**	**2 490**

Table A4.3: Annual number of persons that migrated to the compartment

SC	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
1		6		12				30	12	60
2								5		5
5	11									11
6				16	11	33	54			114
7			65	27	27	38	10	26		193
8					11	11				22
9	5		52		32	31	86	53		259
10			88	15	36	21	15	5		180
11		5	10	75	36		63	5		194
12				62	5			10		77
13	6		12	18	18	30	30	6		120
14	10		15	15	5	25	20	61	15	166
15	20			10			15		15	60
Total	**52**	**11**	**242**	**250**	**181**	**189**	**293**	**201**	**42**	**1 461**

Table A4.4: Annual number of persons that migrated from the compartment

A4.2 Estimation of Labor Used in Agricultural Production

The following table presents an estimation of labor used for each crop during the period 1991 to 1998. The areas came from the cropping pattern survey, the labor requirements were calculated from the input-output survey.

Season	Crop	Labour days needed	1992	1994	1995	1996	1997	1998	1999
Rabi	*Boro* (L)	263	43 898						
	Boro (MV)	273	925 002	1 754 503	1 763 780	1 762 143	1 823 264	1 848 367	1 807 165
	Oilseeds	161	204 225	209 060	360 899	230 659	242 587	317 056	562 061
	Potato	336	166 164		36 254	40 618	62 102	38 939	16 449
	Pulses	190	136 770	137 530	122 523	63 636	116 065	112 456	79 973
	Spices	74	21 333		4 667	2 148	6 519	1 852	
	Veges/minor crops	402	261 447	27 309	10 040	44 579	42 571	122 892	67 470
	Wheat	214	419 714	207 826	246 312	257 644	225 145	242 250	372 462
	Sub-total		2 178 554	2 336 229	2 544 476	2 401 427	2 518 252	2 683 812	2 905 579
Kharif 1	*Aus* (MV)	200	71 252						
	B. *Aus*	190	108 383	90 699	115 038	68 262	65 981	44 114	30 994
	Jute	314	474 738	508 916	439 932	626 503	660 368	652 843	483 204
	Sugarcane	330	228 071	412 574	381 549	244 244	170 971	171 301	180 542
	Sub-total		882 444	1 012 190	936 519	939 010	897 320	868 257	694 740
Kharif 2	D.W. *Aman*	182		192 852	381 143	243 574	328 049	232 991	310 716
	D.W.B. *Aman*	192	33 067						
	D.W.T. *Aman*	173	389 168	218 583	233 950	222 900	242 065	105 839	145 032
	T. *Aman* (L)	276	234 127	607 682	591 117	599 675	485 649	323 582	455 555
	T. *Aman* (MV)	286	63 397	105 947	198 757	412 935	411 221	322 409	703 074
	Sub-total		719 759	1 125 064	1 404 966	1 479 083	1 466 983	984 820	1 614 376
Perennial	Orchards	251	127 834			13 285	30 580	3 008	
Kharif 1&2	B. *Aus* + B. *Aman*	190	332 945						
GRAND TOTAL			4 241 535	4 473 483	4 885 960	4 832 805	4 913 135	4 539 898	5 214 696

Table A4.5: Labor uses in agricultural production (days)

Annex K
Economic Analysis

Table of Contents

Tables

206

Figures

List of Tables in the Appendix

Introduction

The primary objective of this report is to analyze and present the final impact of improved water management with regard to the compartmentalization concept. This concept has been tested by the Compartmentalization Pilot Project (CPP) in Tangail, known also as Flood Action Plan Number 20 (FAP 20), between 1992 and June 2000. It is worthwhile to mention that the project activities started as early as August 1992 but that for analytical purposes the start-up of the project is assumed to be 1993. Consequently, all costs incurred during that short period in August 1992 have been included in the costs for 1993.

The approach followed is that of a Cost/Benefit Analysis with emphasis on economic criterion with regard to national aspects. This is justified as flood protection and improved water management, both main objectives of CPP, cannot be independently provided to selected individuals. The data applied and the information used in forming the conclusions presented in this report originate in most cases from the data provided by CPP's Monitoring and Evaluation Section, as presented in full detail in Annex J. If other sources have been used, they have been cited accordingly.

Principles and Procedures

The methodology adopted for the economic analysis of the CPP follows the Flood Planning and Coordination Organization (FPCO) Guidelines for Project Assessment (GPA). These guidelines were published in 1992 and updated in March 1998, with the aim of standardizing the methodology and assumptions in the economic analysis of all FAP interventions. They are based on widely accepted techniques for the appraisal of water resources development projects and provide a good basis for achieving the necessary degree of uniformity and comparability between different options. Where recent changes have been made by the National Water Management Plan (NWMP), especially with regard to input and output prices and conversion factors, those have been adopted.

As stipulated in the GPA, the analysis period is 30 years, and 1999 has been chosen as the base year. All benefits and costs have been valued in constant 1999 prices. The rates applied to update historic costs and benefits to constant 1999 prices as well as exchange rates used to convert foreign exchange into Taka are those shown in the Table.1 below.

The opportunity cost of capital (discount rate) is 12 % (the "real" interest rate without inflation), considered by donor agencies to be the appropriate rate for project evaluation in Bangladesh. Taking inflation into account, the current interest rate would be, according to NWMP planning data, between 18 and 20%.

	1993	1994	1995	1996	1997	1998	1999	2000
Exchange rate 1)								
- DM	23.73	24.57	28.12	27.77	27.93	25.61	27.20	24.83
- DFL	21.28	21.94	25.11	24.81	24.84	22.72	25.94	23.68
- US $	39.10	40.00	40.20	40.80	42.70	45.30	48.50	50.00
GDP Deflator 2)	1.69	1.76	1.92	2.03	2.06	2.15	2.32	2.50
Inflation Factor 3)	1.37	1.32	1.21	1.14	1.13	1.08	1.00	1.00

Table 1: Exchange Rates and Inflation Factors

Source:
CPP M&E; BBS Statistics (US$, GDP Deflator and Inflation Factor)
1) Taka per unit of foreign exchange, 2) 1984 base, 3) to 1999 prices

Cost of facilities, which already existed prior to project start-up, such as the majority of embankments, have been regarded as sunk costs and have consequently not been taken into account. Neither have residual values for assets been considered which have an economic life beyond the analysis period, as their value, because of discounting practices, becomes negligible, nor have future replacement costs been included.

All farm-gate input and output prices used in forthcoming calculations are those proposed by the NWMP in their Working Paper: "Investment Criteria and Pricing for NWMP Analyses." Because they refer to constant 1997/98 prices, the inflation factor of 1998 has been applied to convert them into 1999 price basis. They are all present prices as opposed to projected prices. This is justified on the basis that:

> *"Forecasting future commodity prices is a notoriously uncertain process and taking present prices as being representative also of future prices at least has the virtue of being based on actual prices which have been applied in practice" (NWMP Working Paper).*

In fact, experience shows that using present prices has often produced more accurate results than if the World Bank forecast prices had been applied.

Financial costs are corrected by means of the conversion factors provided by the same source and shown in Table 2. in order to reflect the economic opportunity costs of resources and commodities.

In order, however, to reflect present conditions in the project area more realistically, in particular with regard to returns to crop production (gross margin) in financial prices, actual farm-gate prices for rice have been applied. The corresponding conversion factor has, therefore, been set at 0.8 as opposed to the NWMP factor of 1, in order not to distort the economic evaluation.

No conversion factor was given in the FPCO guidelines or by NWMP for the financial market prices of fish. Evidence of rising real prices of capture fish and the proven negative impact of increasing boro cultivation[1] on fish migration and recruitment onto the floodplains, are indicators of a depletion of fish stocks, which will most likely continue. In the present analysis a conversion factor of 1.2 has, therefore, assumed to convert the fish output into economic prices.

Taxes have been excluded from the analysis as well secondary benefits and costs in monetary terms. The latter, however, have been discussed in qualitative terms where noticeable impact is to be expected.

[1] for which low lying marshes (*beels*) will be lost for fish production

The economic viability, finally, of the compartmentalization concept has been judged based on three decision criteria:

- Economic Internal Rate of Return (EIRR)
- Net Present Value (NPV)
- Net Benefit / Investment Ratio (N/K Ratio)

Each of the above criterion on its own may not suffice to comprehensively judge the outcome of the economic assessment, in combination, however, they represent the appropriate basis for final judgement in comparing with other projects in the water resources sector.

Construction	Conversion F	Agriculture	Conversion F
Standard Conversion Factor (SCF)	0.90	Unskilled labor	0.85
Skilled labor, SCF	0.90	Rice, all	0.80
Unskilled labor	0.84	Jute	1.05
Cement	0.71	Potato	0.90
Steel	0.73	Wheat	1.00
Metal Products	0.67	Mustard	1.00
Vehicles	0.61	Pulses	1.00
Machinery, normal duty	0.67	Vegetables	0.90
Machinery, concessionary duty	0.86	Sugarcane	1.00
Engines, pumps, motors	0.77	By-products, SCF	0.90
Bricks, SCF	0.90	Seed (Jute, Potato, Vegetables), SCF	0.90
Dredging, earthwork, SCF	0.90	Seed, all other	1.00
Regulators	0.82	Draught power, SCF	0.90
River training	0.77	Urea	1.025
Permanent bank protection	0.75	Triple Super Phosphate	0.92
Slope protection, hard	0.75	Muriate of Potash	1.25
Physical contingencies, SCF	0.90	Plant Protection, Manure, SCF	0.90
Engineering and Administration, SCF	0.90	Fish	1.20

Table 2: Conversion Factors

Source:
NWMP planning data

Project Costs

All costs presented hereafter correspond to actual expenditures as recorded by the project Accountancy Department and monitored by the M&E Section. All costs have been presented in Taka and US $, in current and constant prices, as well as in financial and economic terms.

Total project costs, covering the period from the start-up of the project in August 1992 to the end in June 2000, here labeled project implementation costs, amount to 1,100.9 million Taka (26.05 million US$) in 1999 constant terms. As can be taken from the Figure.1 below, major parts of the funding came from The Netherlands, which financed the Technical Assistance component. Contributions from Germany in terms of financial aid, followed closely behind. The contributions of Bangladesh amounted to about 20% of total costs.

A more detailed break-down of total project costs has been provided in Tables A.1 to A.10 in the Appendix, attached to the present report. The corresponding information refers to major project components, their costs in Taka as well as in US$, both in current and constant (1999) prices, as well as to the timing of investments during the implementation period.

Table 3 recapitulates overall costs, both in Taka and US $ in current and constant 1999 financial prices.

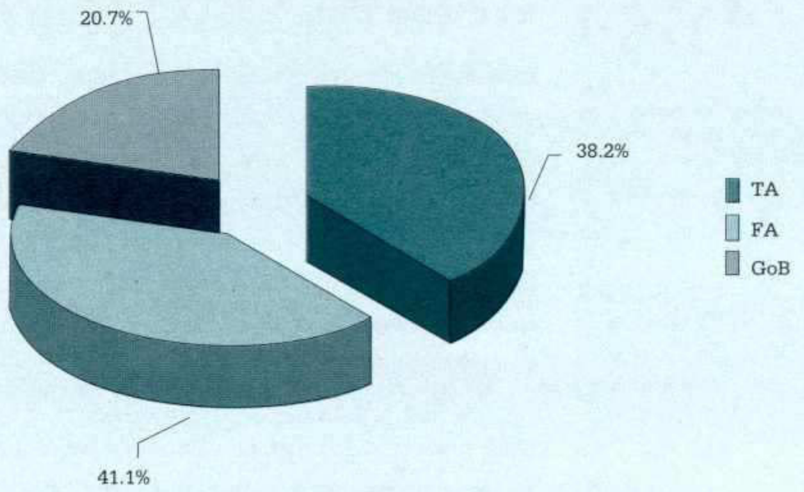

Figure 1: Source of Finance

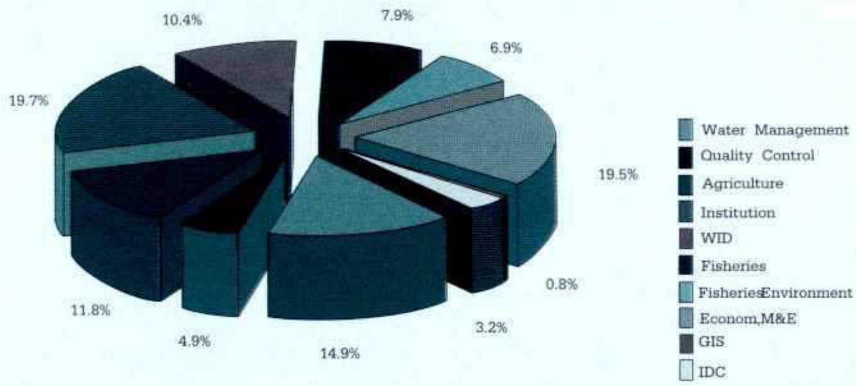

Figure 2: Personnel Costs per Working Section

Source of Finance	Current Prices		Constant 1999 Prices	
	Million TK	Mill US $	Million TK	Mill US $
Financial Assistance	432.26	10.24	498.52	10.28
Technical Assistance	453.89	10,68	536.71	11.07
GoB Contribution	214.73	5.13	249.39	5.14
Total Costs	**1,100.88**	**26.05**	**1,284.62**	**26.49**

Table 3: Project Implementation Costs

Investment Costs

Investment costs have been determined by the flood control and water management structures necessary to achieve the given objectives. Structural requirements and designs, the timing of investments as well as cost estimates have been explained in detail in Annex B. They are recapitulated here in tabular form as shown in Table 4.

The corresponding total construction costs in economic prices would amount to 588.08 million Taka, equivalent to 12.13 million US$, representing 85.8 per cent of financial costs.

Base costs refer to all costs incurred to build the main water control structures such as the main regulator, gated pipe inlets, out-takes, the re-sectioning of substantial parts of the existing embankments and the excavation of major *Khals*, as well as minor works such as culverts. Also included are bridges and roads where those were essential for water management and control purposes.

Investment Costs	1993	1994	1995	1996	1997	1998	1999	2000	Total
Base Costs	0.309	0.582	3.304	1.727	0.679	0.347	0.674	0.588	8.212
Land Acquisition	0.108	0.245	0.348	1.363	1.104	0	0.002	0.005	3.175
Mitigation measures	0	0	0.044	0.059	0.879	0.164	0.084	0.074	1.303
Supplementary Costs	0.090	0.130	0.181	0.171	0.102	0.053	0.025	0.001	0.753
Office Equipment	0.227	0.037	0.024	0.014	0.020	0.011	0.083	0.020	0.435
Contingencies	0.056	0	0.007	0	0.017	0.027	0.071	0.078	0.256
Total	0.791	0.994	3.908	3.334	2.800	0.602	0.938	0.766	14.133
Realization (%)	5.6	7.0	27.6	23.6	19.8	4.3	6.6	5.4	100
cumulative		12.6	40.3	63.9	83.7	87.9	94.6	100	

Table 4: Total Investment Costs (mil. US$, 1999 constant, financial prices)

	Gross Area 13,200 ha	Net Cropped Area NCA (1999) 2) 9,858 ha
Tk/ per ha 1)	30,771	40,416
US $ per ha 1)	622	833

Table 5: Cost of Construction per Hectare

A total of 152.5 ha of land had to be acquired to facilitate the construction of all structures, 19.04 km of new embankments in addition to new roads. Compensation for land was firstly based on the land value as determined by the Land Registration Office. In addition, premiums were paid as fixed by the District Commissioners Office, if the land in question included homesteads or standing crops. Total land acquisition prices included a further 10 % (formerly 5%) service charges to cover the expenses of the authorities in charge. In monetary terms, this amounted to about 636,645 Tk/ha (13,127 US current $/ha, which appears to be extremely high by international standards). It should be noted that out of the total of 153.97 million Taka (4.11 million US$) in constant 1999 financial prices (Conversion factor of 1), paid for land and included in the analysis, 21. 05 million TK (0.43 million US$) still has to be paid to farmers (March 2000).

All active support by the project to eliminate or minimize detrimental impacts such as interruption of communication lines (water and road transport) within the project area as well as in the adjacent areas caused by project activities, have been classified mitigation costs. They include roads, bridges, excavation of *Khals* and protective works, and, as the major component, the Tangail town drain. Total mitigation costs in constant 1999 terms amount to 63.2 million Tk (42.9) equal to 1.3 mill US$ (0.88).

Additional costs not to be grouped under either of the above headings have been included as supplementary costs, comprising surveys, purchase and repair of vehicles, quality control and training costs, but also wages for some local, in particular GoB, staff. In total 37.06 million Tk or 0.76 mill US$ in constant 1999 prices have been included in the analysis.

Office equipment totaled 21.09 mill Tk (0.43 million US$) while additional 12.42 million Tk (0.26 million US$) for contingencies, all in constant 1999 prices, finally completed investment costs.

A breakdown of investment expenditures per year have been calculated and presented in the Appendix at A.11 and A.12. Almost two third (62.3%) of all construction works had been completed by 1996. It was in this year that water management started, as with the completion of the main regulator the same year, the inflow of water into the compartment could be regulated.

Operation and Maintenance Costs

In the context of the present analysis, operation and maintenance will be divided into the following four groups:

- Personnel
- Administration
- Training
- Maintenance.

All **personnel costs** have been included irrespective of their nature as permanent or support staff and their origin such as expatriate long-term or short-term or local staff. In terms of costs, local staff accounted for about one third (27.3%) of all personnel costs and one fifth of all TA. Unfortunately, a detailed presentation of personnel costs per year and per CPP working section could not be established as corresponding information for the First Phase is missing. Based on the figures available for the Final Phase, at least a separation of costs per Section in relative terms could be calculated. The results are shown in Figure 2.

The contents of the legend in Figure 2 refer to CPP working sections, as they have been operational, at least during the second phase of the project. GIS stands for Geographic Information System used synonymously for Modeling, WID means Women in Development and IDS is the abbreviation for Information and Dissemination Center in Tangail town.

Total staff costs up to June 2000 amounted to (399.72 TA + 84.07 GoB) 483.79 mill Tk or 9.98 million US$ in constant 1999 financial terms. It is believed that the weight per section shown below (excluding GoB paid staff), is more or less representative for the overall implementation period.

For personnel costs after the implementation period, 50 % of the last cost spent by the Government, which were 3.87 million Taka (80,000 US$) in the year 2000 is believed to be sufficient to cover the corresponding expenses (supervision, monitoring and evaluation).

Administration costs totaling 43.4 million Taka (0.9 million US$) in 1999 constant terms, are those costs actually incurred during the lifetime of the project. It is assumed that 50% of the costs spent by the FPCO on CPP during the year 2000, equal to 1.87 million Taka (almost 40,000 US$) per year, will suffice to assure operational standards in the project in the future.

Training is self-explanatory and corresponding costs came to 60.07 million Tk (1.24 million US$) in constant 1999 financial prices. No training costs attributable to CPP are foreseen in coming years.

The Water Management Section of CPP has calculated **maintenance costs** per type of structure and corresponding requirements. Typical rates are summarized in Table 6.

All those figures have been taken from Annex B, Appendix 2: Maintenance Plan, which may be consulted for details as to the calculatory background. Table 7 lists the water control and management assets set up by CPP in the project area.

Presently existing assets, as summarized in the Table, multiplied by the respective maintenance costs per type of structure, yield the annual costs for maintenance to be reserved for future operations, indispensable to guarantee the continuation of water management standards achieved. Total annual minimum maintenance costs are consequently in the range of 10 million Tk per year (20,500 US$) in financial terms. All recurrent costs are summarized in Table A.13 and A.14 of the appendix.

226

Cost Item	Maintenance			
	Preventive	Periodic	Emergency	Total
Embankment			300,000	300,000
- peripheral	846,000	1,786,000		2,632,000
- internal	234,000	494,000		728,000
Khals **(Canals)**				
- main	4,684	1,639,400		1,644,084
- secondary	10,899	708,422		719,321
- minor	2,714	108,546		111,260
Structures			200,000	200,000
- peripheral	79,346	746,400		825,746
- along Lohajang	92,411	913,635		1,006,046
- internal	92,742	856,200		948,942
Protective works	150,000	400,000	200,000	750,000

Table 6: Annual Maintenance Cost

Type	Embankments, Km	*Khals, Km*	Structures, Numbers
- peripheral	47.0		14
- internal	13.0		35
- main		23.4	
- secondary		54.5	
- minor		18.1	
- along Lohajang			16

Table 7: Number of Water Control Assets in CPP

It is worth mentioning here that above maintenance costs represent about 2.5% of the initial investment costs for structures (excluding land acquisition and mitigation costs), This compares favorably with the 6% recommended in the GPA for embankments and 3% for regulators and culverts.

Benefits

The project costs could be taken almost exclusively from project accounts; the exception was for future maintenance costs, which have been estimated. The benefits, however, had to be based on estimates drawing on the operational experience of about three years within the CPP area. In addition, some assumptions had to be included with regard to long-term impacts of compartmentalization. Developments in adjacent areas have been compared with developments inside the compartment in order to identify trends solely attributable to improved water management and flood protection.

Major fields for potential direct benefits dealt with include:

- Agriculture
- Fisheries
- Damage prevention.

Agriculture

Given the prevailing climatic conditions in the project area, positive effects to be expected by improved water-management may come from more favorable conditions for agricultural production in the monsoon season. Unfortunately, the system can not allow for bringing extra water to the agricultural land during the Rabi season, when it would most be needed.

Changes will come about by delaying early floods in the *Kharif* 1 season and by lowering water levels in the *Kharif* 2 season combined with faster drainage of water of late floods in the beginning of the *Rabi* season. This will increase the cultivable area in two ways. First, by an increased planting on the edge of *beels* and secondly, an increase in cultivation on land previously left fallow due to flood depth. In addition, there is an intensification of agricultural production by permitting a switch from broadcast aman to Transplanted *Aman* in the monsoon season. It is thus believed that substantial benefit with regard to agricultural production attributable to improved water management by compartmentalization will occur primarily during the monsoon season. However, additional benefits will come, as the faster drainage at the end of the flood season will allow an increased planting of mustard.

The evaluation of benefits in the agricultural sector has been based on the behavior of three indicators within project boundaries as compared to those in the adjacent areas both, North and South of the project. Those indicators are the:

- Cropping intensity
- Cropped areas
- Yield

The corresponding data has been taken from the cropping statistics provided by the Agricultural (see Annex E).

Details as to the land use conditions in the project area prior to the start-up of the project compared to the present situation can be taken from Tables A.15 and A.16 in the Appendix. Over the implementation period, the cropping intensity in the project area increased from 191% to 214 %. In the adjacent areas, over the same period, cropping intensity rose from 191 % to 199 %. Looking at the figures more closely reveals that major changes occurred during the *Rabi* season (*Boro* rice), even more clearly in the CPP area than outside; an observation supported by the large increase in the number of shallow tube wells (STW) from 881 in 1997 to 1,441 in 1999.

In order to discuss the impact with regard to crop areas, the table presented below has been prepared.

Crop	CPP Area			Adjacent Areas		
	1992	1999 1)	Change (%)	1992	1999 1)	Change (%)
T.*Aman*	1,070	3,912	265.6	513	700	36.5
- HYV	222	2,362	964.0	134	377	181.3
- local	848	1,550	82.8	379	323	-14.8
DW. *Aman*	3,718	2,543	-31.6	1,234	1,538	24.6
- broadcasted	1,464	0	-100	943	1,298	37.6
- transplanted	2,254	2,543	12.8	291	240	-17.5
Aus	3,390	139	-95.9	1,178	215	-81.7
- HYV	726	0	-100	62	1	-98.4
- local	2,664	139	-94.8	1,116	214	-80.8
Jute	1614	1,350	-16.4	733	422	-42.4
Sugarcane	691	547	-20.8	786	692	-12

Table 8: Development of Crop Area

Average figures

What is notable from the table is the huge shift into Transplanted *Aman* within the project area.

Based on the data shown in the table above the net impact on crop areas attributable to improved water management by compartmentalization has been determined and summarized in the following table.

Crops	CPP Ha 1992	Recorded Changes		Net Changes	
		% CPP	adj. Area	% Total	p.a.
- ***Boro***					
* HYV	3,390	110.2	43	67.5	7.6
* local	431	-100.0	-34	-65.8	-14.2
- **T. *Aman***					
* HYV	222	964.0	181	782.6	36.5
* local	848	82.8	-15	97.6	10.2
- **DW. *Aman***					
* broadcast	1,464	-100.0	38	-62.35	-13.0
* transplanted	2,254	12.8	-18	30.37	3.9
Total *Kharif* 2 area	4,788				
- ***Aus***					
* HYV	726	-100.0	-98	-99.99	-71.9
* local 1)	2,664	-94.8	-81	-94.78	-34.4
- **Jute**	1,614	-16.4	-42	26.07	3.4
- **Sugarcane**	691	-20.8	-12	-8.88	-1.3
Total *Kharif* 1 area	5,695				
- **Potato**	138	-2.9	-7	4.21	0.6
- **Wheat**	1,963	-17.6	12	-29.61	-4.9
- **Mustard**	1,277	110.2	-14	124.64	12.3
- **Pulses 1)**	733	3.1	113	3.14	0.4
- **Vegetables**	135	104.4	-48	151.94	14.1
- **Other crops**	68	-30.9	0	-30.88	-5.1
	4,314				

Table 9: Net Impact on Land Use with Project

Similar to the identification of the net impact on crop area attributable to the project, crop yields inside and outside the project area have been compared in order to determine yields "with" project for inclusion in the economic analysis.

৩৯

Crop	CPP Area			Adjacent Areas		
	1992	1999 1)	Change (%)	1992	1999 1)	Change (%)
T.*Aman*						
- HYV	3,244	2,905	-10.5	3,244	2,860	-11.8
- local	2,163	1,774	-18.0	2,163	1,779	-17.8
DW. *Aman*						
- broadcasted	1,523			1,523	1,521	-0.9
- transplanted	1,813	1,617	-10.8	1,813	1,703	-6.1
Aus						
- HYV	2,748			2,748	2,099	-23.6
- local	1,450	1,032	-28.8	1,450	922	-36.4
Jute	1,727	1,564	-9.4	1,727	1,574	-8.9
Sugarcane	30,770	44,000	43.0	30,770	35,000	-13.7

Table 10: Development of Crop Yields

1) Average values, CPP 6 years and five years in adjacent areas

Table 10 shows clearly that yields for rice are, in the main, falling in both the project area and the adjacent area. This is almost certainly due to both the more intensive cropping of land, which leaves no opportunity for fallow; and the mono-culture of rice which is both exhausting for the soil and leads to increased incidents of pests and diseases. Within the project area, the decrease in yield is more than compensated for by the increased area under cultivation and the increased intensity.

Yield increases retained in the economic analysis as presented below, therefore, come from the switchover of both, rice varieties (local to HYV) as well as rice types (Deep Water *Aman* to Transplanted *Aman*). For analysis purposes, following rates for value added have been assumed (see Table 11 below). For details as to prices retained in the computation of value added, for conversion factors used to transfer financial into economic prices, and for general assumptions as to variable costs included see Table A.17 to A.19 in the Appendix.

Crop	"with" Project		"without" Project	
	Economic	Financial	Economic	Financial
***Kharif* 1**				
(*Aus* rice, Jute, Sugarcane)	18,244	18,510	16,035	17,677
***Kharif* 2**				
Aman rice	18,346	22,986	14,716	18,496

Table 11: Average Value Added Retained in the Analysis

Kharif 1 crops have been included in the analysis as it is assumed that some additional benefits resulting from improved water management in the project area may come from damages prevented to these crops which would otherwise have occurred in early floods. To determine the damage prevented to *Kharif* 1 crops, it has been assumed that floods of a return period of 2, 5, 10 and 20 years will cause damages worth 5, 15, 40 and 70 per cent of the crop, resulting in damages of 926; 2,777; 8,330 and 13,884 Tk/ha per different return periods respectively.

Return Period	Frequency	Gross Damage	Added Frequency	Mean Damage	Weighted Damage	Yearly prevented Damage
Years	Million Tk		Mil. Tk	Million Tk	Million Tk	Million Tk
1				0	0	0
2	0.50	912	0.50	456	228	228
5	0.80	2,737	0.30	1,824	547	775
10	0.90	8,210	0.10	5,473	547	1,323
20	0.95	13,683	0.05	10,946	547	1,870

Table 12: Annual damage Prevented to *Kharif* I Crops

Based on a probability analysis as outlined in Table 12 above, the annual benefit to be included in the analysis amounts to 1,870 TK (38.6 US$) per ha.

Fisheries

Catch data in the project area since 1992 do not indicate a statistically relevant reduction on capture fish. The general impression is that adverse impacts on capture fisheries are much less serious than has been assumed from the outset of the project. Annex F to this report gives more detail of this.

No disbenefits have been assumed for open water fisheries losses.

There have, however, been positive effects of the project on aquaculture. The reduced risk of flooding (and losing cultured fish) has led to a rapid growth of aquaculture in the project area. The fisheries section of CPP has contributed greatly to this expansion and to increased yields of fish by providing an effective extension service for the project. Aquaculture can be seen as the most successful crop option within the project, but it is one confined to people who have sufficient land to construct a fish pond. These people are the medium to large farmers. It is these farmers too; who have the capital to invest in fish culture.

Table 13 below shows the growth of aquaculture in terms of area and yield.

Category	Number of Ponds	Water Area per Pond (average)	"without" project Production	"with" Project Production	Growth Rate
		M^2	Kg/ha	Kg/ha	%/a
Culture Pond[2]	1,343	1,713	861	2,048	15.5
Culture Pond[6]	944	668	603	857	6.0
Derelict Pond	814	725	373	525	5.7
Total	**3,100**	**803**	**733**	**1,585**	**13.7**

Table 13: Aquaculture with and without the project

Source: Annex F, Fisheries
[2] large
[6] small & medium

Table 14 shows the value added by fish culture within the compartment. As can be seen, it represents a considerable benefit within the project.

	Production Tons/year	Value Taka mil.	Input cost Taka mil.	Value added Taka mil
W/o project	258	18.06	4.46	13.60
With project	558	39.06	7.42	31.64
		$	$	$
W/o project	258	361,200	89,280	271,920
With project	558	781,200	148,465	632,735

Table 14: Aquaculture Benefits

Non-Agriculture Benefits

Floods in the context of compartmentalization will be understood as the combined effect of external floods, caused by overtopping of riverbanks due to events mainly or entirely outside the project area and internal floods, originating from heavy rains inside the project area.

In Bangladesh, little effort, in particular in non-agricultural sectors, has been undertaken so far as to the systematic collection and evaluation of flood damage data. Indeed, official information collected at different stages during project implementation from the Tangail Sadar Thana office of the Ministry of Relief and Rehabilitation differ substantially from those provided by the Department of

Agricultural Extension, also at Tangail Sadar Thana level. The information proved to be incomplete, inconsistent and partially incorrect. Differences in some categories were as high as 500 percent.

In order to establish more reliable information with regard to non-agricultural flood damages avoided, due to the compartmentalization concept to be included in the economic analysis, the unit loss appraisal model has been applied. This model as recently received widespread acceptance for appraising flood alleviation schemes. It has been modified to suit the specific conditions in the project area and involves the identification of flood prone properties and their corresponding values. Through interactive iteractions, it computes potential damage of floods of different frequencies, flood levels and duration. The model and all underlying assumptions have been described in all detail in Annex G.

According to the model, the potential gross damage in the different sectors included in the damage assessment, being:

Residential areas

- Business
- Industry
- Roads
- Public sector

has been identified and summarized in Table 15 below. It should be noted that the potential damage at the same time represents the non-agriculture benefit to be included in the analysis, as it is believed that those damages can be prevented by compartmentalization.

	(Return Periods /Years)							
Category	**2**		**5**		**10**		**20**	
	Mill Tk	**Million US $**	**Mill Tk**	**Million US $**	**Mill Tk**	**Million US $**	**Mill Tk**	**Million US $**
Residential Areas	5.8	0.12	16.8	0.35	87.3	1.80	202.2	4.17
Business	0.3	0.01	3.1	0.06	14.7	0.30	34.2	0.71
Industries	0.9	0.02	2.9	0.06	8.3	0.17	19.6	0.40
Public Buildings	0.2	0.01	2.6	0.05	6.1	0.13	9.4	0.19
Roads	0.3	0.01	3.8	0.08	5.8	0.12	6.2	0.13
Total	**7.5**	**0.15**	**29.2**	**0.62**	**122.2**	**2.52**	**271.6**	**5.60**

Table 15: Flood Damages per Category and Return Period (constant1999 prices)

In determining the gross damage, a division has been made between rural and urban areas, whereby the latter refers to the town of Tangail, located almost in the center of the compartment. It has been shown that about 60 percent of all damages avoided can be achieved in Tangail town alone and that the residential areas benefit most from damage prevention (72 % of all damage avoided). Secondary benefits in "industries" and "business" have not been taken account of in the analysis.

Following the probability analysis, annual damages prevented of 24.8 million Tk (511.340 US$) will be included in the economic analysis here, as can be taken from the Table 16 below. The conversion factor for structures of 0.84 has been applied to convert those benefits into economic prices.

Return Period	Frequency	Gross Damage	Added Frequency	Mean Damage	Weighted Damage	Yearly prevented Damage
Years	Million Tk		Mil. Tk	Million Tk	Million Tk	Million Tk
1		0		0	0	0
2	0.50	7.5	0.50	3.8	1.9	1.9
5	0.80	29.2	0.30	18.3	5.5	7.4
10	0.90	122.2	0.10	75.7	7.6	15.0
20	0.95	271.6	0.05	196.6	9.8	24.8

Table 16: Annual Damage Prevented (million Constant 1999 TK)

In comparison to corresponding benefits identified in the FAP 2, North West Regional Study, above values are extremely high. Data in the source cited above suggest values of about 600 Tk (12 US$) per ha NCA (adjusted by the GDP deflator to 1999 prices) while the equivalent value for CPP would come to 2,517 Tk (52 US$) per ha, more than 4 times as high.

Irrespective of above arguments, the value identified for the CPP area has been retained here mainly because of the high portion of residential urban areas as represented by Tangail town. Yet, damage of floods on physical infrastructure (roads, buildings etc.) and interruptions in commercial and social activities due to floods are most likely less severe than generally assumed because of:

- Mismanagement, indifference and lack of funds of authorities in charge of maintenance of these assets, resulting in their fast degradation outside floods.
- Constant misuse of existing roads by overloaded trucks and busses going at high speeds, thus destroying the sub-structures of the roads, damages which are not or not correctly repaired but which are then later attributed to floods.

- Poor construction and maintenance standards of buildings and roads, and little repair of less severe flood damages, but revaluation of all assets at acquisition prices after each flooding event, rather than on much lower time values.
- Over-estimation of the outcome of in particular industrial and commercial activities within the CPP area due to frequent power cuts, poor communication lines, unreliable supplies of production factors, poor storage facilities, complete absence of any production, processing and quality standards and largely underutilized capacities in addition to low level of professional skills of labor force, obsolete technologies and equipment used in processing.

In reality, exceptional floods uncover largely, man-made deficiencies. Real damages attributable to floods are much less severe, due to the flood awareness of the population and the business community. Flood proofing (construction materials and design in rural houses, being often light shacks that can be packed up and removed within hours if the river rises) and flood damage prevention (storage, re-location in less flood prone areas...) is practiced. On national level floods seem at present to be used to some extent to hide human shortcomings in natural resources management.

For the convenience of an easy evaluation, Figures 3 and 4 show the Flood Damage Curve for both, the urban and the rural area.

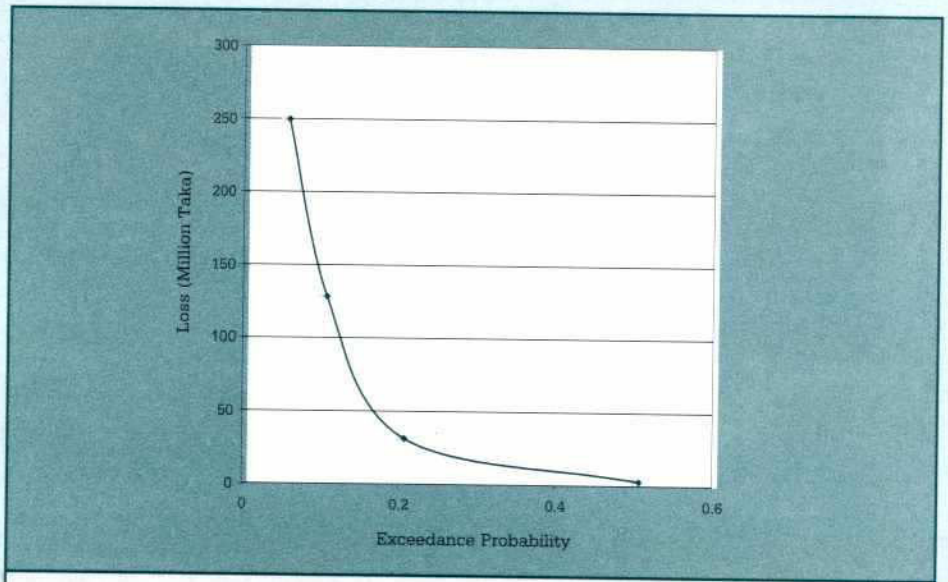

Figure 3: Loss probability curve - SC16

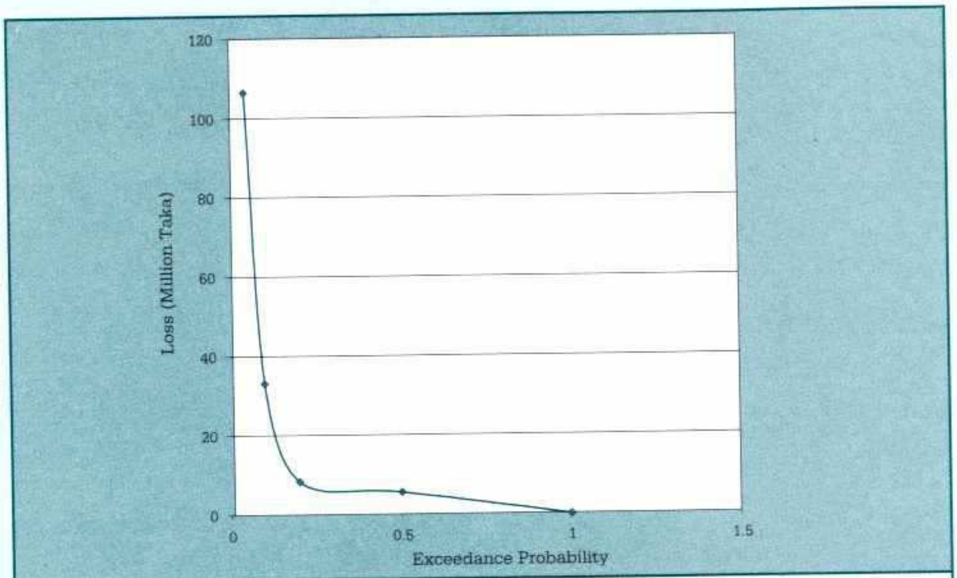

Figure 4: Loss probability curve - SC1- SC15

Secondary Impacts

Secondary impacts will be discussed in qualitative terms. They have not been quantified in monetary terms and are consequently not included in the economic analysis. Where applicable, objectively verifiable indicators have been applied to support our findings.

The *Chari* in the *Bari* Program

Those who suffer most from any reduction in capture fisheries in the flood plains (and thus from worsening nutritional conditions), are the rural poor and land-less. These people do not benefit from increased pond production as they lack the land on which to construct a pond and also lack cash to purchase cultured fish.

Realizing this, the second, component of CPP's aquaculture extension activities has been the *Chari* in the *Bari* program that emphasizes poverty alleviation, by concentrating on the "poorest of the poor". Those households were taught to "grow" good-quality *magur* (African catfish, *Clarias gariepinus*) in a feeding bowl (*Chari*) on their homestead (*Bari*). Even though a *chari* would suffice, the fish is generally kept in holes in the ground, often not bigger than one square meter; where about fifty fish grow from 150 gms to ten to twelve kg within ten weeks (a growth rate of 150 gr/d on average).

It is assumed that this activity will continue on farmer's own initiative once the project has come to an end, which is what one would really hope for. However, it should be realized, that this activity, too, does not need a project such as CPP as a pre-requisite condition.

Dependency on Agricultural Support Services

Dependency on agricultural support services may be evaluated - especially in economies where agricultural production is based predominantly on subsistence criteria - on the ratio of local varieties used in comparison to high yielding varieties. The latter, no doubt, needing complementary services to take full advantage of the higher genetic potential of improved seeds. The pre-project ratio is given with 1:0.6 in favor of local varieties; the present ratio is now 1:0.4 in favor of HYV. This will certainly further increase the dependency on supporting services, such as:

- Input supply services (quality seed and fertilizer, agro-chemicals)
- Extension services
- Marketing
- Rural credit.

The majority of farmers in the project area will by not be able to cope with these challenges on their own. Development in the future will, therefore, have to be more effectively accompanied by an intensification of agricultural support services, including improved institutional support. It should clearly be understood that, for yet a long time to come, this support will continue to be mainly a public sector responsibility.

Livestock

It appears that because of intensified land use systems, in particular in the dry season, the number of cattle will continue to decrease, which may largely be explained with growing competition for agricultural land between crop and livestock production. Maybe because of profitability criteria, cattle will suffer from this competition. Shortage of feed is the major constraint for further dairy development. All concentrate cattle (and poultry) feed comes from Dhaka. However, livestock developments have not been influenced by CPP activities.

Nutrition

The over-proportional expansion of rice crops that apparently took place in the area during the implementation period may undoubtedly be explained with the pressure of growing demand for food (rice) because of population growth. This took place almost exclusively on Rabi areas and would certainly have taken place in the region, even without the project. This reduces the options for crop diversification, which would otherwise improve nutritional standards for the population. Apparently, there will be no compensation for losses in the provision of protein of animal origin (the general reduction of fish production) by a diversified supply of proteins of vegetative origin. However, CPP will have no impact on this in either direction.

Income Distribution

Smallholder farming systems are generally accepted as the most adequate form to promote the primary sector where agriculture is based predominantly on subsistence criteria. There must, however, be a clear distinction between small and marginal farmers. Marginal farmers (at present about 23% of all farms in the project area) will certainly not be able to contribute favorably to economic growth.

Available evidence shows that the average farm size in Bangladesh has decreased from about 1.5 ha in 1977 to about 0.7 ha at present, with a growing proportion of marginal and land-less farmers (depending on share cropping systems). There are signs that this trend will continue. Here again, the project will have no means to influence this development.

Based on the farming systems research, completed in the CPP area in 1996, the average farm size in the project region has been identified to be about 0.8 ha. Small farms (on average 0.7 ha) forming by far (52%) the dominating group, followed by marginal farms (0.34 ha, 23 %) and medium farms (1.36 ha, 15 %).

In any project that leads to improvements in agriculture, and CPP is no exception, the people with the most agricultural land benefit more than those with less land.

Secondary Sector

The greater region of which the project area only forms one, although considerable part may be favored in terms of natural conditions (climate, soils, and water...) and may, therefore, be especially favorable for agricultural production. It offers, however, no outstanding features in favor of industrial development.

Enterprises of truly industrial norms are non-existent. Almost all activities represent, at the best, either semi-industrial standards, mostly in the field of agro-industries, or may be understood as what is best described with the term of "cottage industry". The latter comprises handicrafts related to pottery, bamboo, low-value jewelry and weaving. These activities will not be touched by the project in its present context, nor will they, on the other hand, affect improved water management as practiced by the project.

In addition, there is the wide range of activities of the informal sector, guaranteeing functional processes of daily life. In this category, all services are comprised which are offered by the local trade and transport, traditional construction and repair enterprises (furniture, mechanical and electrical workshops), as well as food processing and production (gur, bakeries...). This informal sector, without question, is the most vital component of further progress, both in the urban and rural setting. It is continuously formed by autonomous processes, which will to the least be influenced by improved water management through compartmentalization.

Industrial development is determined by factors beyond the influence of improved water management such as compartmentalization, which is by definition restricted to rather small areas. Determining factors are, only to name the most popular, the availability of natural resources (raw materials), comparative advantage in geographical location (i.e. flood-safe conditions...) and physical infrastructure (railway, road network, and harbor...) in comparison to other regions as well as human resources (special skills or abilities). None of the above criteria is in particular in favor of the project area and none can be decisively be influenced by the compartmentalization concept.

Evaluation

Benefits to be considered as discussed above are:

- Agricultural benefits
- Aquaculture benefits
- Damage avoided to agriculture
- Damage avoided to non-agricultural activities and structures

At their full level, total economic benefits are 86.89 million Tk (1,780,423 US$) per year. As can be seen from the cash flow, presented in the Appendix Tables A.26 and A.27, first benefits are assumed to have been achieved in 1997 after the system became operational in 1996. Although the cash flow becomes positive from the year 2001 onwards, project benefits will not be able to offset the capital expenditure as shown by the N/K Ratio of 0.80. (Appendix Table A.28)

Although benefits exceed costs from the year 2000 onwards the Internal Economic Rate of Return (EIRR) of 3.1%, can hardly be judged attractive. Consequently, the NPV (at 12%) remains also negative, showing values of -9. 459 million US$. All above figures with regard to investment decision criteria (N/K Ratio, EIRR and NPV) refer to the base case.

It can be argued that because of CPP being a pilot project, some of the capital expenditures on water control structures as well as personnel costs have been unnecessary or at least unnecessarily high. Indeed, it is believed that some costs could have been avoided. Those have been identified as follows.

The mathematical model used in the early years of the project to simulate external flooding patterns and their hydrological consequences for the compartment was not sufficiently refined to allow precise enough simulations of internal water conditions. The number of structures based on those findings and partly their design believed necessary was too high and too costly respectively. Alternative costs of in total 206.54 million Tk (4.26 million US$) have been suggested as reasonable (see Table 10, Annex B).

Even though CPP is a pilot project, it is difficult to justify charging the project with activities such as: women in development; agricultural extension and applied research; M&E; institutional development and an information dissemination center, which are normally linked to regional or rural development. While all of those activities are undoubtedly highly valuable in their own right, they could and should have, at least in parts, been executed and monitored by the existing specialized public organizations. Corresponding costs have consequently eliminated or reduced as follows, including GoB contributions.

Eliminated	Reduced
Women in Development	Agriculture -50 %
Information and Dissemination Center	Institution - 50 %
	M&E - 50 %

Overall, cuts in personnel costs amounted to a total reduction of those costs of 40%.

A fair compensation of landowners, is clearly justified but land acquisition charges of about 700.000 Tk/ha (14,430 US$/ha), including service charges, is not justified. Alternatively, determined fair compensation rates based on payments of production forgone (rent) revealed figures as low as 40% of above payments. It must be feared that farmers did not benefit in full from the compensation payments cited above. A land acquisition price of 50 % of the paid rates has, therefore, been assumed here.

Tangail drain may be useful and necessary. It is, however, doubtful if its inclusion as mitigation cost in a project such a CPP is justified. It has been omitted from further evaluation.

Expenses for surveys (supplementary costs) appear to be extremely high and not justified to that extent. They, too, have been reduced by 50 %.

Summarizing above alterations results in savings as shown in Table 17 below.

	Base Case		Alternative Costs		Savings	
	Million Tk	Million US $	Million TK	Million US $	Million Tk	Million US $
Construction Costs	398.26	8.21	206.54	4.26	191.72	3.95
Personnel Costs	483.79	9.98	290.27	5.99	193.52	3.99
Land Acquisition	153.97	3.17	77.00	1.60	77.00	1.60
Tangail drain	42.88	0.88	0	0	42.88	0.88
Surveys	18.43	0.38	9.22	0.19	9.22	0.19
Total Implementation Costs	**1,284.62**	**26.48**	**770.28**	**15.88**	**514.34**	**10.60**

Table 17: Alternative Project Cost (Financial 1999 constant prices)

Total savings represent about 40% of original implementation costs. Re-evaluating the viability by accepting the alternative parameters gives a much better rate of return of 7.9%. However, if the discount rate is 12 percent this is still far from satisfactory.

ERR	**7.3%**
NPV	**-4 million US$**

The problem is that a project of this type is largely dependent upon agriculture for its benefits. Where, as in the project area, we already have very intensive cropping, any incremental benefits are hard won and although real, are never going to be sufficient to measure up to a 12 percent discount rate.

All of the decision criteria, presented above, clearly indicate that even under the substantially more favorable conditions with regard to the implementation costs, compartmentalization under Tangail (Bangladesh) conditions is not a viable water management program at a discount rate of 12 percent.

A sensitivity analysis adhering to common methodological standards will not permit a judgement differing substantially from the one provided above. Variations of prices or yields, changing implementation schedules or shorter development periods for benefits to reach final values will all have no significant impact, if justifiable ranges are tested. Output would have to increase by 150% before break-even conditions will be obtained (EIRR of 12%, NPV of 0). This is beyond the boundary of probability.

Change			ERR
			3.1 %
a	Construction Costs	- 40%	4.0 %
b	a+ Personnel Costs	- 40%	5.7 %
c	a+b+ Land acquisition	- 50%	6.8 %
d	a+b+c+ Tangail drain out		7.3 %
e	d + Benefits	+ 57%	12.0 %

Table 18: ERR

Conclusion

It is beyond doubt that major justification for flood protection and improved water management in an economy based primarily on agriculture, must come from incremental agricultural benefits. The corresponding potential, however, is understandably marginal in regions which already have a relatively high degree of economic development. This is the case in the Tangail CPP area, where the cropping intensity under pre-project conditions has been as high as 191%.

Appendix A: Analysis and Tables

Investment Costs		1993	1994	1995	1996	1997	1998	1999	2000	Total	%
Main Works											
Embankments 1)		0.58		9.00	18.16	8.74	4.69	3.21	6.70	51.08	11.8
Protective works		3.20	6.87	1.27	5.65	0.38	0.86	20.52	3.47	42.21	9.8
Elangani River Loop cut					3.36	0.75	0.06			4.17	1.0
Khals/Canals		1.95	0.06	4.73	10.82	3.03	3.22	2.61	2.37	28.79	6.7
Main regulator				19.83	3.80			0.24	0.18	24.05	5.6
Gated Pipe Inlet (GPI)								2.30		2.30	0.5
Intake 2)		2.53		15.67	2.76	1.34	0.23	0.34		22.88	5.3
Outlet		1.92	12.91	16.85	17.28	7.76	0.32	1.55	2.18	60.78	14.1
Water Control Structures (WCS)			0.40	43.15	5.65	3.67	3.22	0.71		56.79	13.1
Roads, Bridges and others		0.78	1.16	21.96	6.00	0.68	0.41	0.26	13.55	44.80	10.4
Subtotal		**10.96**	**21.40**	**132.45**	**73.49**	**26.35**	**13.02**	**31.73**	**28.46**	**337.85**	**78.2**
Minor Works											
Culverts						2.79	2.59	0.95	0.05	6.37	1.5
Subtotal		**0.00**	**0.00**	**0.00**	**0.00**	**2.79**	**2.59**	**0.95**	**0.05**	**6.37**	**1.5**
Mitigation Measures											
Road						4.25	1.22	0.17	3.25	8.89	2.1
Bridge				1.75	2.49	3.37	1.54	0.32		9.47	2.2
Tangail Drain						30.12	4.59	3.56	0.34	38.60	8.9
Others 3)								0.03		0.03	0.0
Subtotal		**0.00**	**0.00**	**1.75**	**2.49**	**37.73**	**7.35**	**4.08**	**3.59**	**56.99**	**13.2**
Supplementary Costs 4)											
Surveys		2.76	4.19	4.04	1.57	1.35	0.64	0.04	0.20	14.77	3.4
Wages local staff 5)		0.04		3.13	4.42	2.62	1.44	1.14	0.40	13.19	3.1
Miscellaneous costs 6)		0.40	0.59	0.07	1.28	0.40	0.31	0.03		3.09	0.7
Subtotal		**3.20**	**4.77**	**7.25**	**7.26**	**4.36**	**2.40**	**1.21**	**0.60**	**31.05**	**7.2**
Total	**mil. Tk**	**14.15**	**26.17**	**141.45**	**83.24**	**71.23**	**25.34**	**37.98**	**32.70**	**432.26**	**100.0**
	%	3.3	6.1	32.7	19.3	16.5	5.9	8.8	7.6	100.0	

Table A 1: FA Costs (million TK), current financial prices

1) External and internal, including Embankment Maintenance Groups (EMG) costs and petty repair works during construction
2) Including steel gate for Panch Kahania in 1996
3) Khals, protective works...
4) Contribution to the BWDB
5) Incl. wages for Water Council staff, augmentation of the project team and environmental management staff
6) Purchase and repair of vehicles, quality control and training costs

268

Recurrent Costs	1993	1994	1995	1996	1997	1998	1999	2000	Total	
										%
Contract staff 1)										
- Expatriate 2)	80.96	9.98	21.56	33.63	27.82	13.43	25.06	31.22	243.67	53.7
- Local	23.77	13.42	16.20	9.35	7.59	9.59	9.51	0.00	89.42	19.7
- Total	104.73	23.40	37.76	42.98	35.41	23.02	34.57	31.22	333.09	73.4
% local staff	23	57	43	22	21	42	28	0	27	
Office equipment 1)	8.02	1.36	0.97	0.58	0.85	0.48	4.02	0.97	17.25	3.8
Administrative costs 1)	7.54	2.79	3.90	5.47	3.57	4.14	6.20	3.74	37.35	8.2
Training	2.09	3.55	7.68	6.75	3.54	4.71	13.17	13.28	54.77	12.1
Contingencies 3)	2.00		0.27		0.73	1.23	3.43	3.77	11.43	2.5
Total	**124.38**	**31.10**	**50.58**	**55.78**	**44.10**	**33.58**	**61.39**	**52.98**	**453.89**	**100.0**
%	27.4	6.9	11.1	12.3	9.7	7.4	13.5	11.7	100.0	

Table A 2: TA Costs (mill. TK), current financial prices

1) Including costs spent in Aug.-Dec. 1992
2) Including reporting in 1995 and 1996 (320.000 Tk)
3) Incl. transferred funds

	1993	1994	1995	1996	1997	1998	1999	2000	Total	
										%
Land Acquisition 1)	3.81	8.99	13.94	58.00	47.37	0.00	0.12	0.25	132.48	61.7
Staff 2)	11.60	8.87	11.30	10.14	8.48	8.83	8.25	3.87	71.34	33.2
Taxes		1.35							1.35	0.6
Mainten. during construct.							8.25	1.31	9.56	4.5
Total	**15.41**	**19.21**	**25.24**	**68.14**	**55.85**	**8.83**	**16.62**	**5.43**	**214.73**	**100.0**
%	7.2	8.9	11.8	31.7	26.0	4.1	7.7	2.5	100.0	

Table A 3: Government Contribution (mill. TK), current prices

1) Including 21.02 mill. Tk for land acquisition not yet paid
2) Including costs spent in Aug.-Dec. 1992

Implementation costs	1993	1994	1995	1996	1997	1998	1999	2000	Total	
										%
FA Costs	14.15	26.17	141.45	83.24	71.23	25.34	37.98	32.70	432.26	39.3
%	9.2	34.2	65.1	40.2	41.6	37.4	32.7	35.9		
TA Costs	124.38	31.10	50.58	55.78	44.10	33.58	61.39	52.98	453.89	41.2
%	80.8	40.7	23.3	26.9	25.8	49.6	52.9	58.2		
GoB Contribution	15.41	19.21	25.24	68.14	55.85	8.83	16.62	5.43	214.73	19.5
%	10.0	25.1	11.6	32.9	32.6	13.0	14.3	6.0		
Total	153.94	76.48	217.27	207.16	171.18	67.75	115.99	91.11	1,100.88	100.0
%	14.0	6.9	19.7	18.8	15.5	6.2	10.5	8.3	100.0	

Table A 4: Summary: Implementation Costs (mill. TK), current prices

Implementation costs	1993	1994	1995	1996	1997	1998	1999	2000	Total	
										%
FA Costs	361,939	654,318	3,518,726	2,040,215	1,668,050	559,440	782,997	653,960	10,239,645	39.3
%	9.2	34.2	65.1	40.2	41.6	37.4	32.7	35.9		
TA Costs	3,181,074	777,500	1,258,209	1,367,157	1,032,787	741,280	1,265,773	1,059,600	10,683,380	41.0
%	80.8	40.7	23.3	26.9	25.8	49.6	52.9	58.2		
GoB Contribution	394,118	480,250	627,861	1,670,098	1,307,963	194,923	342,680	108,600	5,126,492	19.7
%	10.0	25.1	11.6	32.9	32.6	13.0	14.3	6.0		
Total	3,937,130	1,912,068	5,404,796	5,077,470	4,008,799	1,495,643	2,391,451	1,822,160	26,049,517	100
%	15.1	7.3	20.7	19.5	15.4	5.7	9.2	7.0	100.0	

Table A 5: Summary: Total Implementation Costs (current US$), financial prices

Investment Costs		1993	1994	1995	1996	1997	1998	1999	2000	Total	
											%
Main Works											
Embankments 1)		0.79	0.00	10.89	20.70	9.88	5.07	3.21	6.70	57.24	11.5
Protective works		4.38	9.07	1.53	6.45	0.43	0.92	20.52	3.47	46.77	9.4
Elangani River Loop cut		0.00	0.00	0.00	3.83	0.85	0.07	0.00	0.00	4.74	1.0
Khals/Canals		2.67	0.08	5.72	12.34	3.43	3.48	2.61	2.37	32.69	6.6
Main regulator		0.00	0.00	24.00	4.33	0.00	0.00	0.24	0.18	28.75	5.8
Gated Pipe Inlet (GPI)		0.00	0.00	0.00	0.00	0.00	0.00	2.30	0.00	2.30	0.5
Intake 2)		3.47	0.00	18.96	3.15	1.52	0.25	0.34	0.00	27.69	5.6
Outlet		2.62	17.05	20.39	19.70	8.77	0.35	1.55	2.18	72.61	14.6
Water Control Structures (WCS)		0.00	0.52	52.21	6.44	4.14	3.48	0.71	0.00	67.50	13.5
Roads, Bridges and others		1.07	1.53	26.58	6.84	0.77	0.44	0.26	13.55	51.03	10.2
Subtotal		**15.01**	**28.25**	**160.27**	**83.78**	**29.78**	**14.06**	**31.73**	**28.46**	**391.32**	**78.5**
Minor Works											
Culverts		0.00	0.00	0.00	0.00	3.15	2.79	0.95	0.05	6.94	1.4
Subtotal		**0.00**	**0.00**	**0.00**	**0.00**	**3.15**	**2.79**	**0.95**	**0.05**	**6.94**	**1.4**
Mitigation measures											
Road		0.00	0.00	0.00	0.00	4.80	1.32	0.17	3.25	9.54	1.9
Bridge		0.00	0.00	2.12	2.84	3.80	1.66	0.32	0.00	10.74	2.2
Tangail Drain		0.00	0.00	0.00	0.00	34.03	4.96	3.56	0.34	42.88	8.6
Others 3)		0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.0
Subtotal		**0.00**	**0.00**	**2.12**	**2.84**	**42.63**	**7.93**	**4.08**	**3.59**	**63.20**	**12.7**
Supplementary Costs 4)											
Surveys		3.78	5.53	4.89	1.79	1.52	0.69	0.04	0.20	18.43	3.7
Wages local staff 5)		0.05	0.00	3.79	5.04	2.95	1.56	1.14	0.40	14.93	3.0
Miscellaneous costs 6)		0.55	0.78	0.09	1.45	0.45	0.34	0.03	0.00	3.70	0.7
Subtotal		**4.38**	**6.30**	**8.77**	**8.28**	**4.93**	**2.59**	**1.21**	**0.60**	**37.06**	**7.4**
Total	mil. Tk	**19.39**	**34.55**	**171.16**	**94.89**	**80.49**	**27.37**	**37.98**	**32.70**	**498.52**	**100.0**
	%	3.9	6.9	34.3	19.0	16.1	5.5	7.6	6.6	100.0	

Table A 6: FA Costs (constant mill. TK), 1999 financial prices

1) External and internal, including Embankment Maintenance Groups (EMG) costs and repair during construction
2) Including steel gate for Panch Kahania in 1996
3) *Khals*, protective works...
4) Contribution to the BWDB
5) Incl. wages for Water Council staff, augmentation of the project team and environmental management staff
6) Purchase and repair of vehicules, quality control and training costs

Recurrent Costs	1993	1994	1995	1996	1997	1998	1999	2000	Total	%
- Expatriate 2)	110.92	13.18	26.08	38.34	31.43	14.51	25.06	31.22	290.75	54.2
- Local	32.56	17.71	19.61	10.66	8.58	10.35	9.51	0.00	108.97	20.3
- Total	143.48	30.89	45.69	49.00	40.01	24.86	34.57	31.22	399.72	74.5
% local staff	22.7	57.3	42.9	21.8	21.4	41.6	27.5	0.0	27.3	
Office equipment 1)	10.99	1.80	1.17	0.66	0.96	0.52	4.02	0.97	21.09	3.9
Administrative costs 1)	10.33	3.68	4.72	6.24	4.03	4.47	6.20	3.74	43.41	8.1
Training	2.86	4.69	9.29	7.70	4.00	5.09	13.17	13.28	60.07	11.2
Contingencies 3)	2.74	0.00	0.33	0.00	0.82	1.33	3.43	3.77	12.42	2.3
Total	**170.40**	**41.05**	**61.20**	**63.59**	**49.83**	**36.27**	**61.39**	**52.98**	**536.71**	**100.0**
%	31.7	7.6	11.4	11.8	9.3	6.8	11.4	9.9	100.0	

Table A 7: TA Costs (constant mill. TK), 1999 financial prices

1) Including costs spent in Aug.-Dec. 1992
2) Including reporting in 1995 and 1996 (320.000 TK)
3) Incl. transferred funds

	1993	1994	1995	1996	1997	1998	1999	2000	Total	%
Land Acquisition 1)	5.22	11.87	16.87	66.12	53.53	0.00	0.12	0.25	153.97	61.7
Staff 2)	15.89	11.71	13.67	11.56	9.58	9.54	8.25	3.87	84.07	33.7
Taxes	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.7
Mainten. during construct.	0.00	0.00	0.00	0.00	0.00	0.00	8.25	1.31	9.56	3.8
Total	**21.11**	**25.36**	**30.54**	**77.68**	**63.11**	**9.54**	**16.62**	**5.43**	**249.39**	**100.0**
%	8.5	10.2	12.2	31.1	25.3	3.8	6.7	2.2	100.0	

Table A 8: Government Contribution (mill. constant TK), constant 1999 financial prices

1) Including costs spent in Aug.-Dec. 1992

Implementation costs	1993	1994	1995	1996	1997	1998	1999	2000	Total	%
FA Costs	19.39	34.55	171.16	94.89	80.49	27.37	37.98	32.70	498.52	38.8
%	9.19	34.22	65.10	40.18	41.61	37.40	32.74	35.89		
TA Costs	170.40	41.05	61.20	63.59	49.83	36.27	61.39	52.98	536.71	41.8
%	80.80	40.66	23.28	26.93	25.76	49.56	52.93	58.15		
GoB Contribution	21.11	25.36	30.54	77.68	63.11	9.54	16.62	5.43	249.39	19.4
%	10.01	25.12	11.62	32.89	32.63	13.03	14.33	5.96		
Total	**210.90**	**100.96**	**262.90**	**236.16**	**193.43**	**73.17**	**115.99**	**91.11**	**1,284.62**	**100.0**
%	16.4	7.9	20.5	18.4	15.1	5.7	9.0	7.1	100.0	

Table A 9: Summary: Total Implementation Costs (mill. constant TK), 1999 financial prices

Implementation costs	1993	1994	1995	1996	1997	1998	1999	2000	Total	
										%
FA Costs	399,752	712,330	3,529,029	1,956,587	1,659,486	564,331	782,997	674,186	10,278,697	38.8
%	9	34	65	40	42	37	33	36		
TA Costs	3,513,414	846,433	1,261,893	1,311,118	1,027,485	747,761	1,265,773	1,092,371	11,066,247	41.8
%	81	41	23	27	26	50	53	58		
GoB Contribution	435,293	522,829	629,699	1,601,641	1,301,247	196,627	342,680	111,959	5,141,975	19.4
%	10	25	12	33	33	13	14	6		
Total	4,348,459	2,081,592	5,420,620	4,869,346	3,988,218	1,508,719	2,391,451	1,878,515	26,486,920	100
%	16.4	7.9	20.5	18.4	15.1	5.7	9.0	7.1	100.0	

Table A 10: Summary: Total Implementation Costs (constant 1999 US$), financial prices

Investment Costs	1993	1994	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020	2021	2022
Base Costs 1)														
Embankments	0.71	0.00	9.80	18.63	8.89	4.56	2.89	6.03						
Protective works	3.29	6.80	1.15	4.83	0.32	0.69	15.39	2.60						
Khals (canals)	2.41	0.07	5.15	14.93	3.93	3.20	2.34	2.14						
Structures	5.00	14.41	94.75	27.57	11.83	3.34	4.22	1.94						
Roads, Bridges and others	0.76	1.09	18.87	4.86	0.54	0.31	0.18	9.62						
Culverts	0.00	0.00	0.00	0.00	2.58	2.29	0.78	0.04						
Total Base Costs	12.16	22.36	129.72	70.83	28.10	14.40	25.80	22.37						
Land acquisition	5.22	11.87	16.87	66.12	53.53	0.00	0.12	0.25						
Mitigation measures	0.00	0.00	1.51	2.02	30.27	5.63	2.89	2.55						
Supplementary Costs	3.94	5.67	7.89	7.45	4.43	2.33	1.09	0.54						
Office Equipment	9.89	1.62	1.06	0.60	0.86	0.47	3.62	0.87						
Contingencies	2.47	0.00	0.29	0.00	0.74	1.20	3.09	3.39						
Total Investment Costs	33.68	41.52	157.33	147.01	117.94	24.02	36.61	29.97	0.00	0.00	0.00	0.00	0.00	0.00

Table A 11: Investment Costs (mill. constant TK), 1999 prices economic prices

1) for details, see Tables 1.1 to 1.3

Investment Costs	1993	1994	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020	2021
Base Costs 1)													
Embankments	14,643	0	202,001	384,207	183,349	94,083	59,580	124,311					
Protective works	67,773	140,233	23,707	99,674	6,605	14,279	317,320	53,660					
Khals (canals)	49,600	1,421	106,206	300,015	79,242	65,815	48,340	44,035					
Structures	103,075	297,024	1,953,611	568,394	244,011	68,967	86,920	39,935					
Roads, Bridges and others	15,623	22,435	389,039	100,165	11,216	6,419	3,733	198,419					0
Culverts	0	0	0	0	53,227	47,202	16,096	845					
Total Base Costs	250,714	461,112	2,674,565	1,452,455	577,650	296,765	531,989	461,206					
Land acquisition	107,623	244,676	347,781	1,363,299	1,103,672	0	2,474	5,155					
Mitigation measures	0	0	31,052	41,571	624,123	116,143	59,684	52,555					
Supplementary Costs	81,271	116,956	162,753	153,585	91,424	48,003	22,540	11,134					
Office Equipment	203,890	33,313	21,780	12,270	17,824	9,620	74,598	18,000					
Contingencies	50,845	0	6,062	0	15,307	24,651	63,649	69,959					
Total Investment Costs	694,343	856,058	3,243,993	3,023,180	2,430,000	495,181	754,934	618,008	0	0	0	0	0

Table A 12: Investment Costs (constant 1999 US$)

economic prices

1) for details, see Tables 1.1 to 1.3

Investment Costs	1993	1994	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020	2021	2022
Staff costs	99.83	11.86	23.48	34.51	28.29	13.06	22.56	28.10						
- Expatriate	40.70	24.71	27.95	18.66	15.26	16.71	14.92	3.25	1.63	1.63	1.63	1.63	1.63	1.63
- Local 1)	140.53	36.57	51.43	53.17	43.55	29.76	37.47	31.35	1.63	1.63	1.63	1.63	1.63	1.63
Total	9.30	3.31	4.25	5.61	3.63	4.02	5.58	3.37	1.68	1.68	1.68	1.68	1.68	1.68
Administration 2)	2.58	4.22	8.36	6.93	3.60	4.58	11.85	11.95	0.00	0.00	0.00	0.00	0.00	0.00
Training														
Maintenance							6.93	1.10						
- during construction	0.09	0.34	1.69	2.40	2.64	2.77	3.04	3.07	3.07	3.07	3.07	3.07	3.07	3.07
- Embankments 3)	0.00	0.23	1.14	1.62	1.79	1.87	2.06	2.08	2.08	2.08	2.08	2.08	2.08	2.08
- Khals (Canals) 3)	0.03	0.28	1.38	1.95	2.15	2.25	2.48	2.50	2.50	2.50	2.50	2.50	2.50	2.50
- Structures 3)	0.00	0.07	0.35	0.49	0.54	0.57	0.62	0.63	0.63	0.63	0.63	0.63	0.63	0.63
- Protective works 3)	0.01	0.03	0.38	0.51	0.67	0.72	0.73	0.95	0.95	0.95	0.95	0.95	0.95	0.95
- Tangail Drain 5)	0.00	0.00	0.00	0.00	0.86	0.98	1.07	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Sub-total	0.14	0.94	4.94	6.98	8.65	9.16	16.94	11.42	10.32	10.32	10.32	10.32	10.32	10.32
Total	152.54	45.05	68.98	72.68	59.43	47.53	71.84	58.08	13.63	13.63	13.63	13.63	13.63	13.63

Table A 13: Recurrent Costs (mill. constant TK), 1999 prices

economic prices

1) Including supporting staff and staff paid by GoB, 50% of which is considered necessary for future operation
2) 50% of 2000 costs considered as ongoing costs
3) According to rates recommended by the Engineering Department of CPP (see Annex B, Engineering and Construction), following Implementation schedule (1993 = 4% and 8; 44; 23; 8; 4; 9% in the subsequent years up to 999 respectively)
4) Assumed 2% of investment costs
5) Assumed 3% of investment costs

Investment Costs	1993	1994	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020	2022
Staff costs													
- Expatriate	2,058,337	244,520	484,038	711,465	583,279	269,253	465,086	579,340					
- Local 1)	839,144	509,533	576,367	384,785	314,583	344,457	307,545	67,027	33,513	33,513	33,513	33,513	33,513
Total	2,897,482	754,053	1,060,405	1,096,250	897,862	613,709	772,630	646,367	33,513	33,513	33,513	33,513	33,513
Administration 2)	191,687	68,341	87,569	115,716	74,860	82,971	115,052	69,402	34,701	34,701	34,701	34,701	34,701
Training	53,133	86,957	172,444	142,794	74,231	94,394	244,392	246,433	0	0	0	0	
Maintenance													
- during construction							142,887	22,689					
- Embankments 3)	1,902	6,973	34,864	49,444	54,515	57,051	62,756	63,390	63,390	63,390	63,390	63,390	63,390
- Khals (Canals) 3)	0	4,715	23,573	33,431	36,860	38,574	42,432	42,860	42,860	42,860	42,860	42,860	42,860
- Structures 3)	1,549	5,679	28,394	40,268	44,398	46,463	51,109	51,625	51,625	51,625	51,625	51,625	51,625
- Protective works 3)	0	1,429	7,144	10,132	11,171	11,691	12,860	12,990	12,990	12,990	12,990	12,990	12,990
- Roads and bridges 4)	262	639	7,910	10,576	13,745	14,885	15,116	19,576	19,576	19,576	19,576	19,576	19,576
- Tangail Drain 5)	0	0	0	0	17,682	20,256	22,106	22,283	22,283	22,283	22,283	22,283	22,283
Sub-total	3,713	19,434	101,886	143,851	178,370	188,919	349,265	235,412	212,723	212,723	212,723	212,723	212,723
Total	3,146,015	928,785	1,422,303	1,498,610	1,225,323	979,993	1,481,339	1,197,614	280,937	280,937	280,937	280,937	280,937

Table A 14: Recurrent Costs (constant US$), 1999 prices

economic prices

1) Including supporting staff and staff paid by GoB, 50% of which is considered necessary for future operation
2) 50% of 2000 costs considered as ongoing costs
3) According to rates recommended by the Engineering Department of CPP (see Annex B, Engineering and Construction), following Implementation schedule (1993 = 4% and 8; 44; 23; 8; 4; 9% in the subsequent years up to 999 respectively)
4) Assumed 2% of investment costs
5) Assumed 3% of investment costs

Sub-Compart-ment	Gross area	Settlement srea		*Beel* Area		River Area		Cultivable area		Temporary Fallow		Crop area	Single crop		Double crop		Triple crop		Crop intensity
	Ha	Ha	% 1)	Ha	% 1)	Ha	% 1)	Ha	% 1)	Ha	% 2)	Ha	Ha	% 3)	Ha	% 3)	Ha	% 3)	%
1	247	55	22.3	1	0.4	0	0.0	191	77.3	3	1.6	338	83	44.0	60	32.0	45	24.0	177
2	544	105	19.3	0	0.0	0	0.0	439	80.7	7	1.6	800	162	37.4	173	40.0	98	22.6	182
3	1,116	170	15.2	15	1.3	0	0.0	931	83.4	15	1.6	1,681	389	42.5	289	31.5	238	26.0	181
4	804	195	24.3	31	3.9	0	0.0	578	71.9	10	1.7	1,076	212	37.3	205	36.0	152	26.7	186
5	369	101	27.4	6	1.6	0	0.0	262	71.0	4	1.5	560	68	26.4	78	30.3	112	43.3	214
6	669	133	19.9	13	1.9	0	0.0	523	78.2	9	1.7	1,100	136	26.4	171	33.3	207	40.3	210
7	796	120	15.1	6	0.8	0	0.0	670	84.2	11	1.6	1,362	194	29.4	227	34.5	238	36.1	203
8	778	134	17.2	3	0.4	0	0.0	641	82.4	10	1.6	1,353	174	27.6	192	30.4	265	42.0	211
9	402	86	21.4	28	7.0	0	0.0	288	71.6	5	1.6	484	140	49.5	85	30.0	58	20.5	168
10	876	169	19.3	25	2.9	0	0.0	682	77.9	11	1.6	1,299	249	37.1	216	32.2	206	30.7	191
11	1,167	337	28.9	0	0.0	0	0.0	830	71.1	13	1.6	1,668	255	31.2	273	33.4	289	35.4	201
12	1,037	222	21.4	0	0.0	0	0.0	815	78.6	13	1.6	1,762	185	23.1	273	34.1	343	42.8	216
13	457	122	26.7	3	0.7	0	0.0	332	72.6	5	1.5	583	120	36.7	158	48.3	49	15.0	176
14	1,186	260	21.9	63	5.3	0	0.0	863	72.8	14	1.7	1,544	280	33.0	441	52.0	127	15.0	179
15	767	203	26.5	14	1.8	0	0.0	550	71.7	9	1.6	1,009	182	33.6	251	46.4	108	20.0	183
16 4)	619	431	69.6	26	4.2	6	1.0	156	25.2	0	0.0	312	0	0.0	156	100.0	0	0.0	200
LFP 5)	1,366	255	18.7	27	2.0	72	5.3	1,012	74.1	17	1.7	1,687	498	50.0	304	30.5	194	19.5	167
Total	13,200	3,098	23.5	261	2.0	78	0.6	9,763	74.0	155	1.6	18,618	3,326	34.1	3,552	36.4	2,729	28.0	191

Table A 15: Land Utilization in the Project Area - Pre-project Situation

Source: offical statistics, CPP Sub-Compartmental - and CCP House-Hold Survey
1)of total area 2) of cultivable area 3) of cropped area 4) urban Tangail 5) Lohajang Flood Plain

Sub-Compartment	Gross area	Settlement srea		*Beel* Area		River Area		Cultivable area		Temporary Fallow		Crop area	Single crop		Double crop		Triple crop		Crop intensity
	Ha	Ha	% 1)	Ha	% 1)	Ha	% 1)	Ha	% 1)	Ha	% 2)	Ha	Ha	% 3)	Ha	% 3)	Ha	% 3)	%
1	247	55	22.3	2	0.8	0	0.0	190	76.9	3	1.58	400	0	0.0	161	86.0	26	14.0	211
2	544	105	19.3	0	0.0	0	0.0	439	80.7	7	1.59	1,015	13	3.0	255	59.0	164	38.0	231
3	1,116	170	15.2	1	0.1	0	0.0	945	84.7	15	1.59	1,962	112	12.0	605	65.0	214	23.0	208
4	804	195	24.3	22	2.7	0	0.0	587	73.0	10	1.70	1,010	225	39.0	271	47.0	81	14.0	172
5	369	101	27.4	1	0.2	0	0.0	267	72.4	4	1.50	690	0	0.0	100	38.0	163	62.0	258
6	669	133	19.9	11	1.6	0	0.0	525	78.5	9	1.71	1,203	93	18.0	160	31.0	263	51.0	229
7	796	120	15.1	5	0.6	0	0.0	671	84.3	11	1.64	1,380	132	20.0	337	51.0	191	29.0	206
8	778	134	17.2	1	0.1	0	0.0	643	82.7	10	1.55	1,507	44	7.0	304	48.0	285	45.0	234
9	402	86	21.4	12	2.9	0	0.0	304	75.7	5	1.64	816	7	2.2	69	23.0	224	74.8	268
10	876	169	19.3	11	1.2	0	0.0	696	79.5	11	1.58	1,542	144	21.0	226	33.0	315	46.0	221
11	1,167	337	28.9	19	1.6	0	0.0	811	69.5	13	1.60	1,844	192	24.0	168	21.0	439	55.0	227
12	1,037	222	21.4	10	0.9	0	0.0	805	77.7	13	1.61	1,640	87	11.0	563	71.0	143	18.0	204
13	457	122	26.7	4	0.8	0	0.0	331	72.5	5	1.51	558	186	57.0	49	15.0	91	28.0	168
14	1,186	260	21.9	35	2.9	0	0.0	891	75.1	15	1.68	1,893	105	12.0	526	60.0	245	28.0	212
15	767	203	26.5	4	0.5	0	0.0	560	73.0	9	1.61	1,229	28	5.0	369	67.0	154	28.0	219
16 4)	619	431	69.6	23	3.7	6	1.0	159	25.7	0	0.00	353	16	10.0	92	58.0	51	32.0	222
17 5)	1,366	255	18.7	9	0.6	72	5.3	1,030	75.4	17	1.65	2,087	253	25.0	446	44.0	314	31.0	203
Total	13,200	3,098	23.5	166	1.3	78	0.6	9,858	74.7	157	1.6	21,131	1,636	16.6	4,700	47.7	3,365	34.1	214

Table A 16: Land Utilization in the Project Area - Situation with Project (1999)

Source: CPP land-use survey of Kharif-1 1999, CPP Monitoring plots
1) of total area 2) of cultivable area 3) of cropped area 4) urban Tangail 5) Lohajang Flood Plain

Crop	Output			variable costs														Total var. costs	Gross margin	Value added
	Yield	By-prod.	Gross return	Seed		Fertilizer Urea	TSP	MP	Sub-total	Plant protection		Family labour	Labour hired labour			Oxen labour	Irrigat-ion			
	Kg/ha	Kg/ha	Tk/ha	Kg/ha	Tk/ha	Kg/ha	Kg/ha	Kg/ha	Tk/ha	Kg/ha	Tk/ha	m/d/ha	ratio % 2)	md/ha	Tk/ha	ox/d/ha	Tk/ha	Tk/ha	Tk/ha	Tk/ha
Boro HYV	4,467	4,467	32,305	40	440	185	103	32	2,680	0.9	500	116	75	87	3,698	50	1,985	11,552	20,754	29,381
Boro local	2,921	5,842	23,228	40	440	60	29	7	781	0.1	57	88	50	44	1,870	40	953	5,900	17,328	22,938
T *Aman* HYV	3,244	3,244	23,510	40	520	151	96	21	2,277	0.7	351	96	66	63	2,693	45	615	8,481	15,030	21,803
T *Aman* local	2,163	4,326	18,012	40	520	60	29	7	866	0.1	57	88	50	44	1,870	42	0	5,203	12,809	18,419
DW *Aman* broad.	1,523	1,523	11,449	100	1,300	33	16	6	453	0.2	90	93	60	56	2,372	42	0	6,104	5,345	11,669
DW *Aman* transpl.	1,813	1,813	13,629	50	650	65	16	6	645	0.2	90	100	65	65	2,763	42	0	6,038	7,591	14,604
***Kharif* 2 crops, average, weighted by cropped area**																			**8,173**	**14,716**
Aus HYV	2,748	2,748	19,021	40	440	185	103	32	2,680	0.9	500	116	75	87	3,698	42	0	9,207	9,814	18,441
Aus local	1,450	2,900	10,820	100	1,100	34	20	3	475	0.2	108	95	60	57	2,423	35	0	5,681	5,139	11,599
Jute	1,727	3,454	18,852	11	396	120	70	50	2,084	0.8	432	80	100	80	3,400	40	0	8,112	10,740	17,540
Sugarcane	30,770	0	29,576	5,000	4,806	120	50	30	1,634	0.5	270	95	150	143	6,056	50	1,191	16,207	13,369	23,463
***Kharif* 1 crops, average, weighted by cropped araea**																			**8,321**	**15,594**
Potato	9,455	0	41,632	1,500	17,550	140	70	50	2,204	0.8	405	120	74	89	3,774	38	318	25,960	15,672	24,546
Wheat	2,100	2,100	19,694	145	1,885	130	100	30	2,293	0.0	0	85	45	38	1,626	36	238	7,662	12,032	17,270
Mustard	859	1,031	15,957	12	300	120	60	30	1,754	0.0	0	80	20	16	680	28	238	4,232	11,725	15,805
Pulses	747	971	16,586	35	1,050	0	0	0	0	0.0	0	68	20	14	578	30	238	3,216	13,370	16,838
Vegetables 1)	7,970	0	41,477	1	176	120	50	30	2,129	0.5	270	100	140	140	5,950	48	1,588	12,272	29,205	39,405
																Tk/ha average			**12,574**	**19,499**

Table A 17: Crop Production 1992 - Economic Parameters — Without project — economic prices

Source: Project computations based on official statistics and project surveys (subcompartmet, House-hold)
1) incl. manure (veg. = 1.100 Kg à 0.5 Tk/kg, local T.Aman = 190 Kg) 2) of family labour

Crop	Output: Yield	Output: By-prod.	Output: Gross return	Seed		Fertilizer: Urea	Fertilizer: TSP	Fertilizer: MP	Sub-total	Plant protection		Family labour	Labour hired labour			Oxen labour	Irrigat-ion	Total var. costs	Gross margin	Value added
	Kg/ha	Kg/ha	Tk/ha	Kg/ha	Tk/ha	Kg/ha	Kg/ha	Kg/ha	Tk/ha	Kg/ha	Tk/ha	m/d/ha	ratio % 2)	md/ha	Tk/ha	ox/d/ha	Tk/ha	Tk/ha	Tk/ha	Tk/ha
Boro HYV	4,868	4,868	34,917	40	440	185	103	32	2,680	0.9	500	116	75	87	3,698	50	1,985	11,552	23,365	31,993
Boro local	1,275	2,550	12,509	40	440	60	29	7	781	0.1	57	88	50	44	1,870	40	953	5,900	6,609	12,219
T *Aman* HYV	2,860	2,860	20,935	40	520	151	96	21	2,277	0.7	351	96	66	63	2,693	45	615	8,481	12,454	19,227
T *Aman* local	1,779	3,558	15,436	40	520	60	29	7	866	0.1	57	88	50	44	1,870	42	0	5,203	10,233	15,843
DW *Aman* broad.	1,521	1,521	11,436	100	1,300	33	16	6	453	0.2	90	93	60	56	2,372	42	0	6,104	5,331	11,655
DW *Aman* transpl.	1,703	1,703	12,891	50	650	65	16	6	645	0.2	90	100	65	65	2,763	42	0	6,038	6,853	13,866
Kharif **2 crops, average, weighted by cropped area**																			**9,714**	**16,302**
Aus HYV	2,099	2,099	14,879	40	440	185	103	32	2,680	0.9	500	116	75	87	3,698	42	0	9,207	5,672	14,300
Aus local	922	1,844	7,450	100	1,100	34	20	3	475	0.2	108	95	60	57	2,423	35	0	5,681	1,769	8,229
Jute	1,574	3,148	17,485	11	396	120	70	50	2,084	0.8	432	80	100	80	3,400	40	0	8,112	9,373	16,173
Sugarcane	35,000	0	33,642	5,000	4,806	120	50	30	1,634	0.5	270	95	150	143	6,056	50	1,191	16,207	17,435	27,529
Kharif **1 crops, average, weighted by cropped araea**																			**11,020**	**18,681**
Potato	9,455	0	41,632	1,500	17,550	140	70	50	2,204	0.8	405	120	74	89	3,774	38	318	25,960	15,672	24,546
Wheat	1,771	1,771	16,905	145	1,885	130	100	30	2,293	0.0	0	85	45	38	1,626	36	238	7,662	9,243	14,481
Mustard	777	932	14,487	12	300	120	60	30	1,754	0.0	0	80	20	16	680	28	238	4,232	10,255	14,335
Pulses	679	883	15,132	35	1,050	0	0	0	0	0.0	0	68	20	14	578	30	238	3,216	11,915	15,383
Vegetables 1)	9,560	0	49,752	1	176	120	50	30	2,129	0.5	270	100	140	140	5,950	48	1,588	12,272	37,480	47,680
Other Crops	1,800	0	12,045	477	12,843	102	54	22	1,492	0.4	209	95	70	66	2,816	41	0	19,183	(7,139)	(299)
																Tk/ha average			**14,282**	**20,756**

Table A 18: Crop Production 1999 - Economic Parameters — With project — economic prices

Source: Project computations based on official statistics and project surveys (subcompartmet, House-hold)
1) incl. manure (veg. = 1.100 Kg à 0.5 Tk/kg, local T.Aman = 190 Kg) 2) of family labour

Crop	Market price	By-product	Seed	Labour		Urea	Fertilizer TSP	MP	Plant protect	Irrig.
				Man/d	Ox/d					
Boro HYV	0.8	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Boro local	0.8	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Aman HYV	0.8	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Aman (T)	0.8	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Aman (DW)	0.8	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Aus HYV	0.8	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Aus local	0.8	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Jute	1.05	0.9	0.9	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Potato	0.9	0.9	0.9	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Wheat	1	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Mustard	1	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Pulses	1	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Vegetables	0.9	0.9	0.9	0.85	0.9	1.025	0.92	1.25	0.9	0.63
Sugar cane	1	0.9	1	0.85	0.9	1.025	0.92	1.25	0.9	0.63

Table A 19: Economic Prices - Conversion Factors

Source: FAP, Guidelines for Project Assessment, 1998 revised version and NWMP planning data

Crop	Farmgate price	By-product	Seed	Labour		Urea	Fertilizer 1) TSP	MP	Plant protect	Irrig. Tk/ha
				Man/d	Ox/d					
Boro HYV	8.14	0.8	11.0	50.0	50.0	5.86	13.01	8.40	600	3,150
Boro local	8.14	0.8	11.0	50.0	50.0	5.86	13.01	8.40	600	1,512
Aman HYV	8.38	0.6	13.0	50.0	50.0	5.86	13.01	8.40	600	977
Aman (T)	8.38	0.9	13.0	50.0	50.0	5.86	13.01	8.40	600	0
Aman (DW)	8.38	0.9	13.0	50.0	50.0	5.86	13.01	8.40	600	0
Aus HYV	7.98	0.6	11.0	50.0	50.0	5.86	13.01	8.40	600	0
Aus local	7.98	0.9	11.0	50.0	50.0	5.86	13.01	8.40	600	0
Jute	8.51	1.1	40.0	50.0	50.0	5.86	13.01	8.40	600	0
Potato	4.89	0.0	13.0	50.0	50.0	5.86	13.01	8.40	600	504
Wheat	8.48	1.0	13.0	50.0	50.0	5.86	13.01	8.40	600	378
Mustard	17.93	0.6	25.0	50.0	50.0	5.86	13.01	8.40	600	378
Pulses	21.38	0.7	30.0	50.0	50.0	5.86	13.01	8.40	600	378
Vegetables 2)	5.78	0.0	390.0	50.0	50.0	5.86	13.01	8.40	600	2,520
Sugar cane	0.96	0.0	1.5	50.0	50.0	5.86	13.01	8.40	600	1,890
Other crops	6.69	0.0	26.9	50.0	50.0	5.86	13.01	8.40	600	2,520

Table A 20: Farm-gate Prices, 1999 (in Tk/Kg, constant prices) 1)

Source: for rice crops, pulses and seed = CPP, M&E Section, all others NWMP planning data

1) manure at 0.5 TK/KG, applying SCF for economic price s0.5

2) 30% onions, 70% radish

Crop	Market price	By-product	Seed	Labour		Urea	Fertilizer TSP	MP	Plant protect	Irrig. Tk/ha
				Man/d	Ox/d					
Boro HYV	6.21	0.7	10.0	50.0	45.0	4.58	5.40	4.05	504	3,150
Boro local	6.21	1.0	10.0	50.0	45.0	4.58	5.40	4.05	504	1,512
Aman HYV	6.44	0.7	10.0	50.0	45.0	4.58	5.40	4.05	504	977
Aman (T)	6.44	1.0	10.0	50.0	45.0	4.58	5.40	4.05	504	0
Aman (DW)	6.44	1.0	10.0	50.0	45.0	4.58	5.40	4.05	504	0
Aus HYV	6.07	0.7	8.5	50.0	45.0	4.58	5.40	4.05	504	0
Aus local	6.07	1.0	10.5	50.0	45.0	4.58	5.40	4.05	504	0
Jute	8.01	2.6	24.0	50.0	45.0	4.58	5.40	4.05	504	0
Potato	4.58	0.0	8.5	50.0	45.0	4.58	5.40	4.05	504	504
Wheat	6.31	0.4	12.0	50.0	45.0	4.58	5.40	4.05	504	378
Mustard	13.47	0.6	19.0	50.0	45.0	4.58	5.40	4.05	504	378
Pulses	14.92	0.7	13.2	50.0	45.0	4.58	5.40	4.05	504	378
Vegetables	4.10	0.0	500.0	50.0	45.0	4.58	5.40	4.05	504	2,520
Sugar cane	1.01	0.0	5.0	50.0	45.0	4.58	5.40	4.05	504	1,890
Other crops	6.20	0.0	26.9	50.0	45.0	4.58	5.40	4.05	504	2,520

Table A 21: Agricultural Prices 1992 (in Tk/Kg)

Source: FAP, Guidelines for Project Assessment

Criteria	Land Utilization within CPP Area								Land Utilization in Adjacent Areas							
	1992		1999		Changes				1992		1999		Changes			
	Area	Yield	Area		Area %		Yield %		Area	Yield	Area		Area %		Yield %	
	ha	Kg/ha	ha 1)	Kg/ha 1)	per a	total	per a	total	ha	Kg/ha	ha 1)	Kg/ha 1)	per a	total	per a	total
Cultivable area	9,763		9,858		0.1	1.0			4,260		4,260		0.0	0.0		
Cropped area	18,618		21,131		1.8	13.5			8,180		8,494		0.5	3.8		
Fallow	193		160		-2.6	-17.1			n.a.		n.a.					
Cropping intensity %	191		214		1.7	12.4			192		199		0.5	3.8		
Rice area																
- total	11,999		13,719		1.9	14.3			4,816		5,120		0.9	6.3		
- *Boro*	3,821		7,125		9.3	86.5			1,891		2,667		5.0	41.0		
* HYV	3,390	4,467	7,125	5,671	11.2	110.2	3.5	27.0	1,850	4,467	2,640	4,868	5.2	42.7	1.2	9.0
* local	431	2,921	0	0	-69.7	-100.0	-100.0	-100.0	41	2,921	27	1,275	-5.8	-34.1	-11.2	-56.4
- T.*Aman*	1,070		3,912		20.3	265.6			513		700		4.5	36.5		
* HYV	222	3,244	2,362	2,905	40.2	964.0	-1.6	-10.5	134	3,244	377	2,860	15.9	181.3	-1.8	-11.8
* local	848	2,163	1,550	1,774	9.0	82.8	-2.8	-18.0	379	2,163	323	1,779	-2.3	-14.8	-2.8	-17.8
- DW.*Aman*	3,718		2,543		-5.3	-31.6			1,234		1,538		3.2	24.6		
* broadcasted	1,464	1,523	0		-74.6	-100.0	-100.0	-100.0	943	1,523	1,298	1,521	4.7	37.6	0.0	-0.1
* transplanted	2,254	1,813	2,543	1,617	1.7	12.8	-1.6	-10.8	291	1,813	240	1,703	-2.7	-17.5	-0.9	-6.1
- *Aus*	3,390		139		-36.6	-95.9			1,178		215		-21.6	-81.7		
* HYV	726	2,748	0		-71.9	-100.0	-100.0	-100.0	62	2,748	1	2,099	-44.5	-98.4	-3.8	-23.6
* local	2,664	1,450	139	1,032	-34.4	-94.8	-4.7	-28.8	1,116	1,450	214	922	-21.0	-80.8	-6.3	-36.4
- Jute	1,614	1,727	1,350	1,564	-2.5	-16.4	-1.4	-9.4	733	1,727	422	1,574	-7.6	-42.4	-1.3	-8.9
- Sugarcane	691	30,770	547	44,000	-3.3	-20.8	5.2	43.0	786	30,770	692	35,000	-1.8	-12.0	1.9	13.7
- Potato	138	9,455	134	9,995	-0.4	-2.9	0.8	5.7	239	9,455	222	9,455	-1.0	-7.1	0.0	0.0
- Wheat	1,963	2,101	1,618	2,101	-2.7	-17.6	0.0	0.0	615	2,100	689	1,771	1.6	12.0	-2.4	-15.7
- Mustard	1,277	859	2,684	854	11.2	110.2	-0.1	-0.6	719	859	615	777	-2.2	-14.5	-1.4	-9.5
- Pulses	733	747	756	748	0.4	3.1	0.0	0.1	94	747	200	679	11.4	112.8	-1.4	-9.1
- Vegetables	135	7,970	276	10,000	10.8	104.4	3.3	25.5	160	7,970	84	9,560	-8.8	-47.5	2.6	19.9
- Other crops	68	2,000	47	2,010	-5.1	-30.9	0.1	0.5	18	2,000	450	1,800	58.4	2400.0	-1.5	-10.0

Table A 22: Development of Agricultural Production - 1992 to 1999

Source:
CPP, Tangail 1) average values:for CPP = last 2 years, average of both adjacent areas dark shaded area = Kharif 2, light shaded area = Kharif 1 crops

Criteria	Land utilization within CPP					Land utilization Adjacent Areas							
	1992		1999		Changes	1992		1999		Changes			
	Area	Yield	Area		Area %	Area	Yield	Area		Area %		Yield %	
	ha	Kg/ha	ha 1)	Kg/ha 1)	per a	ha	Kg/ha	ha 1)	Kg/ha 1)	per a	total	per a	total
Cultivable area	9,763		9,858		0.1	4,260		4,260		0.0	0.0		
Cropped area	18,618		21,131		1.8	8,180		8,494		0.5	3.8		
Fallow	193		160		-2.6	n.a.		n.a.					
Cropping intensity %	191		214		1.7	192		199		0.5	3.8		
Rice area													
- total	11,999		13,719		1.9	4,816		5,120		0.9	6.3		
- *Boro*	3,821		7,125		9.3	1,891		2,667		5.0	41.0		
* HYV	3,390	4,467	7,125	5,671	11.2	1,850	4,467	2,640	4,868	5.2	42.7	1.2	9.0
* local	431	2,921	0	0	-69.7	41	2,921	27	1,275	-5.8	-34.1	-11.2	-56.4
- T.*Aman*	1,070		3,912		20.3	513		700		4.5	36.5		
* HYV	222	3,244	2,362	2,905	40.2	134	3,244	377	2,860	15.9	181.3	-1.8	-11.8
* local	848	2,163	1,550	1,774	9.0	379	2,163	323	1,779	-2.3	-14.8	-2.8	-17.8
- DW.*Aman*	3,718		2,543		-5.3	1,234		1,538		3.2	24.6		
* broadcasted	1,464	1,523	0		-74.6	943	1,523	1,298	1,521	4.7	37.6	0.0	-0.1
* transplanted	2,254	1,813	2,543	1,617	1.7	291	1,813	240	1,703	-2.7	-17.5	-0.9	-6.1
- *Aus*	3,390		139		-36.6	1,178		215		-21.6	-81.7		
* HYV	726	2,748	0		-71.9	62	2,748	1	2,099	-44.5	-98.4	-3.8	-23.6
* local	2,664	1,450	139	1,032	-34.4	1,116	1,450	214	922	-21.0	-80.8	-6.3	-36.4
- Jute	1,614	1,727	1,350	1,564	-2.5	733	1,727	422	1,574	-7.6	-42.4	-1.3	-8.9
- Sugarcane	691	30,770	547	44,000	-3.3	786	30,770	692	35,000	-1.8	-12.0	1.9	13.7
- Potato	138	9,455	134	9,995	-0.4	239	9,455	222	9,455	-1.0	-7.1	0.0	0.0
- Wheat	1,963	2,101	1,618	2,101	-2.7	615	2,100	689	1,771	1.6	12.0	-2.4	-15.7
- Mustard	1,277	859	2,684	854	11.2	719	859	615	777	-2.2	-14.5	-1.4	-9.5
- Pulses	733	747	756	748	0.4	94	747	200	679	11.4	112.8	-1.4	-9.1
- Vegetables	135	7,970	276	10,000	10.8	160	7,970	84	9,560	-8.8	-47.5	2.6	19.9
- Other crops	68	2,000	47	2,010	-5.1	18	2,000	450	1,800	58.4	2400.0	-1.5	-10.0

Table A 23: Summary of Impact on Agricultural Production

Source:
CPP, Tangail 1) average values:for CPP = last 2 years, average of both adjacent areas

Crops	CPP Ha 1992	Recorded Changes %		Net Changes %	
		CPP	adj. Area	Total	p.a
- *Boro*					
* HYV	3,390	110.2	43	67.5	7.6
* local	431	-100.0	(34)	-65.8	-14.2
- T. *Aman*					
* HYV	222	964.0	181	782.6	36.5
* local	848	82.8	(15)	97.6	10.2
- DW. *Aman*					
* broadcasted	1,464	-100.0	38	-62.35	-13.0
* transplanted	2,254	12.8	(18)	30.37	3.9
Total *Kharif* 2 area	4,788				
- *Aus*					
* HYV	726	-100.0	(98)	-99.99	-71.9
* local 1)	2,664	-94.8	(81)	-94.78	-34.4
- Jute	1,614	-16.4	(42)	26.07	3.4
- Sugarcane	691	-20.8	(12)	-8.88	-1.3
Total *Kharif* 1 area	5,695				
- Potato	138	-2.9	(7)	4.21	0.6
- Wheat	1,963	-17.6	12	-29.61	-4.9
- Mustard	1,277	110.2	(14)	124.64	12.3
- Pulses 1)	733	3.1	113	3.14	0.4
- Vegetables	135	104.4	(48)	151.94	14.1
- Other crops	68	-30.9	0	-30.88	-5.1
	4,314				

Table A 24: Net Impact on Land-use within CPP Area

Source:
Own computations 1) CPP growth rates retained for a more realistic development scenario

	Without Project	With Project
Total area		
- *Kharif* 1	5,695	2,804
- *Kharif* 2	4,788	7,124
additional *Kharif* 2 area 1)	0	2,336
Value added 2)		
- *Kharif* 1	15,594	18,681
- *Kharif* 2	14,716	16,302
Benefit		
- aditional area, Tk/ha		16,302
- damage prevented, Tk/ha		1,919
- Total benefit, Tk/ha		**18,222**

Table A 25: Benefit assessment

1) only area directly affected by recommended water management

2) economic prices

	Unit	1993	1994	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020	2022
Investment Costs														
Construction	mill. TK	12.16	22.36	129.72	70.83	28.10	14.40	25.80	22.37	0	0	0	0	0
Land Acquisition	mill. TK	5.22	11.87	16.87	66.12	53.53	0.00	0.12	0.25	0	0	0	0	0
Mitigation measures	mill. TK	0.00	0.00	1.51	2.02	30.27	5.63	2.89	2.55	0	0	0	0	0
Office Equipment	mill. TK	9.89	1.62	1.06	0.60	0.86	0.47	3.62	0.87	0	0	0	0	0
Contingencies	mill. TK	6.41	5.67	8.19	7.45	5.18	3.52	4.18	3.93	0	0	0	0	0
Total Investment Costs	mill. TK	33.68	41.52	157.33	147.01	117.94	24.02	36.61	29.97	0	0	0	0	0
Recurrent Costs														
Personnel	mill. TK	140.53	36.57	51.43	53.17	43.55	29.76	37.47	31.35	1.63	1.63	1.63	1.63	1.63
Administration	mill. TK	9.30	3.31	4.25	5.61	3.63	4.02	5.58	3.37	1.68	1.68	1.68	1.68	1.68
Training	mill. TK	2.58	4.22	8.36	6.93	3.60	4.58	11.85	11.95	0.00	0.00	0.00	0.00	0.00
Maintenance	mill. TK	0.14	0.94	4.94	6.98	8.65	9.16	16.94	11.42	10.32	10.32	10.32	10.32	10.32
Total recurrent costs		152.54	45.05	68.98	72.68	59.43	47.53	71.84	58.08	13.63	13.63	13.63	13.63	13.63
Total Costs	mill. TK	**186.21**	**86.56**	**226.32**	**219.69**	**177.37**	**71.55**	**108.46**	**88.06**	**13.63**	**13.63**	**13.63**	**13.63**	**13.63**
BENEFITS														
Agriculture														
- Production on addition. Area	mill. TK					7.62	15.24	30.47	38.09	40.03	42.07	42.07	42.07	42.07
- Damage prevented	mill. TK					1.08	2.15	4.30	5.38	5.66	5.94	5.94	5.94	5.94
Progress	%					18.1	36.2	72.4	90.5	95.1	100.0	100.0	100.0	100.0
Fisheries	mill. TK					6.00	12.00	18.04	18.04	18.04	18.04	18.04	18.04	18.04
Non-Agricult. Benefits														
- Damage prev. Tangail Town	mill. TK								14.03	14.03	14.03	14.03	14.03	14.03
- Damage prev. rural Areas	mill. TK								6.80	6.80	6.80	6.80	6.80	6.80
Sub-Total	mill. TK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.83	20.83	20.83	20.83	20.83	20.83
Total Benefits	mill. TK	**0.00**	**0.00**	**0.00**	**0.00**	**14.69**	**29.39**	**52.82**	**82.34**	**84.56**	**86.89**	**86.89**	**86.89**	**86.89**
Per cent of costs	%					8.3	41.1	48.7	93.5	620.6	637.7	637.7	637.7	637.7

TABLE A 26 : Cash Flow

1) Kharif 2, Aman crops 2) Kharif 1 crops (Aus, Jute and Sugarcane)

	Unit	1993	1994	1995	1996	1997	1998	1999	2000	2005	2010	2015	2022
Investment Costs													
Construction	US $	250,714	461,112	2,674,565	1,452,455	577,650	296,765	531,989	461,206	0	0	0	0
Land Acquisition	US $	107,623	244,676	347,781	1,363,299	1,103,672	0	2,474	5,155	0	0	0	0
Mitigation measures	US $	0	0	31,052	41,571	624,123	116,143	59,684	52,555	0	0	0	0
Office Equipment	US $	203,890	33,313	21,780	12,270	17,824	9,620	74,598	18,000	0	0	0	0
Contingencies	US $	132,117	116,956	168,816	153,585	106,731	72,653	86,189	81,093	0	0	0	0
Total Investment Costs	US $	694,343	856,058	3,243,993	3,023,180	2,430,000	495,181	754,934	618,008	0	0	0	0
Recurrent Costs													
Personnel	US $	2,897,482	754,053	1,060,405	1,096,250	897,862	613,709	772,630	646,367	33,513	33,513	33,513	33,513
Administration	US $	191,687	68,341	87,569	115,716	74,860	82,971	115,052	69,402	34,701	34,701	34,701	34,701
Training	US $	53,133	86,957	172,444	142,794	74,231	94,394	244,392	246,433	0	0	0	0
Maintenance	US $	3,713	19,434	101,886	143,851	178,370	188,919	349,265	235,412	212,723	212,723	212,723	212,723
Total recurrent costs	US $	3,146,015	928,785	1,422,303	1,498,610	1,225,323	979,993	1,481,339	1,197,614	280,937	280,937	280,937	280,937
TOTAL COSTS	US $	3,840,358	1,784,843	4,666,297	4,521,790	3,655,323	1,475,174	2,236,273	1,815,621	280,937	280,937	280,937	280,937
Benefits													
Agriculture													
- Production on addition. Area	US $					157,069	314,138	628,275	785,344	825,404	867,508	867,508	867,508
- Damage prevented 2)	US $					22,190	44,380	88,760	110,950	116,609	122,557	122,557	122,557
Progress	%					18.1	36.2	72.4	90.5	95.1	100.0	100.0	100.0
Additional Area	Ha	2,336											
	US $/Ha	336											
Damage pervented	Ha	2,804											
	US $/Ha	40											
0.01						0.2	0.4	0.8	1.00	1.01	1.01	1.00	1.00
Fisheries	US $					120,000	240,000	360,815	360,815	360,815	360,815	360,815	360,815
Non-Agricult. Benefits													
- Damage prev. Tangail Town	US $								289,254	289,254	289,254	289,254	289,254
- Damage prev. rural Areas	US $								140,289	140,289	140,289	140,289	140,289
Sub-Total	US $	0	0	0	0	0	0	0	429,543	429,543	429,543	429,543	429,543
Total Benefits	US $	0	0	0	0	299,259	598,517	1,077,850	1,686,651	1,732,371	1,780,423	1,780,423	1,780,423
Per cent of costs	%					8.2	40.6	48.2	92.9	616.6	633.7	633.7	633.7
Cash Flow	US $	-3,840,358	-1,784,843	-4,666,297	-4,521,790	-3,356,064	-876,657	-1,158,423	-128,970	1,451,434	1,499,486	1,499,486	1,499,486

Table A 27: Cash Flow

1) Kharif 2, Aman crops 2) Kharif 1 crops (Aus, Jute and Sugarcane)

30 years Project Period						
				EIRR		NPV
Sensitivity						000 US$
				3.1%		
	a	Construction Costs	- 40%	4.0 %	12%	-9,459
	b	a+ Personnel Costs	- 40%	5.7 %		
	c	a+b+ Land acquisition	- 50%	6.8 %		
	d	a+b+c+ Tangail drain out		7.3 %		N/K Ratio
	e	d + Benefits	+ 51%	12.0 %	12%	-0.80

Table A 28: Economic Internal rate of return

Annex L
Modeling of Multi-compartments.

This study was carried out by the
Surface Water Modeling Center
on contract to CPP.

202

Table of Contents

Appendix A

Tables

Figures

Introduction

Background

The concept of Compartmentalization, evolved from the Bangladesh Flood Policy Study, has been recommended as a potentially effective measure of flood protection. It has been applied for the first time in Bangladesh as a test case in the Compartmentalization Pilot Project (CPP), Tangail. The CPP has concentrated in testing the technical and institutional viability of the concept in a single compartment. From the experience of the project, the results are found encouraging.

Setting up of a series of compartments along the flood plain of a river system means an interruption of the natural condition of flow and thereby must have some impacts on the overall flooding condition of the system. Prior to making any comments about the replicability of this multi-compartment setting (MCS) concept; there is a need to investigate the impacts of MCS on the flood situation in Bangladesh. This is possible by conducting a mathematical model study.

In the flood policy of Bangladesh, potential areas for compartmentalization have been indicated along the three major rivers: the Jamuna, the Meghna and the Ganges. The experience of CPP indicates that the compartmentalization along the Meghna river is not suitable as the major area is low lying and without adequate drainage. One of the conclusions of CPP has been that adequate drainage is essential for compartmentalization to work. Overall, drainage on the left bank of Jamuna is away from the main river through a number of distributary channels. The ground slope of the area is also away from the main river. Considering this, the best potential areas for compartmentalization are found on the left bank of the Jamuna, lying in the North Central Region of Bangladesh. This area has been modeled in this study.

SWMC has validated the regional models for 1995-98 conditions under the Annual Validation of Regional Models for the National Water Management Plan Project. The present model study is conducted using the North Central Region Model (NCRM) validated for 1996-97 condition incorporating the information from the CPP model.

Objectives

The main objective of the study is to investigate the impact of the embankments for compartmentalization on the flooding situation in the study area. However, the specific objectives are:

- To investigate the impacts of multiple compartment setting on the overall flooding condition within the region concerned.

- To quantify the change in water level at the upstream and downstream of the compartmentalization units considering a varying number of compartments.
- To observe the flooding condition within the compartmentalized area

Scope of the Work

The scopes of the work is as follows:

- Development of base model using the NCRM models and incorporating information of the CPP model.
- Identification of hypothetical compartments in the potential areas for compartmentalization within the North Central Region.
- Formulation of various options incorporating compartments in the base model.
- Determination of simulation years corresponding to 1:2 year, 1:5 year and 1:25 year flood condition.
- Model simulations for base condition and all the options for the above 3 flood events and analysis of model results.
- Conversion of the base model to a Flood Management Model and preparation of flood maps for all the options.

730

Modeling Study

Modeling Technique

Detailed studies of various hydrologic and hydraulic scenarios are necessary to assess the impacts of the proposed development activities. Such a study can only be carried out realistically by a well-calibrated mathematical model of the flow system of the study area.

The envisaged model applied in the present study is based on the North Central Region Model developed at the Surface Water Modeling Centre (SWMC). SWMC uses MIKE 11 river modeling software developed at the Danish Hydraulic Institute (DHI) as the standard tool for the river modeling. A brief description of the modeling systems used to simulate the hydrological and hydraulic processes in the study area is presented below:

Rainfall Runoff Model (MIKE 11-NAM)

NAM is an integrated module of MIKE 11 for the hydrological simulation. A mathematical hydrological model such as NAM is a set of linked mathematical statements describing, in a simplified quantitative form, the behavior of the land phase of the hydrological cycle. The NAM model is deterministic, conceptual, lumped type of model with moderate input data requirement.

Inputs to the NAM model are rainfall and evaporation time-series, groundwater abstraction rates, and irrigation demands (if applicable). The model continuously accounts for the volumes of water in different surface and sub-surface storage zones. The model calculates discharge runoff for each sub-catchment. Resulting runoff is used as input to the hydrodynamic model.

Hydrodynamic Model (MIKE 11-HD)

The MIKE 11 hydrodynamic model simulates flows and water levels in rivers and channels. It is commonly applied as a flood management tool to model flooding behavior of rivers and floodplains. Models numerically represent the river and floodplain topography and are calibrated to observed water levels and discharges. Once a base model is established, flood impacts from artificial or natural causes can be quantified and displayed as changes in flood level and discharge.

MIKE 11 is based on an efficient numerical solution of the complete non-linear de Saint Venant equations for 1-D flow. Abbott's 6-points finite difference scheme has been considered for the numerical solution of the partial differential equation. A network configuration schematizes the rivers and floodplains as a system of inter-connected branches. Water levels and discharges are computed at alternative points along the branches as a function of time.

Flood Management Model (MIKE 11-GIS)

MIKE 11-GIS integrates MIKE 11 dynamic river modeling with a Geographic Information System (GIS). The modeling system uses the spatial data manipulation techniques of GIS for enhanced mapping of flood levels.

The MIKE 11-GIS interfaces is developed and fully integrated within the Arc View GIS environment. MIKE 11-GIS uses the information from the MIKE 11 model network, flood simulations and Digital Elevation Model (DEM). Other useful inputs are maps of rivers, infrastructures etc. The main outputs are flood maps (depth/extend, duration) and impact maps (comparison).

Development of Base Model

The base model for the present model study is based on the existing North Central Regional Model (NCRM) of the SWMC. The North Central Region Model is one of the six regional river models of Bangladesh developed at SWMC under the Surface Water Simulation Modeling Program, (SWSMP) Phase-II and recently validated for the s1997-98 hydrological year under the Annual Validation Program of Water Resources Planning Organisation (WARPO). For the present study, the 1997-98 validated model set-up has been updated incorporating all of the river systems and major infrastructure information of the CPP model.

River Systems

The Base Model covers the entire North Central Region bounded by the Jamuna, the Ganges, the Meghna and the Old Brahmaputra. The central part of the region is mainly the result of spilling from the left bank of the Jamuna and drains in a southeasterly direction to the confluence of the Ganges and the Meghna Rivers. Consequently, high river stages in these two rivers impede the drainage of the region. The main spill fed rivers in the region include the Old Brahmaputra, Jhenai, Dhaleswari, Kaliganga, Pungli, Elanjani, Lohajang, Bangshi, Lakhya, Turag and Buriganga. Smaller, mainly rain fed, rivers include Khiro, Banar, Balu and Sutia. The river systems included in the model setup are shown in the Figure 1.

Rainfall Runoff

The rainfall runoff model (NAM) of the base model includes 20 catchments covering an area of 14,000 km^2. Rainfall from 35 stations and evaporation from three stations are used as input to the model. Monthly water abstraction of 1998 estimated from the

NMIDP census and irrigation coverage is also used as input to the model. Groundwater levels at 18 well locations are used to calibrate the model. The detail of the NAM model setup, the model parameters finally adopted, and the validation results for the 1997-98 validation, are available in the Annual Validation of North Central Region, 1997-98 hydrological Year Report of SWMC.

Boundaries

18 boundaries have been used in the present hydrodynamic model. The upstream boundaries are generally defined with the rated discharge time series and the downstream boundaries with water level time series. In some cases. zero flow (QC=0) is assigned as a closed upstream boundary, where no significant inflow from outside occurs. In a few cases, interpolated water level is used where the observed data is not available. Under the 1997-98 validation, simulated water level from a General Model of the Padma river at chainage 29.00 km is used as upstream boundary on the Ichhamati river at chainage 0.0 km. Table 1 shows the model boundaries.

River	Chainage (km)	Locations	Boundary Type	Upstream/ Downstream	Remarks
Balu	0.0000	Pubail	WL	Upstream	Used without any adjustment
Dhaleswari	178.00	Kalagachia	WL	Downstream	Used with adjustment and infilling
Ichamati	0.0000	Ichamati	WL	Upstream	Simulated WL from General Model
Dadbhanga	0.0000	Dadbhanga	Q	Upstream	Closed Boundary
Banar	37.000	Banar	Q	Upstream	Closed Boundary
Khiro	0.0000	Khiro	Q	Upstream	Closed Boundary
Sutia	0.0000	Sutia	Q	Upstream	Closed Boundary
Kaoraid	0.0000	Kaoraid	Q	Upstream	Closed Boundary
Old Brahmaputra	257.50	Bhairab Bazar	WL	Downstream	Used without any adjustment
Haridhoa	36.500	Narsingdi	WL	Downstream	Used without any adjustment
Arial Khan	49.000	Narsingdi	WL	Downstream	Used without any adjustment
Deonai	0.0000	Deonai	Q	Upstream	Closed Boundary
Bangshi	37.000	Madhupur	Q	Upstream	Rated discharge based on old rating
Jamuna	37.100	Chilmari	Q	Upstream	Bahadurabad discharge with 5 hour time lead was used
Jamuna	235.65	Aricha	WL	Downstream	Used with adjustment

Table 1: Model Boundaries

Setting up the Compartments

Adequacy of drainage is a pre-requisite for Compartmentalization. Potential areas for possible Compartmentalization are restricted by some factors such as ground slope, land elevation and the drainage network of the area. The size and boundary of the compartments are determined based on the hydrological conditions of the area. Each compartment can be treated as a hydrological unit. Considering these requirements and consulting the North Central Regional Study conducted by FAP-3, nine compartments (See location map at Figure 2) have been identified for the present study on the left bank of the river Brahmaputra. A brief description of the selected compartments and the problems associated in those areas are described below.

Compartment 1: This compartment is located in Jamalpur and Tangail districts. Total area for this compartment is 536 km^2. Average elevation is 16 m-PWD. This area has some local drainage problem and affected by flash floods in every rainy season. The active flood plain area of the compartment is affected by river erosion and sand deposition due to annual floods. Flooding mainly occurs from Jamuna, Old Brahmaputra and local rainfall. About 25% area is flooded in normal years.

Compartment 2: This compartment is located in Jamalpur and Tangail districts. Total area for this compartment is 247 km^2. Average elevation is 12 m-PWD. About 40% of the cultivable area are flooded in every year. Flooding occurs from the Jamuna and local rivers, and rainfall. The area is flooded for a period of 4 -6 months at a depth of 2 to 4 meters.

Compartment 3: This compartment is located in Tangail district. Total area for this compartment is 534 km^2. Average elevation is 12 m-PWD. Flooding occurs mainly from the Jamuna, Bangshi and local rivers and rainfall. About 70% of the cultivable area floods in every year during the monsoon.

Compartment 4: This compartment is located in Tangail district. Flooding is from the Jamuna, Dhaleswari, local rivers and rainfall. Total area for this compartment is 205 km^2. Average elevation is 7 m-PWD. About 80 to 90% of the cultivable area is flooded every year. This area has local drainage problems.

Compartment 5: This compartment is located in Dhaka and Manikganj district. Flooding is from the Jamuna, Dhaleswari, local rivers and rainfall. Total area for this compartment is 374 km^2. Average elevation is 6.75 m-PWD. About 80% of the cultivable area flooded in every year during the monsoon.

Compartment 6: This compartment is located in Dhaka and Manikganj district. Total area for this compartment is 139 km^2. Average elevation is 5.75 m-PWD. Flooding is from the Padma, regional rivers and rainfall. About 80% of the cultivable area is flooded every year. The area is flooded about 6 months in every year.

Compartment 7: This compartment is located in Gazipur and Dhaka districts. Total area for this compartment is 316 km^2. Average elevation is 8.0 m-PWD. Most of the area is used for homesteads. Flooding occurs from the regional rivers and local rainfall. The area is flooded about 3 to 4 months of each year.

Compartment 8: This compartment is located in Gazipur and Narayanganj district. Total area for this compartment is 1059 km^2. Average elevation is 6.0 m-PWD. Most of the area is used for homesteads. The area remains flooded for nearly 3 to 4 months each year. Flooding occurs from the regional rivers and local rainfall.

Compartment 9: This compartment is located in Dhaka, Keraniganj and Narayanganj district. Total area for this compartment is 157 km^2. Average elevation is 4.0 m-PWD. About 85 to 90% of the cultivable area is flooded every year. Flooding occurs from the regional rivers and local rainfall.

Incorporation of Compartments

The physical description of a compartment is the enclosing of an area by constructing embankments and control structures around the major rivers for controlled flooding and drainage. Embankment is introduced in the model by removing the flood plain from the cross-section data. This will reduce the flow area, and will have an impact on flow depth.

In the present study, nine hypothetical compartments have been incorporated sequentially in five different options in the model as described in Figure 1. The base model has been developed using the latest validated model available for the North Central Regional Model incorporating the information of CPP, Tangail compartment. Only those channels, which have been incorporated in the latest validated model, have been considered for the present study.

Five different options, each having a varying numbers of compartments have been simulated for the present study. CPP Tangail compartment has been incorporated in the base model. Each option has been simulated for 1976, 1984 and 1995 hydrological years, corresponding to 1:2 year, 1:5 year and 1:25 year return period respectively. As the flooding pattern of the entire North Central Region is mainly dominated by the Jamuna river, the flood frequency distribution made by FAP-2 at Bahadurabad on the Jamuna river was used to determine the simulation years, corresponding to the above the return periods.

Comparisons of water level and inundated area were made for each option with base condition. Longitudinal water level profiles were also checked for some of the rivers to observe the possibility of back flow for the options. Detailed comparison of water levels and statistics of inundated area are included in the Tables 2 to 7. Water Level profiles for some of the rivers and flood maps showing inundation are included in the figures at the end of this report.

The models setup for different options and a brief analysis of the simulated results for each option is described in the following.

Option 1

In this option two additional compartments i.e. Compartment 1 and 2 (see Figure 2) have been added to the base model. The base model has been updated for option 1 in the following way to incorporate the compartments.

- Chatal River has been disconnected from Jamuna River.
- Jhenai River has been disconnected from Old Brahmaputra River.
- Futikjani River has been disconnected from the Jamuna River.
- Jhenai-East River, from chainage 0.0 to Chainage 36.8km has been embanked.

The model was run and the water level was compared with the base condition. The changes in water level for different options have been shown in Tables 2 to 4.

From the results, it is observed that the maximum change in water level due to option 1 is in the Chatal and Futikjani River. In the Chatal River the maximum change in water level is -1.18m at chainage 5.0 km in 1995. In the Futikjani River the maximum change in water level is -1.0m at chainage 9km in 1995. These reductions are due to the enclosures of the above rivers from the Jamuna River.

For all other channels, the changes in water level are very negligible. The changes in inundation due to different options are given in Table 4 to 6. The result shows that due to option 1, the dry land increases about 100 km^2 in 1976 and in 1984 the increase is about 70 km^2. In 1995, the change is not considerable.

Option 2

In this option two more compartments i.e. Compartment 3 and 4 have been added to option 1. The model for Option 1 has been updated for this option in the following way to incorporate the compartments.

- Bangshi River has been embanked from chainage 45.0 km to chainage 93.0.
- Pungli River, from Ch 35.0 to Ch. 55.0 km. has been embanked.
- Bangshi river has been embanked from chainage 148 km to chainage 173.5
- Barinda river been embanked from chainage 0.0 km to Chainage 30.0 km.
- From the model simulation, the water levels have been compared. For Bangshi River the comparison of water level with base condition was made in Chainage 85 Km, 166 km and 182.5 km. In chainage 85 km and 173.5 km of Bangshi river, a reduction in water level is still observed compared to the base condition. This is due to the reduction in flow to the system. Whereas the water level increased compared to the Option1. The maximum increase of water level observed is 20 cm at chainage 166 km in 1984. This increase is due to the embankment. In Barinda River, the change in water level is negligible.
- In Pungli River the water level, comparison was made at Chainage 20 km and 45 km. In chainage 20 km, the maximum increase in water level observed about 31 cm and in Chainage 45 km, it is 71 cm.
- Comparing the flooding situation, no significant change is observed. In 1976, here is an increase in dry land, which is about 70 km^2. In 1984, the dry land is reduced by about 20 km^2 and in 1995, the reduction is about 48 km^2.

Option 3

In this option two additional compartments i.e. Compartment 5 and 6 (see: location map) have been added with option 2. The model for Option 2 has been updated for this option in the following way to incorporate the compartments.

- Cross-sections of Barinda River from chainage 0.0 km to Chainage 9.0 km has been further reduced as it is embanked on the other banks.
- Bangshi south from chainage 31.0 to chainage 40.1 is embanked.
- Structure at Bangshi south at chainage 40.1 km is kept permanently closed.
- Dhantara-k from chainage 1.0 km Chainage 14.25 km has been embanked.
- Bangshi has been embanked from chainage 177.0 km to chainage 202.0 km.

- Dhaleswari has been embanked from chainage 36 km to chainage 120 km.
- Dhaleswari River has been embanked again from chainage 120 km to Chainage 135 km.
- Kaliganga River has been embanked from chainage 20 km to Chainage 70.0 km.

From the simulated results, it is observed that due to the embankment the maximum increase in water level in the Bangshi south is 1.50 m at chainage 40 km in 1984.

- The maximum increase in water level in Dhantara khal is 1.18 m in chainage 9.1 km in 1984.
- The maximum increase for water level for Dhaleswari River is 0.51 m at chainage 82.5 in 1995.
- The maximum increase in water level for Kaliganga River is 0.31 m at chainage 37.5 km in 1995.

In the flooding situation, no significant improvement is observed.

Option 4

In this option two additional compartments i.e. Compartment 7 and 9 (see location map) have been added with option three. The model for Option 3 has been updated for this option in the following way to incorporate the compartments.

- Bangshi River has been embanked from chainage 177.0 km to Chainage 202.0 km.
- Karnatali River has been embanked from chainage 1.0 to Chainage 11.4 km.
- Turag River has been embanked from chainage 0.0 km to chainage 64.0 km.
- Buriganga chainage 23.0 km to Buriganga 40.0 km has been embanked.
- Dhaleswari River has been embanked from chainage 146.0 km to chainage 164.0 km.

From the simulations the maximum change in water level observed due to option 4 is as follows:

- For Bangshi River, the increase is 85 cm at chainage 201 km in 1995.
- For Karnatali River, the increase is 83 cm at chainage 4.9 km in 1995.
- For Turag River, the increase is 43 cm at chainage 30 km in 1995.
- For Buriganga River, the increase is 8cm at chainage 30 km in 1995. For

Dhaleswari River, the increase is 55cm at chainage 135 km in 1995. For inundation event, the dry area is increased about 100 km^2 in 1976 and 1984. In 1995, the increase is negligible.

Option 5

In this option one additional compartments i.e. Compartment 8 has been added with option 4.

The model for Option 4 has been updated in the following way to incorporate the compartment.

- Lakhya River has been embanked from chainage 45.0 km to chainage 100.0 km
- Cross-section of Turag from chainage 14.0 km to chainage 64.0 km has been further reduced as it is embanked on the other bank.
- Cross-sections of Buriganga from chainage 23.0 km to chainage 40.0 km has been further reduced as it is already embanked on the other bank.

From the simulated result, the maximum change in water levels for this option is as follows:

- For Lakhya River, the maximum change is at 62 cm at chainage 77.5 km in 1995.
- For Turag River, it is 44 cm in chainage 30km in 1995.
- For Buriganga River, it is only 8cm at chainage 30 km in 1995.

Comparing the flooding the increase in dry area is about 377 km^2 in 1976, 446 km^2 in 1984 and 385 km^2 in 1995.

Conclusion and Recommendation

Conclusion

In this study, the main objective was to investigate the impacts on water levels upstream and downstream of the major rivers and the extent of flooding due to incorporation of series of hypothetical compartments within the North Central Region. Accordingly, compartments were coarsely delineated following the guidelines of North Central Regional Study (FAP-3). Five options have been formulated combining compartments in sequential order. The options have been simulated for three different hydrological years corresponding to 1:2 year, 1:5 year and 1:25 year return period.

Model results were analyzed for investigating the change in water levels in the rivers at the upstream, downstream, within the compartments, and the inundated areas under different options. It is observed from the model results that due to the compartmentalization water levels increased in most of the channels. In most cases the increase of water level is not significant, maximum increase is observed in option 5. Maximum increase of water level in Bangshi River is at chainage 201 km. Dhaleswari at chainage 135km. Pungli at chainage 45km are 0.85 m, 0.55 m and 0.77 m respectively.

Water level profiles for different channels were also investigated and no back flow was observed. While comparing the flooded area, it is observed that in option 1 and 2 the dry area is increased significantly in is average year with respect to base condition. However, in option 3 the increase is not significant. Whereas in option 4, when two additional compartments were added with option 3 on the left bank of Bangshi and Dhaleswari river, the dry area increased significantly. Finally, in option 5 when all the nine compartments are incorporated, the flooding situation improved significantly.

It is to be mentioned here that already some of the portions of the major rivers such as Bangshi, Turag, Pungli, Lohajang, Buriganga, Dhaleswari and Kaliganga are already embanked.

Considering the model output, it can be concluded that the flooding situation in the region would improve significantly due to the multiple compartment setting, which justifies the concept of replicability of multiple compartment setting.

Recommendation

The river system within the North Central Region is very dynamic and changes year to year. For the present study, the latest available validated model setup was used. Due to the limited scope and time constraints of the study the internal water management within the compartments have not been considered. It is assumed that rainfall contribution within the compartment will drain properly to the adjacent connecting rivers. In the present model setup, only significant rivers have been considered, minor channels and beels could not be included due to lack of such information at the regional level. Furthermore, the land elevation data used in the study are obtained from survey data from early sixties that doesn't fully represent the land topography of the area due to morphological changes in the floodplains over the years.

Despite the limitations mentioned, model results could be used for water resources planning at the national level but with some reservation. However, prior to any implementation a detailed level model study is suggested.

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Appendix A

292

River	Chainage	Base	Option 1	Change	Option 2	Change	Option 3	Change	Option 4	Change	Option 5	Change
		m,pwd	m,pwd	m	m,pwd	m	m,pwd	m	m,pwd	m	m,pwd	m
Chatal	5	16.6	15.44	-1.16	15.44	-1.16	15.44	-1.16	15.44	-1.16	15.44	-1.16
Chatal	36.5	15.79	15.44	-0.35	15.44	-0.35	15.44	-0.35	15.44	-0.35	15.44	-0.35
Jhenai	5	16.9	15.5	-1.4	15.5	-1.4	15.5	-1.4	15.5	-1.4	15.5	-1.4
Jhenai	78	12.2	11.9	-0.3	12	-0.2	12	-0.2	12	-0.2	12	-0.2
Futikjani	9	11.7	10.9	-0.8	11.1	-0.6	11.1	-0.6	11.1	-0.6	11.1	-0.6
Futikjani	12.5	11.5	10.8	-0.7	11.1	-0.4	11.1	-0.4	11.1	-0.4	11.1	-0.4
Jhenai-East	15	12.74	12.69	-0.05	12.71	-0.03	12.71	-0.03	12.71	-0.03	12.71	-0.03
Bangshi	85	9.76	9.6	-0.16	9.68	-0.08	9.69	-0.07	9.69	-0.07	9.69	-0.07
Bangshi	166	7.01	6.96	-0.05	6.97	-0.04	7.13	0.12	7.25	0.24	7.25	0.24
Bangshi	182.5	6.18	6.17	-0.01	6.17	-0.01	6.44	0.26	6.68	0.5	6.68	0.5
Bangshi	201	5.79	5.82	0.03	5.82	0.03	5.93	0.14	6.28	0.49	6.28	0.49
Pungli	20	11.28	11.27	-0.01	11.56	0.28	11.56	0.28	11.57	0.29	11.57	0.29
Pungli	45	8.39	8.35	-0.04	8.97	0.58	8.99	0.6	9	0.61	9	0.61
Lohajang	40	9.01	9	-0.01	9.01	0	9.18	0.17	9.19	0.18	9.19	0.18
Barinda	15	8.35	8.33	-0.02	8.33	-0.02	8.79	0.44	8.8	0.45	8.8	0.45
Barinda	30	6.41	6.39	-0.02	6.4	-0.01	6.81	0.4	6.97	0.56	6.97	0.56
Bansi-south	35	7.9	7.88	-0.02	7.89	-0.01	8.7	0.8	8.72	0.82	8.72	0.82
Bansi-south	40	7.27	7.25	-0.02	7.26	-0.01	8.52	1.25	8.55	1.28	8.55	1.28
Dhantara-K	9.1	6.68	6.66	-0.02	6.67	-0.01	7.62	0.94	7.7	1.02	7.7	1.02
Dhaleswari	52	9.03	9.01	-0.02	9.01	-0.02	9.25	0.22	9.26	0.23	9.26	0.23
Dhaleswari	82.5	7.42	7.4	-0.02	7.4	-0.02	7.89	0.47	7.91	0.49	7.91	0.49
Dhaleswari	135	5.65	5.68	0.03	5.68	0.03	5.7	0.05	5.96	0.31	5.96	0.31
Dhaleswari	154	5.31	5.36	0.05	5.36	0.05	5.37	0.06	5.41	0.1	5.41	0.1
Dhaleswari	170	5.25	5.3	0.05	5.3	0.05	5.3	0.05	5.3	0.05	5.3	0.05
Kaliganga	37.5	6.91	6.9	-0.01	6.9	-0.01	7.15	0.24	7.2	0.29	7.2	0.29
Kaliganga	70	5.65	5.68	0.03	5.68	0.03	5.7	0.05	5.96	0.31	5.96	0.31
Karnatali	4.9	5.48	5.52	0.04	5.52	0.04	5.55	0.07	5.99	0.51	5.99	0.51
Turag	30	5.89	5.91	0.02	5.91	0.02	5.96	0.07	6.2	0.31	6.2	0.31
Turag	61	5.53	5.57	0.04	5.57	0.04	5.59	0.06	5.58	0.05	5.58	0.05
Buriganga	30	5.3	5.35	0.05	5.35	0.05	5.35	0.05	5.36	0.06	5.36	0.06
Buriganga	40	5.28	5.33	0.05	5.33	0.05	5.33	0.05	5.34	0.06	5.34	0.06
Lakhya	77.5	5.77	5.84	0.07	5.84	0.07	5.84	0.07	5.84	0.07	6.23	0.46
Lakhya	99	5.43	5.49	0.06	5.49	0.06	5.49	0.06	5.5	0.07	5.53	0.1

Table 2: Water Level Comparison for 1976 condition

River	Chainage	Base	Option 1	Change	Option 2	Change	Option 3	Change	Option 4	Change	Option 5	Change
		m,pwd	m,pwd	m	m,pwd	m	m,pwd	m	m,pwd	m	m,pwd	m
Chatal	5	17.14	15.97	-1.17	15.97	-1.17	15.97	-1.17	15.97	-1.17	15.97	-1.17
Chatal	36.5	16.24	15.96	-0.28	15.96	-0.28	15.96	-0.28	15.96	-0.28	15.96	-0.28
Jhenai	5	17.2	16	-1.2	16	-1.2	16	-1.2	16	-1.2	16	-1.2
Jhenai	78	12.6	12.4	-0.2	12.5	-0.1	12.5	-0.1	12.5	-0.1	12.5	-0.1
Futikjani	9	12.2	11.4	-0.8	11.7	-0.5	11.7	-0.5	11.7	-0.5	11.7	-0.5
Futikjani	12.5	12	11.3	-0.7	11.6	-0.4	11.6	-0.4	11.6	-0.4	11.6	-0.4
Jhenai-East	15	13.15	13.19	0.04	13.2	0.05	13.2	0.05	13.2	0.05	13.2	0.05
Bangshi	85	10.26	10.08	-0.18	10.25	-0.01	10.25	-0.01	10.25	-0.01	10.25	-0.01
Bangshi	166	7.6	7.45	-0.15	7.65	0.05	7.84	0.24	7.98	0.38	7.98	0.38
Bangshi	182.5	6.68	6.63	-0.05	6.7	0.02	7.08	0.4	7.4	0.72	7.4	0.72
Bangshi	201	6.23	6.21	-0.02	6.25	0.02	6.53	0.3	6.99	0.76	6.99	0.76
Pungli	20	11.79	11.77	-0.02	12.1	0.31	12.1	0.31	12.1	0.31	12.1	0.31
Pungli	45	8.89	8.74	-0.15	9.63	0.74	9.66	0.77	9.68	0.79	9.68	0.79
Lohajang	40	9.55	9.53	-0.02	9.57	0.02	9.75	0.2	9.77	0.22	9.77	0.22
Barinda	15	8.86	8.84	-0.02	8.85	-0.01	9.43	0.57	9.45	0.59	9.45	0.59
Barinda	30	6.92	6.86	-0.06	6.96	0.04	7.47	0.55	7.69	0.77	7.7	0.78
Bansi-south	35	8.41	8.39	-0.02	8.41	0	9.38	0.97	9.41	1	9.41	1
Bansi-south	40	7.7	7.67	-0.03	7.71	0.01	9.2	1.5	9.24	1.54	9.24	1.54
Dhantara-K	9.1	7.15	7.12	-0.03	7.18	0.03	8.33	1.18	8.43	1.28	8.43	1.28
Dhaleswari	52	9.62	9.6	-0.02	9.61	-0.01	9.95	0.33	9.97	0.35	9.97	0.35
Dhaleswari	82.5	7.96	7.94	-0.02	7.95	-0.01	8.45	0.49	8.47	0.51	8.47	0.51
Dhaleswari	135	6.08	6.06	-0.02	6.09	0.01	6.24	0.16	6.63	0.55	6.63	0.55
Dhaleswari	154	5.64	5.64	0	5.65	0.01	5.7	0.06	5.9	0.26	5.9	0.26
Dhaleswari	170	5.48	5.48	0	5.48	0	5.5	0.02	5.5	0.02	5.5	0.02
Kaliganga	37.5	7.3	7.3	0	7.3	0	7.56	0.26	7.64	0.34	7.64	0.34
Kaliganga	70	6.08	6.06	-0.02	6.09	0.01	6.24	0.16	6.63	0.55	6.63	0.55
Karnatali	4.9	5.82	5.82	0	5.84	0.02	5.94	0.12	6.6	0.78	6.6	0.78
Turag	30	6.31	6.26	-0.05	6.33	0.02	6.42	0.11	6.71	0.4	6.72	0.41
Turag	61	5.92	5.91	-0.01	5.94	0.02	6.01	0.09	6	0.08	6	0.08
Buriganga	30	5.57	5.57	0	5.58	0.01	5.62	0.05	5.64	0.07	5.64	0.07
Buriganga	40	5.54	5.54	0	5.55	0.01	5.58	0.04	5.61	0.07	5.61	0.07
Lakhya	77.5	5.98	6.04	0.06	6.04	0.06	6.04	0.06	6.05	0.07	6.5	0.52
Lakhya	99	5.63	5.65	0.02	5.65	0.02	5.66	0.03	5.66	0.03	5.72	0.09

Table 3: Water Level Comparison for 1984

River	Chainage	Base	Option 1	Change	Option 2	Change	Option 3	Change	Option 4	Change	Option 5	Change
		m,pwd	m,pwd	m	m,pwd	m	m,pwd	m	m,pwd	m	m,pwd	m
Chatal	5	17.41	16.23	-1.18	16.23	-1.18	16.23	-1.18	16.23	-1.18	16.23	-1.18
Chatal	36.5	16.51	16.22	-0.29	16.22	-0.29	16.22	-0.29	16.22	-0.29	16.22	-0.29
Jhenai	5	17.4	16.2	-1.2	16.2	-1.2	16.2	-1.2	16.2	-1.2	16.2	-1.2
Jhenai	78	12.8	12.6	-0.2	12.6	-0.2	12.6	-0.2	12.6	-0.2	12.6	-0.2
Futikjani	9	12.4	11.4	-1	11.7	-0.7	11.7	-0.7	11.7	-0.7	11.7	-0.7
Futikjani	12.5	12.2	11.3	-0.9	11.7	-0.5	11.7	-0.5	11.7	-0.5	11.7	-0.5
Jhenai-East	15	13.23	13.36	0.13	13.37	0.14	13.37	0.14	13.37	0.14	13.37	0.14
Bangshi	85	10.36	10.17	-0.19	10.23	-0.13	10.31	-0.05	10.31	-0.05	10.31	-0.05
Bangshi	166	7.74	7.67	-0.07	7.72	-0.02	7.95	0.21	8.07	0.33	8.07	0.33
Bangshi	182.5	6.79	6.84	0.05	6.8	0.01	7.23	0.44	7.54	0.75	7.54	0.75
Bangshi	201	6.28	6.38	0.1	6.29	0.01	6.69	0.41	7.13	0.85	7.13	0.85
Pungli	20	11.99	11.97	-0.02	12.27	0.28	12.27	0.28	12.27	0.28	12.27	0.28
Pungli	45	9.08	8.95	-0.13	9.78	0.7	9.83	0.75	9.85	0.77	9.85	0.77
Lohajang	40	9.71	9.69	-0.02	9.73	0.02	9.92	0.21	9.94	0.23	9.94	0.23
Barinda	15	9.12	9.11	-0.01	9.1	-0.02	9.71	0.59	9.73	0.61	9.73	0.61
Barinda	30	7.06	7.09	0.03	7.07	0.01	7.62	0.56	7.83	0.77	7.83	0.77
Bansi-south	35	8.72	8.71	-0.01	8.72	0	9.68	0.96	9.7	0.98	9.69	0.97
Bansi-south	40	8.02	7.97	-0.05	8.02	0	9.48	1.46	9.5	1.48	9.5	1.48
Dhantara-K	9.1	7.4	7.37	-0.03	7.41	0.01	8.58	1.18	8.66	1.26	8.66	1.26
Dhaleswari	52	10.02	10	-0.02	10.01	-0.01	10.31	0.29	10.32	0.3	10.32	0.3
Dhaleswari	82.5	8.23	8.26	0.03	8.22	-0.01	8.74	0.51	8.74	0.51	8.74	0.51
Dhaleswari	135	6.16	6.21	0.05	6.17	0.01	6.35	0.19	6.71	0.55	6.71	0.55
Dhaleswari	154	5.73	5.73	0	5.74	0.01	5.78	0.05	5.93	0.2	5.93	0.2
Dhaleswari	170	5.65	5.66	0.01	5.65	0	5.67	0.02	5.68	0.03	5.68	0.03
Kaliganga	37.5	7.46	7.45	-0.01	7.46	0	7.77	0.31	7.82	0.36	7.82	0.36
Kaliganga	70	6.16	6.21	0.05	6.17	0.01	6.35	0.19	6.71	0.55	6.71	0.55
Karnatali	4.9	5.89	5.93	0.04	5.9	0.01	6.04	0.15	6.72	0.83	6.72	0.83
Turag	30	6.32	6.38	0.06	6.33	0.01	6.47	0.15	6.75	0.43	6.76	0.44
Turag	61	5.95	6.02	0.07	5.96	0.01	6.08	0.13	6.08	0.13	6.08	0.13
Buriganga	30	5.7	5.7	0	5.7	0	5.74	0.04	5.78	0.08	5.78	0.08
Buriganga	40	5.68	5.68	0	5.69	0.01	5.71	0.03	5.75	0.07	5.75	0.07
Lakhya	77.5	6.17	6.26	0.09	6.24	0.07	6.27	0.1	6.27	0.1	6.79	0.62
Lakhya	99	5.79	5.82	0.03	5.81	0.02	5.83	0.04	5.83	0.04	5.91	0.12

Table 4: Water Level Comparison For 1995

Base		Option-01		Option-02		Option-03		Option-04		Option-05	
Condition											
Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area
	(KM^2)		(KM^2)		(KM^2)		(KM^2)		(KM^2)		(KM^2)
Dry	11065	Dry	11175	Dry	11135	Dry	11060	Dry	11195	Dry	11442
F_0(0-300)	791	F_0(0-300)	775	F_0(0-300)	770	F_0(0-300)	766	F_0(0-300)	749	F_0(0-300)	711
F_1(300-900)	1347	F_1(300-900)	1311	F_1(300-900)	1311	F_1(300-900)	1309	F_1(300-900)	1267	F_1(300-900)	1202
F_2(900-1800)	1515	F_2(900-1800)	1463	F_2(900-1800)	1469	F_2(900-1800)	1470	F_2(900-1800)	1408	F_2(900-1800)	1326
F_3(>1800)	1126	F_3(>1800)	1122	F_3(>1800)	1161	F_3(>1800)	1240	F_3(>1800)	1227	F_3(>1800)	1165

Table 5: Statistics of inundated area for 1976

Base		Option-01		Option-02		Option-03		Option-04		Option-05	
Condition											
Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area
	(KM^2)		(KM^2)		(KM^2)		(KM^2)		(KM^2)		(KM^2)
Dry	9676	Dry	9746	Dry	9658	Dry	9595	Dry	9777	Dry	10122
F_0(0-300)	837	F_0(0-300)	847	F_0(0-300)	854	F_0(0-300)	852	F_0(0-300)	829	F_0(0-300)	786
F_1(300-900)	1545	F_1(300-900)	1531	F_1(300-900)	1541	F_1(300-900)	1534	F_1(300-900)	1501	F_1(300-900)	1413
F_2(900-1800)	1746	F_2(900-1800)	1697	F_2(900-1800)	1704	F_2(900-1800)	1707	F_2(900-1800)	1635	F_2(900-1800)	1542
F_3(>1800)	2042	F_3(>1800)	2025	F_3(>1800)	2089	F_3(>1800)	2158	F_3(>1800)	2104	F_3(>1800)	1983

Table 6: Statistics of inundated area for 1984

Base		Option-01		Option-02		Option-03		Option-04		Option-05	
Condition											
Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area	Land Type	Area
	(KM^2)		(KM^2)		(KM^2)		(KM^2)		(KM^2)		(KM^2)
Dry	8433	Dry	8466	Dry	8384	Dry	8321	Dry	8482	Dry	8817
F_0(0-300)	940	F_0(0-300)	953	F_0(0-300)	967	F_0(0-300)	969	F_0(0-300)	950	F_0(0-300)	907
F_1(300-900)	1860	F_1(300-900)	1832	F_1(300-900)	1851	F_1(300-900)	1842	F_1(300-900)	1804	F_1(300-900)	1718
F_2(900-1800)	2428	F_2(900-1800)	2395	F_2(900-1800)	2390	F_2(900-1800)	2392	F_2(900-1800)	2312	F_2(900-1800)	2215
F_3(>1800)	2185	F_3(>1800)	2200	F_3(>1800)	2253	F_3(>1800)	2322	F_3(>1800)	2297	F_3(>1800)	2189

Table 7: Statistics of inundated area for 1995

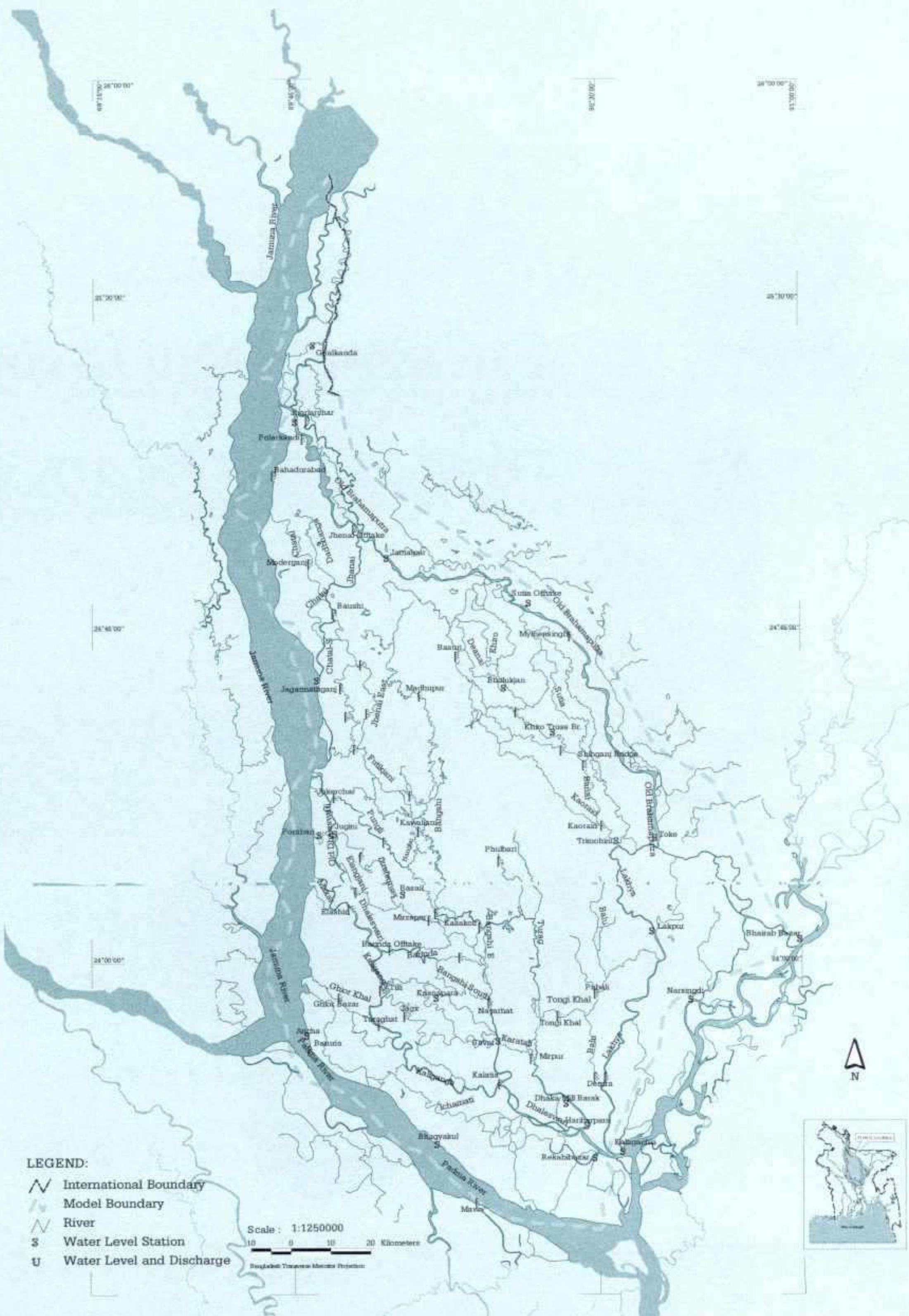

Figure : 1 North Central Region Model River Systems and Hydrological Stations

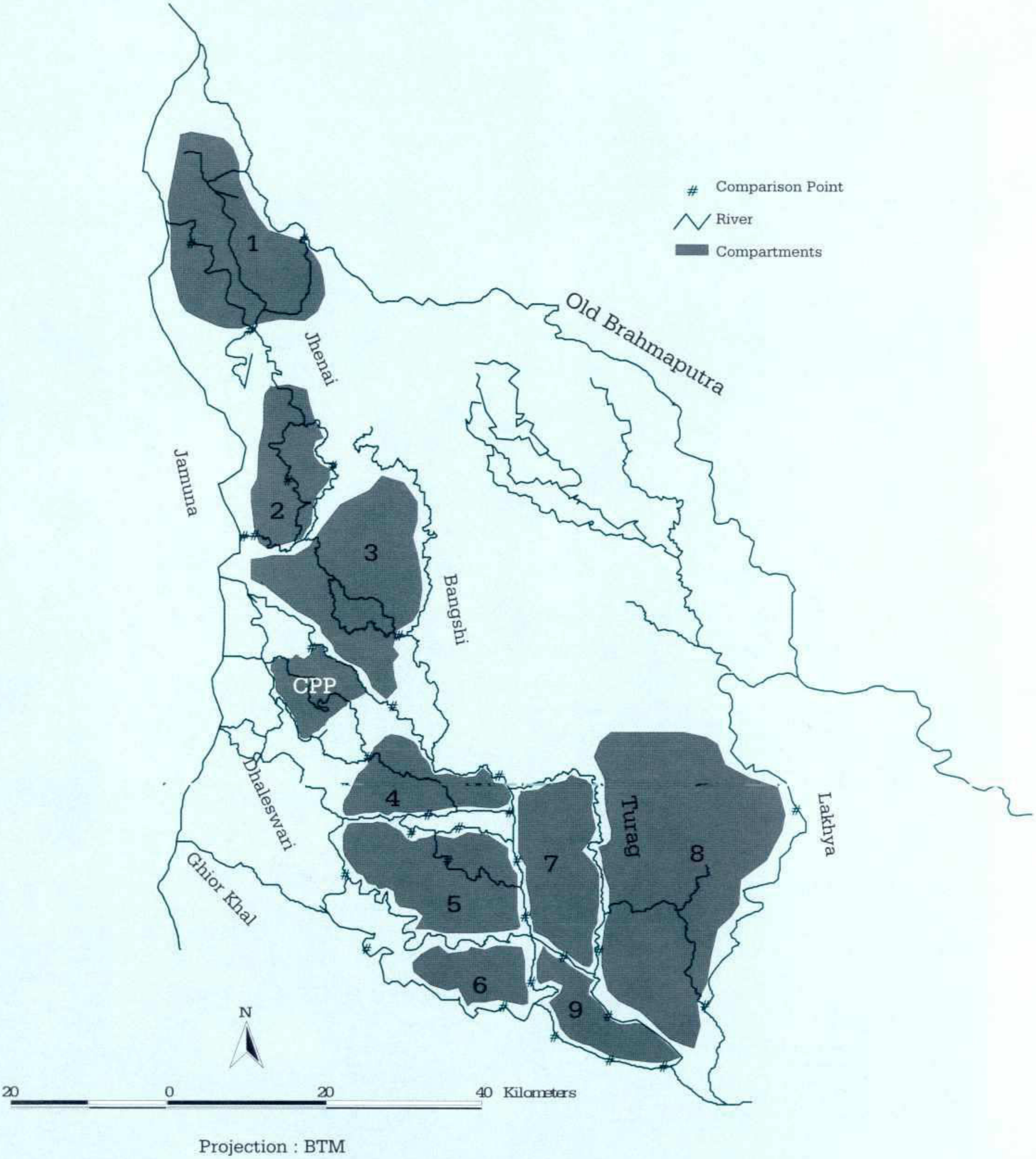

Figure 2: Location of the Compartments

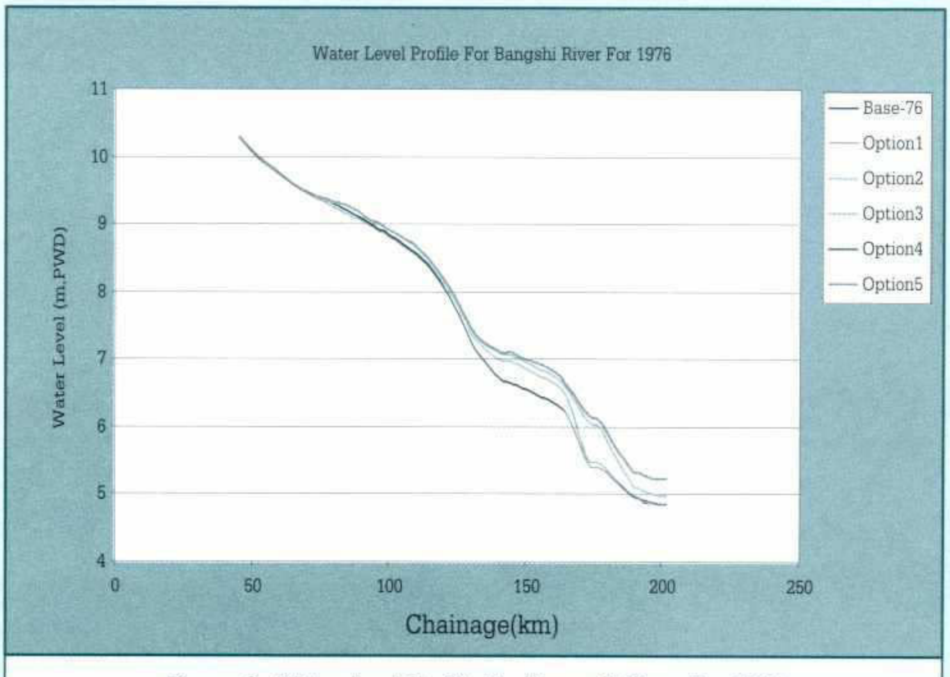

Figure 3 : Water level Profile For Bangshi River For 1976

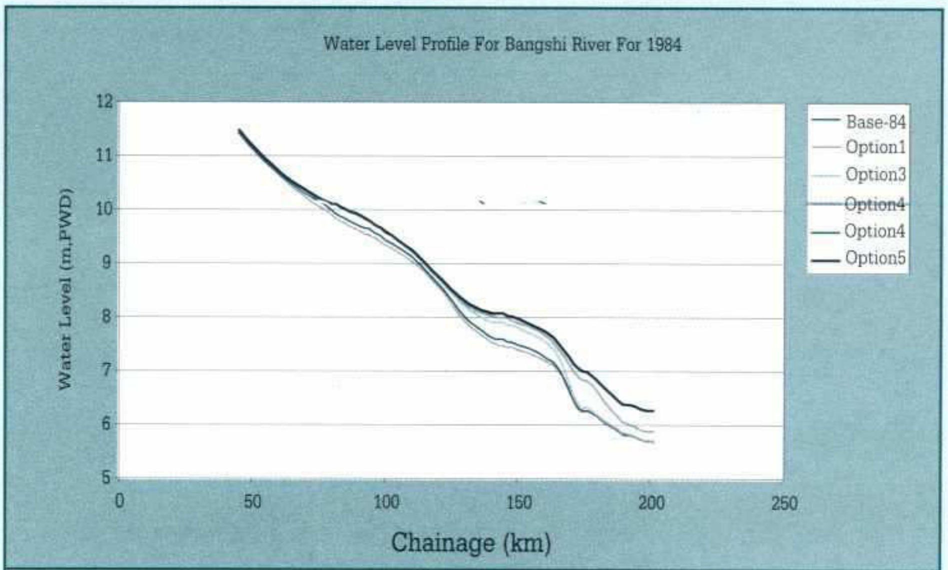

Figure 4 : Water level Profile For Bangshi River For 1984

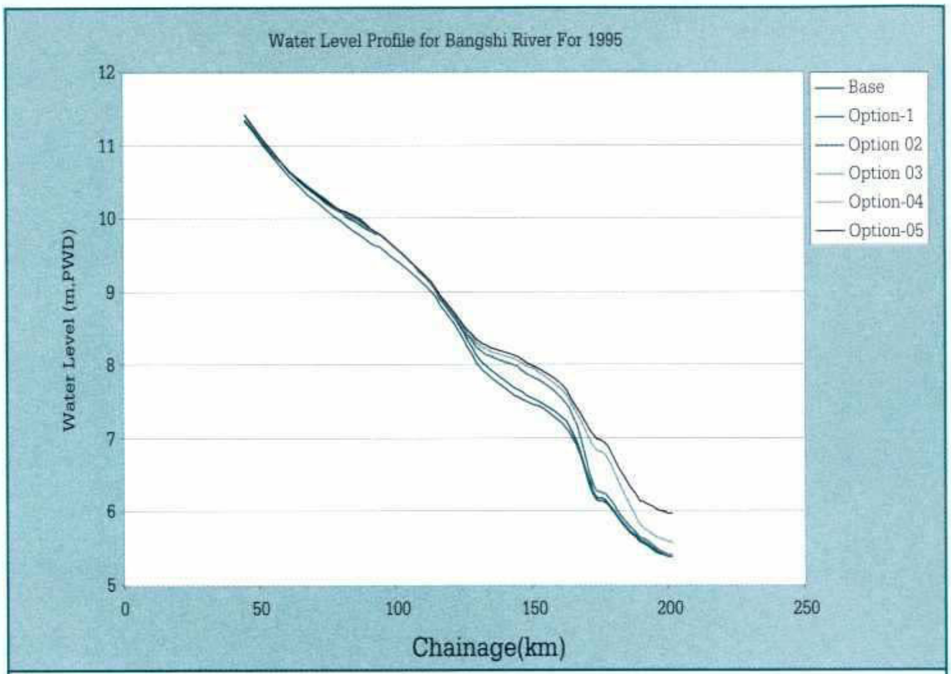

Figure 5 : Water level Profile For Bangshi River For 1995

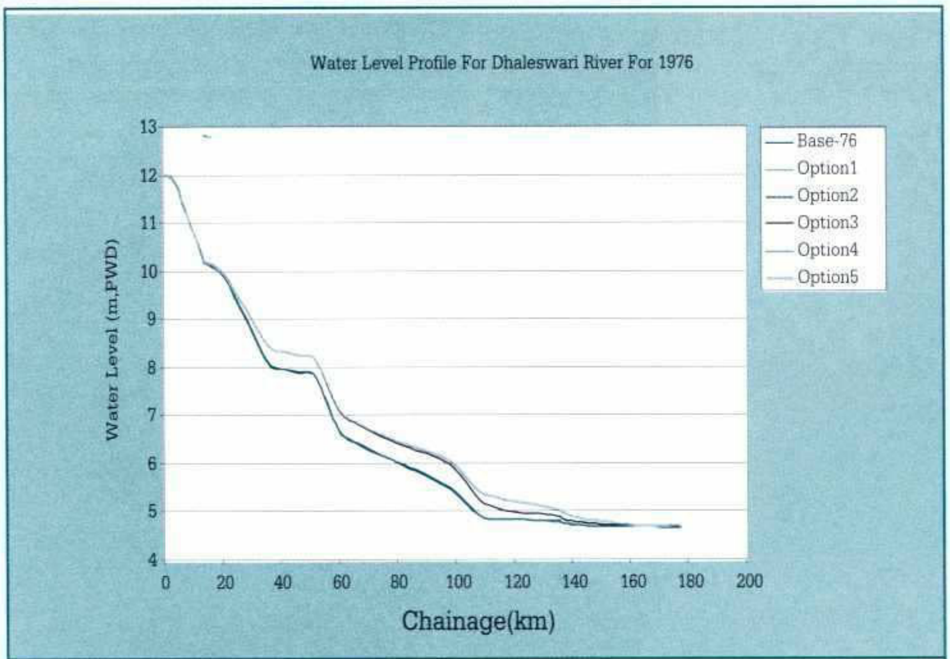

Figure 6 : Water Level Profile For Dhaleswari River For 1976

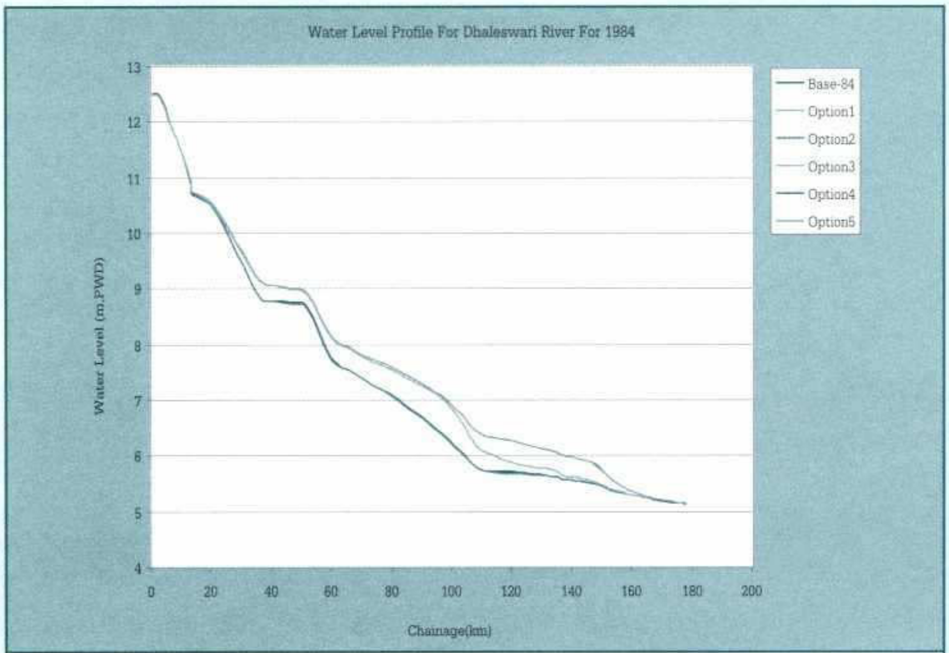

Figure 7 : Water Level Profile For Dhaleswari River For 1984

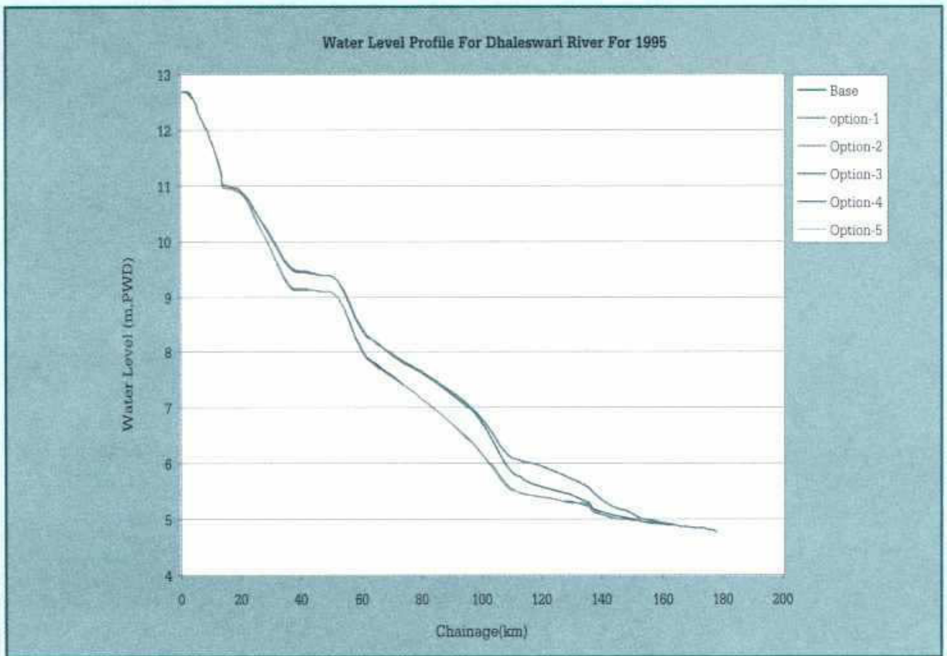

Figure 8 : Water Level Profile For Dhaleswari River For 1995

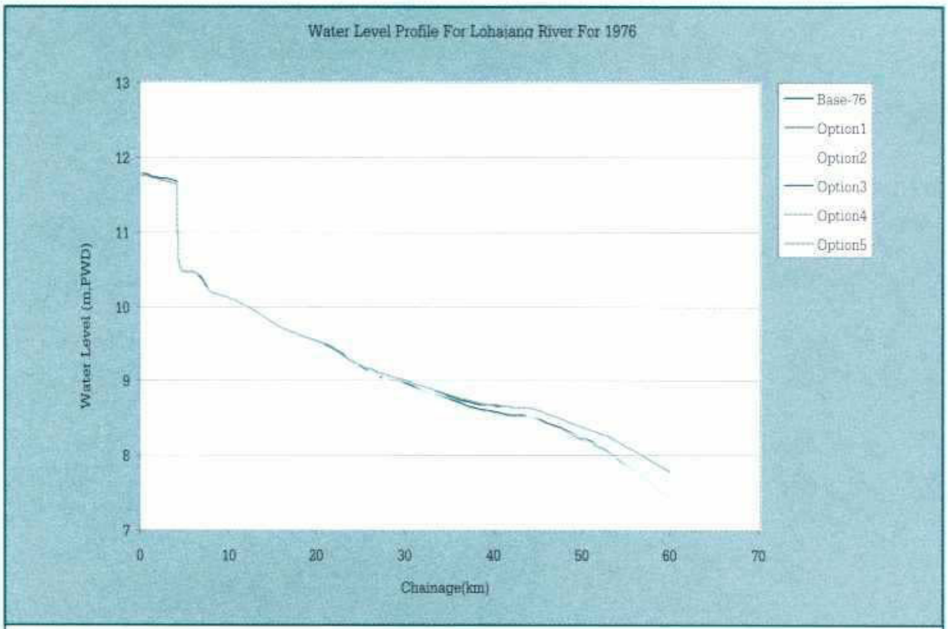

Figure 9 : Water Level Profile For Lohajang River For 1976

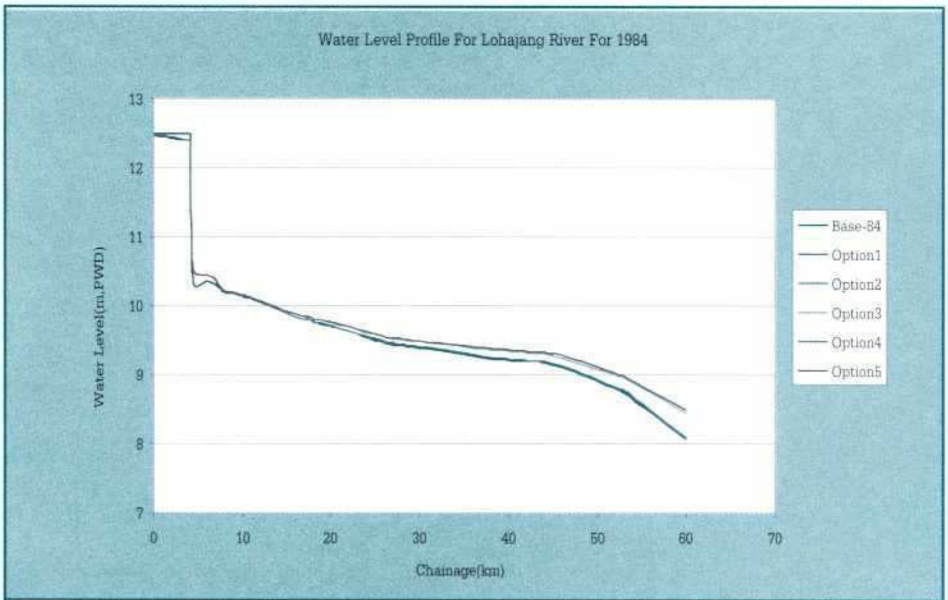

Figure 10 : Water Level Profile For Lohajang River For 1984

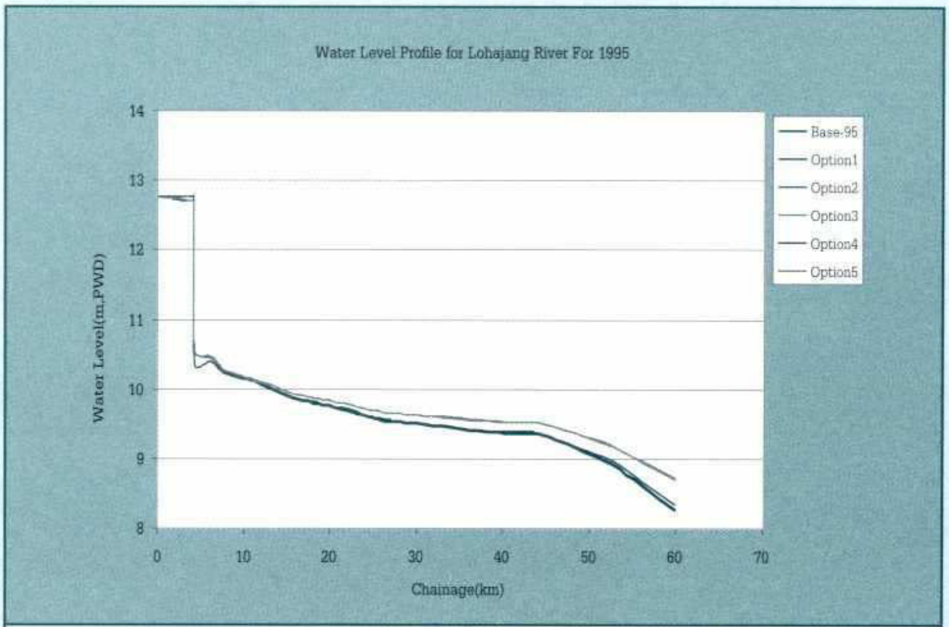

Figure 11 : Water Level Profile For Lohajang River For 1995

Figure12: Flood Map: Simulated for Base Condition : 1995

Figure13: Flood Map: Simulated for Option1: 1995

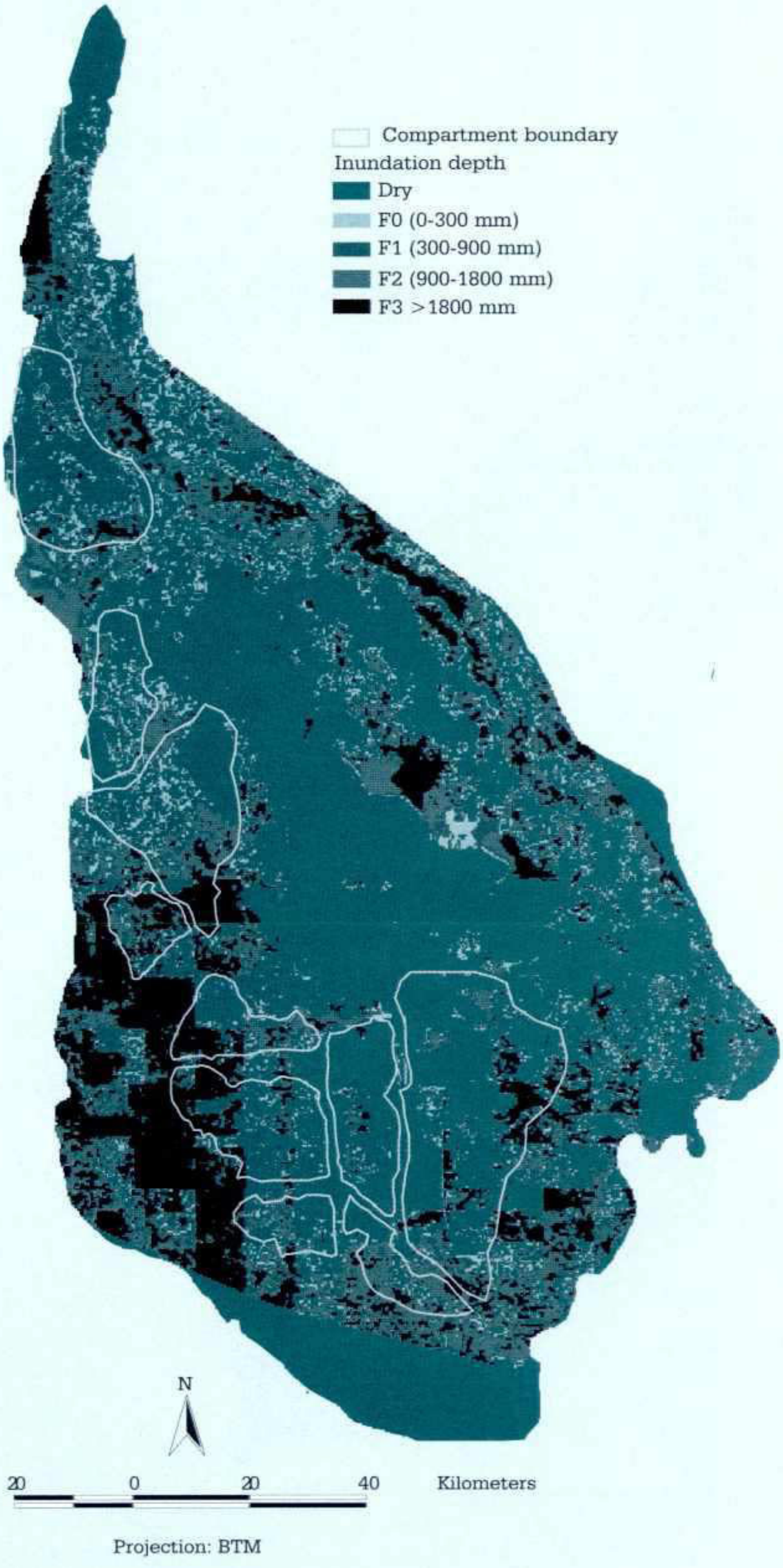

Figure14: Flood Map: Simulated for Option 2: 1995

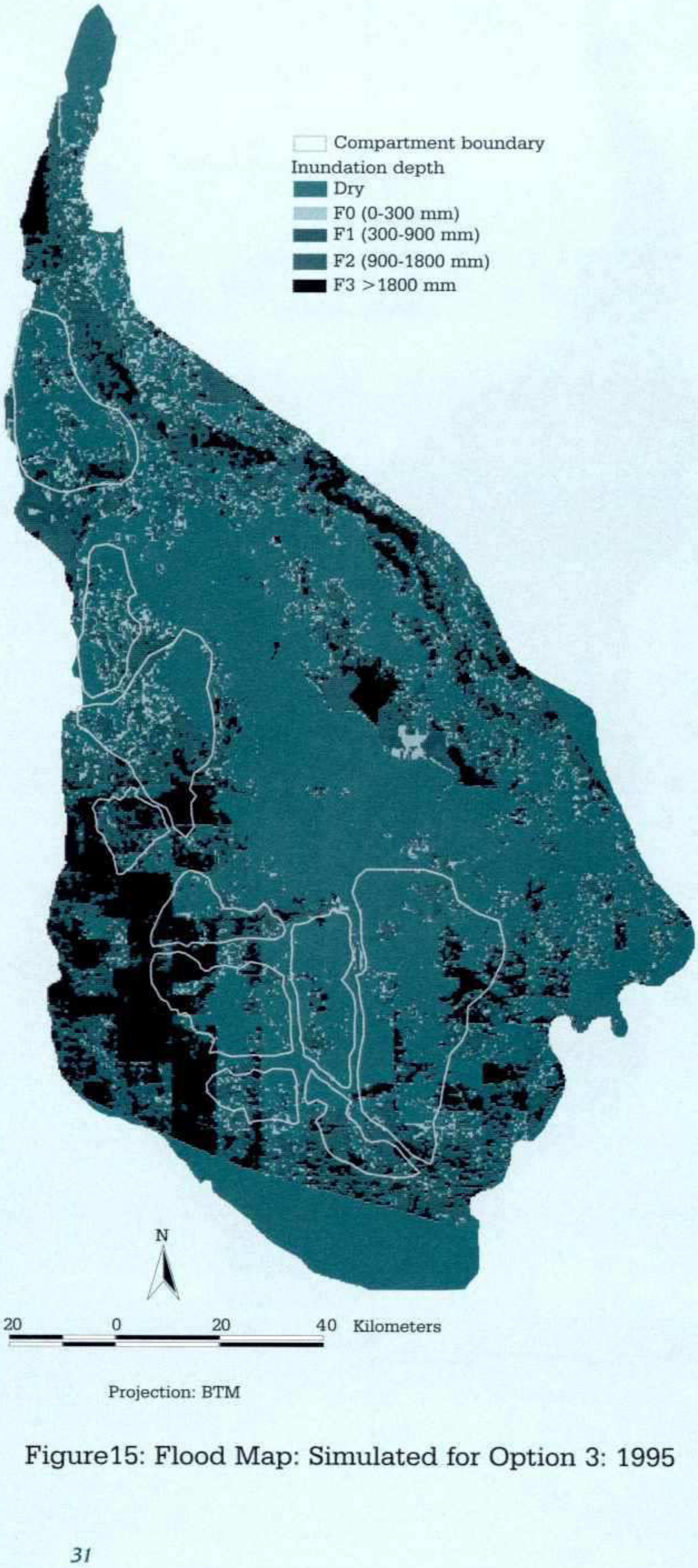

Figure15: Flood Map: Simulated for Option 3: 1995

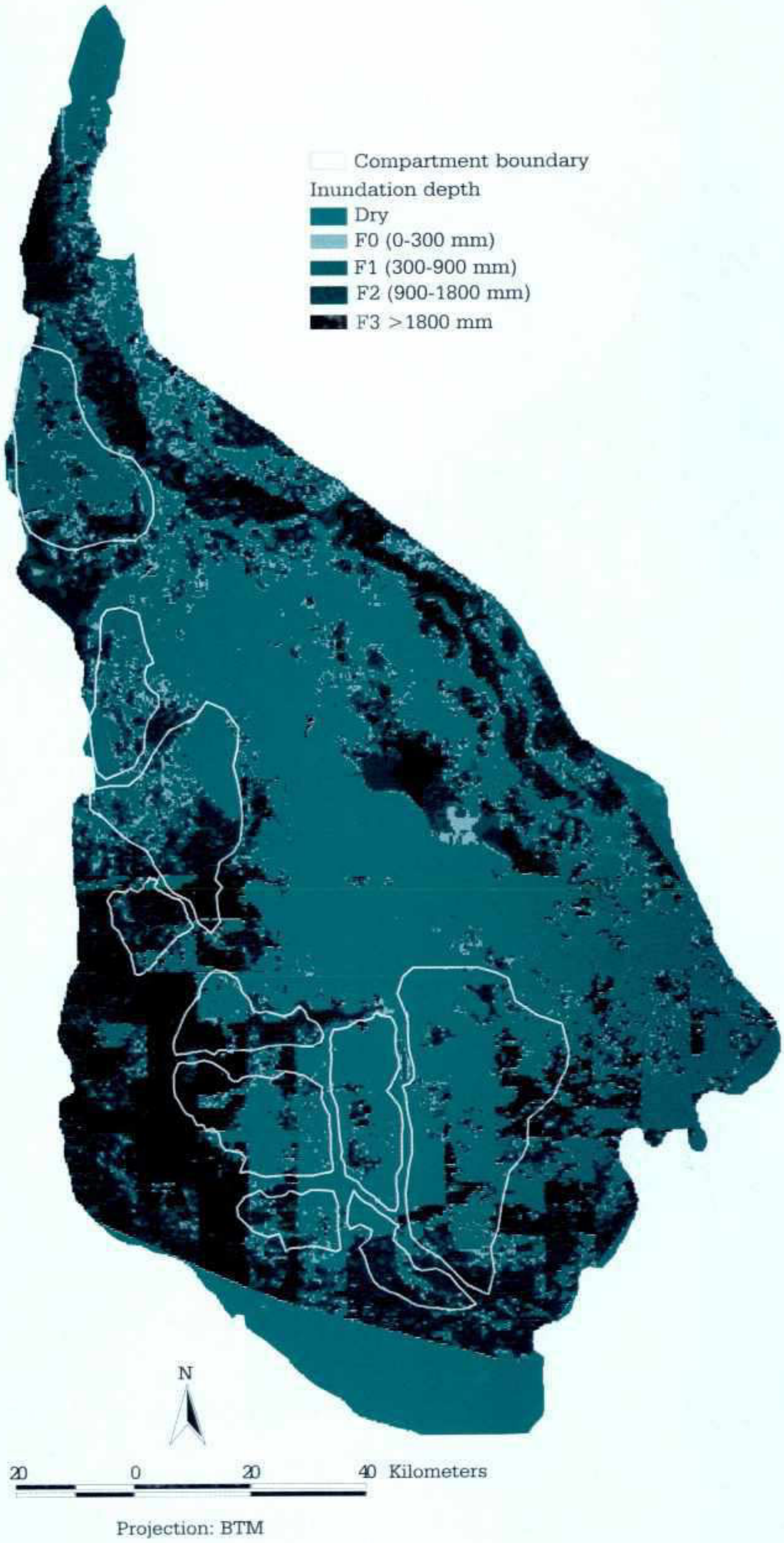

Figure16: Flood Map: Simulated for Option 4: 1995

Figure17: Flood Map: Simulated for Option 5: 1995

Annex M
Guideline

Table of Contants

Tables

Introduction

The following guidelines follow from the experience of CPP over the eight years that it was implementing the Compartmentalization Pilot Project in Tangail.

Considerably more information on the project, and the background to the guidelines, is contained in the rest of this Final Report.

Modeling

Due to the complexities of water management, modeling at an early stage of planning is essential and should start as soon as sufficient data are available. It should be in place before the project design is completed.

It is better to start with a model encompassing the entire project area and bring in more detail as water management and databases develop, than to model parts of the area separately and join them later. The major difficulty in the latter approach is the establishment of boundary conditions for the partial models. Partial models are likely to be interdependent. Changes in one area have their impact in the other areas.

Although simulation of water management is feasible with models, it is difficult to design operation scenarios which lead to maximum benefits. In the first place, there are unknowns that can not be predicted, such as rainfall, outside water conditions and possible failures of the system. In the second place, criteria for maximum benefit are not sufficiently known. This is truer for water management and fisheries than for water management and agriculture.

Modeling can best be used to evaluate water management during and after a monsoon. Requirements are that water behavior and operation procedures are sufficiently monitored. It also requires opinions of the water management committees about the quality of water management.

Design and Construction

Water Management Systems

The drainage requirements of protected areas in the flood plain are more determined by field storage than by rainfall intensity. A requirement of about 3 l/sec/ha is sufficient. That value may increase with increases drainage intensity. However, one may expect that field storage will remain dominant for the time being in most cases.

The excavation of secondary drains has priority above the construction of structures. Without properly excavated drains, structures may not function. On the other hand, the excavation of drains is likely to meet opposition of the local population and/or lengthy delays due to land acquisition problems. An approach that may be further investigated, is to obtain the consent of the committees, before drain excavation starts, under the condition that no land acquisition procedures are started. If the committees can not consent to that, no drainage works are undertaken.

Implementation of improved drainage takes time. A flexible approach is required. Works should be executed per system, moving from downstream to upstream. A flexible approach goes against the strict implementation schedules most projects have to cope with.

Minor work programs should be maintained in water management projects. There is great demand for such works, but there is a problem during the identification. Earthworks are likely to spread their benefits more widely than structural works. In addition, minor works should not be evaluated on technical merits only but also based on the support they have among the larger population.

Procedures during the detailed design of water management systems involving BWDB are unsatisfactory. Design reports containing the design criteria should be produced. Greater involvement of local consultants in design and supervision is recommended. The present status of the consultant as an advisor on quality control only is weak and unsatisfactory.

To better control implementation costs, more use should be made of cost indicators.

BWDB construction standards for embankments are clearly unsatisfactory. At present they are largely quantitative and are lacking in qualitative aspects. Embankments should be constructed of earth that meets a minimum specification and should be layered, watered and mechanically compacted.

It is essential that areas, in which water management is to be improved, be protected by embankments of good quality. Security provided by flood protection is as important as the improvement of water management.

In projects similar to the Compartmentalization Pilot Project, the emphasis should be on water management rather than on drainage alone. This implies that the water management should not be confined to the monsoon months only, but encompass the entire year. It also implies that the intake of water from outside sources should be given about equal weight as the evacuation of excess water.

With respect to the intake of outside water, the availability of the water has its limitations. High lands cannot be reached, because of their topographical level. In addition, when water is most needed, during dry spells or at the start of the monsoon, the outside water may be too low to enter.

The distance between intake and outlet structures on one hand and the lands that benefit on the other, is a factor of importance in water management. Land users can not travel large distances all the time. To improve communication between the structures and the land, level indicators may be set up along the way the water travels.

In designing water management systems, intake and outlet structures, together with drains should be given priority above internal water management structures. The latter are often bypassed by other structures or cuts in embankments or roads. In addition, given the flat topography of flood plains, water management structures often suffer from downstream water backing up, which renders them less effective.

Land users in the flood plain are used to flood conditions and their demand for additional water may be unexpectedly high if flood protection is provided. This can not be turned around easily as changes in attitude require profound changes in production methods. To satisfy the users of the higher lands and to protect those of the lower lands, one may base the operation of water management systems on a more or less continuous flow from intake to outlet. It has the advantage that water is available and is refreshed all the time. This does not mean that this way of operation leads to the greatest benefits. For the time being, one should have to admit that operation guidelines specifying how the greatest benefits can be achieved, are not yet known.

Chawks and Sub-Compartments

It is a good approach to divide large water management areas, into sub-compartments and chawks. This renders the system more manageable, while it provides a framework for consultations between water management institutions and the local population. However, chawk and sub-compartment boundaries should be based on hydrological systems.

It is helpful when infrastructure is classified as primary, secondary or tertiary infrastructure. This assigns priorities to interventions, while responsibilities for operation and maintenance are easier defined. It also makes the system more transparent to the beneficiaries.

Consultations with committees in water management projects, about interventions in their infrastructure, should be conducted within the framework of an overall plan.

As far as water management is concerned, there is much emphasis on committee meetings. In actual practice, once land users know what the system has to offer, operation becomes a matter of routine. Meetings are required for consultations between different committees, to draw annual or seasonal management plans, to evaluate experiences or for conflict resolution. Meetings on the maintenance of the system and its funding are most important. At least one annual meeting should be devoted to that.

Participation

A project is a temporary intervention in an existing environmental and social system. It should ensure the intervention's sustainability and quality.

The implementation program needs to be split between "one-time" activities, e.g. consultation meetings and training, and "to be sustained" activities, e.g. monitoring, operation and maintenance. The "to be sustained" activities, where emphasis is on sustainability, should be done by those who will be responsible for O&M, i.e. the BWDB/LGED as Executing Agency and/or the beneficiaries. The one-time activities, in which the emphasis is on output quality, can be done also by temporarily involved parties such as consultants, NGO's and other institutions.

The following table summarizes which party should be ideally involved, in which stage and how:

Stage	Project Year	Exec. Agency District	Local People	Elected Gover-nment	Project TA	Line Agency	NGO's
Identification/ Feasibility	-1-3	no	subject	subject	no	subject	subject
Need Assessment	1	actor	subject	subject	actor	subject	subject
Concept Development	1	actor	actor	actor	actor	actor	actor
Studies/ Data Collection	1	actor	assist	assist	actor	actor	actor
Participation in Planing	1	actor	subject	subject	actor	support	support
Participation in Design	1	actor	subject	subject	actor	support	support
WMC Formation	1	subject	subject	subject	actor	subject	support
Institutional Support	1-3	subject/actor	subject	subject	actor	no	support
O&M Arrangements	1-2	actor	actor	actor	advice	actor	no
Planning and Design	1-2	actor	endorse	endorse	actor	support	no
Construction	2	actor	actor	monitor	Monitor	Monitor	no
Construction Funding	2-5	sharing	sharing	sharing	no	no	no
O&M During Project	3-5	actor	actor	actor	Monitor	no	no
Post-Project O&M	6-	actor	actor	actor	Monitor	actor	no
Monitoring & Evaluation	1-5	actor	actor	actor	actor	actor	actor

Table 1: Stage of Involvement Per Type of Institution, Recommendation

Summary Institutional Model

In order to understand the model of consultation and institutional development used in the following sections, it is shortly presented in the following table. For optimum result, the character and name of the various platforms is adjusted for each phase. However they are not completely newly constituted for each phase, as they emerge from the platforms used in the previous phase. Active participants might be platform key players in all three phases. The trend from beginning phase to end phase is from political processes to daily fieldwork, from informal discussion to formal platforms, from project initiative to local initiative, from dependency to independence, from big gatherings to small teamwork.

Level	Feasibility Study Phase	Project Phase	O&M Phase
Interest Groups	Consultation Meetings (up to 100's of people	Consultation Meetings (10 - 150 people) & System level Reference Groups(10 - 50 people)	-
Chawk (20 -200)	Consultation Meetings (up to 100's of people	Consultation Meetings & Periodical Meetings	Periodical Meetings (10's to 100's)
Sub-System (5 - 20)	Consultation Platforms chaired by UP Chairman (up to 100's of people)	System Project Committee chaired by UP Chairman (10 - 50 member)	Sub-System WMC with elected Presid. (5 to 15 members)
System(1)	Consultation Platform (up to 100's of people)	System Project Committee chaired by EA.(10 -50 member)	System WMC chaired by EA. (10 - 25 members)

Table 2: Institutional Model

The process will be as follows:

- Identification
- Opportunity identified
- Concept developed
- Concept accepted

Identification

Water management systems in Bangladesh are nearly all inter-related. Therefore in order to assess any newly identified project, a regional overview and plan is needed, if possible based on modeling. Before any reaction or field screening to a proposal, it should be assessed whether it fits within the regional plan and what the level of benefit might be. Where possible this must be assessed by modeling. This will enable a team to keep villagers' expectations realistic from the first field visit onwards.

Projects are identified in three ways:

- **Local people submitting a complete and concrete proposal**
  Ideally, a project is identified by local people themselves. After which a consultation, proposal and screening process can start. SSWRDP has developed elaborate guidelines for this. This concerns smaller systems. The main institutional issue is to check the opinions among all interest groups about the proposals.

- **Outsiders integrating local complaints and requests in to a proposal**
  This concerns often the bigger systems, which can not be conceived by local parties, whose outlook is often limited to the own village or Union. As the concept is developed by outsiders and not owned by local people, the institutional development approach will be more complex and intensive. It should start with a general need assessment to check the local priority assigned to the identified problem. In the second part of this need assessment, the developed concept will be introduced and discussed in the context of the earlier identified needs. If the problem has low priority or if the concept is not felt to address the problem, the project may be abandoned or adjusted.

- **Outsiders studying an area and identifying an opportunity**
  This concerns bigger systems identified in regional studies, e.g. under FAP. Ownership feelings will be again lower than in the previous case. Screening against analysis and plans for a larger region will not be needed, as it emerges from such plans.

Projects not first conceived by local people mean, under the circumstances prevailing in Bangladesh, a risk, as ownership feelings and chances of sustainability will be low. They also indicate that a lot of extra effort needs to be made in the field of participation and institutional development.

As for people's participation and institutional development, identification should include an assessment of societal structure, organizational capabilities, needs and development opportunities.

Feasibility Study

The feasibility study should consist of preliminary appraisals, multidisciplinary need assessment study, formation of consultation platforms, preliminary planning and design, consultation on plans and designs and agreement on cost sharing arrangement for construction and O&M. A feasibility study made with the CPP experiences as building blocks will work. CPP's Interim Report provides the methodology for the process from preliminary appraisal, household survey, multi-disciplinary area-wise survey and institutional survey.

Preliminary Appraisal

First, a reconnaissance survey is conducted by a few core team members, as a basis for the subsequent appraisal. This rapid appraisal will produce a preliminary check on earlier assessments of needs, opportunities and issues. More ideas will also emerge about how to divide the area in to smaller units. The consultation and planning process will be designed on basis of the results. This appraisal should be left to the senior experts in the team as understanding in the project team at that project stage will be still low and complex issues need expert interpretation.

Need Assessment/Multidisciplinary Study

This exercise will consist of a household level baseline survey (questionnaire), engineering related surveys (technical surveys), multi-disciplinary area survey (rapid appraisal) and institutional baseline survey (checklists). It will produce insight in the societal structure (power structure, culture, organizations, institutional abilities, and resources), the physical environment and the people's needs and ideas. One of the outputs will be preliminary sub-area demarcation. The results will be used for program and infrastructure design as well as for monitoring and evaluation.

What should be added in this phase is the collection of suggestions from local people about how people might be involved in planning, implementation and O&M. Further, the names of candidates for any consultation platform should be collected during individual household interviews and group discussions.

Part of these jobs can be done by private firms or specialized NGO's, although project staff should be involved to a maximum extent, as it is the best opportunity to get acquainted with the area.

Formation of Consultation Platforms

Rationale

In this phase people have to commit themselves formally to the project and its consequences. As not all local people can be involved all of the time, consultation platforms with elected members will be needed. For formation of such platforms, it will suffice to hold two or three mass meetings per sub-area, in which also other subjects can be dealt with.

202

The Level of Consultation and Organization

The lowest level at which people need to be consulted and organized should be sufficiently below Union-level. At that level needs and suggestions will concentrate on development and specific area and group interests will get sufficient attention. At that level some bigger village or bazar can be found, on which the activities can center.

Allowing for sufficient representation from lowest to medium level, and avoiding big platforms, the area of the next level should be in this stage 5 to 15 times as big as the lowest level. It then depends on the intensity and type of intervention as well as the homogeneity of the population whether the lowest level is skipped.

Sub-areas may be defined in two ways at this stage. If sufficient insight is obtained in water management, the hydrological units might be used as sub-areas. It is also safe to use bazaars and their service areas. The possibly affected neighboring areas need to be covered, too.

There might be a separate compartment platform for GO's and NGO's, as their inclusion in committees with stakeholders will lead to large committees and domination of the meeting by the, often better educated, officials.

Interest Groups

It needs to be explored in this phase whether groups will have different interests. Priority needs to be given to the proportionate representation of people from highland, medium and lowland, of people from inside and outside the project area and of people from rural and urban areas. Area-wise meetings will take care of urban areas and adjacent areas, but people from highland, medium and lowland should be separately consulted before area-wise meetings take place.

Separate consultation meetings are also needed with, for example, fishermen, women, landless, bazar people and boatmen. Also needs to be discussed with them how, and by whom, their interests will be represented in the area platforms.

Preliminary Planning and Design

The project team will process all the collected data and assessed needs in to various possible overall project concepts and designs, A zero option and a minimal intervention option should be included. What should be added for each option is an estimate of O&M costs for both GoB and beneficiaries. This will make discussions realistic. In addition, the institutional set-ups for different options should be designed in this stage for both the project phase and the post-project phase. They can then be taken along in the subsequent consultation process.

Cost Sharing Arrangements

It is important to test willingness and capabilities during planning and implementation. The only proven method and seemingly best way is the condition that both beneficiary committees and the Executing Agency contribute to the construction costs to show their ability and willingness to bear post-project O&M costs. If they cannot manage during construction, they will probably also not manage afterwards.

The post-project requirements should logically define the level of contribution. For example, if post-project annual maintenance cost is estimated to be 3% of the total investment and the project lasts 5 years, Executing Agency should at least fund 15% (i.e. 5yrs*3%) of the total project cost. And if for example the beneficiaries are supposed to pay for 10% of that annual maintenance cost, their contribution would amount to at least 1.5% of total investment (i.e.10%*3%*5 yr.).

Specific types of infrastructure should be allotted that each would be completely built and funded by Executing Agency or beneficiaries. Completion by beneficiaries should be made a condition for the EA. to start the GoB-funded part of the works, and completion of that again will be condition to start donor-funded works.

Consultation on Preliminary Planning and Design

The developed options need discussion with the formed consultation platforms and the interest groups. Because different options will benefit different groups and areas differently, not all groups and areas might prefer the same option. Therefore, each group and sub-area needs to list all the options acceptable to them and prioritize. The planners can then integrate all the needs and preferences to come to an overall design that is acceptable to most parties.

This consultation round should be finalized with a meeting at system level in which the representatives of the whole system commit themselves to one option, to the operation and maintenance of the resulting system and to a contribution to the costs of both implementation and O&M.

208

Such a meeting should be held with responsible Government representatives at district and national level, too.

Feasibility Study Report

The results of the planning, design and consultation process will be integrated in to the feasibility study report. This report should indicate whether the result is compatible with the decisions made in the final consultation meetings or whether it deviates. Major deviations should then result in new consultation rounds at system level, probably during the first project implementation year.

Implementation

An implementation project normally starts with an inception report, in which the feasibility study results are reviewed and adjusted in the light of the Terms of Reference, providing detailed work plan. An important output of this stage is the demarcation offurther a areas along which stakeholders will be divided, consulted, and organized. From the viewpoint of institutional development, the implementation is ideally done by the same parties as the feasibility study to ensure consistency and continuity of approach.

Detailed Stakeholder Inventory

For baseline surveys, often samples of households are taken, but for institutional development, it is preferable to have a list of all stakeholders. It is possible to have such a list made in 2 months with 4 to 8 local data collectors. They go to each corner of each chawk and inventory households by asking around. This inventory ideally takes place during a detailed water management inventory when engineers do an equally intensive chawk-to-chawk inventory of infrastructure, land types and drainage situation. Households will be categorized by urban-rural, high-medium-low land, farmer-landless-fisherman-other, inhabitants outsider users (e.g. sharecroppers). It is better that such detailed inventory is done during implementation and not during preparation as more will be known how to categorize stakeholders and as the implementation team can in this way familiarize themselves with the area and its people.

Area-wise Option Development

While the preparatory activities for the consultation process take place, the technical staff will have time to develop options for each sub-area. Proposals will consist of objectives and water management system for each area and option, specifying the location, type and size of each piece of infrastructure. The cost of infrastructure and the cost of O&M will be indicated, too. Well worked out options are needed because leaving the choice of infrastructure at sub-area level completely to people, carries the risk that the end result will be incomplete and inconsistent within itself and with other areas.

Information Dissemination

In order to achieve optimum participation all stakeholders need to be informed about the project's objectives, approach, planned interventions and about the upcoming consultation process and formation of institutions. Dissemination of this information will take place via:

- Meetings with the feasibility study platforms, with Unions, NGO's, schoolmasters, etceteras.
- Announcements on notice boards of Union Parishads, schools, NGO's, social organizations, cooperatives, bazaars and public places
- Invitations for the upcoming consultation meetings to all stakeholders as per the prepared stakeholder list

Formation of Project Committees

Role of the Project Committees

The role of these institutions is:

- Feed back and contribution to project proposals/options
- Endorsement of project proposals and commitment to future O&M obligations
- Resource mobilization and implementation for community-paid infrastructure
- Monitoring and evaluation of overall project implementation
- Problem solving within area of jurisdiction and representing the area in conflicts at higher levels
- Managing information flow between stakeholders and project

The Project Committees remain until the end of the project. Their planning and implementation mandate reverts then to the Unions, who normally plan, implement and monitor all development activities in the Union.

209

U.P. Officials

The Union *Parishads* and their elected officials have the official mandate of planning and monitoring development at Union level and therefore should play the leading role in the Project Committees. This should be complemented by strengthening the (position of) participants and institutions from lower planning and interest group levels, and by counterbalance from project side.

The *ex-officio* role of Union officials will be played at the level where sub-areas are about the size of Unions. Project Committees should however not be organized Union-wise as water system rarely coincide with Union boundaries. The chairmanship should be given to a representative of the Union with the biggest land area within the system sub-area. This might be the Union Chairman, but if he lives outside that particular area, it is better that he delegates the job to a UP member, who has to report to him.

General Composition

Equal representation of area-wise interests (highlanders, lowlanders, upstream, downstream, insiders and outsiders) is the most important composition condition in all stages.

Highlanders and Lowlanders

It is most practical to use the farmers' own definition of what high, medium and low land is. Equal representation of each group will be practical in most cases.

Upstreamers and Downstreamers

Mostly this refers to highland and lowland for a larger area and often they will belong to different sub-areas No specific measure has to be taken to ensure representation.

Insiders and Outsiders

Outsiders should be organized and represented only if water management of inside and outside mutually influence each other. The party that is affected by the other must through an agreement or mitigative measures are compensated. In case an agreement is made about system management measures, the outsiders should be represented in the system management committee, too. Outsiders can be organized for the lowest and medium levels in meetings, who elect representatives to the highest system level project committee. In many cases, however no committees are needed and UP Chairmen, whose Unions straddle the system border can represent outsider interests

Rural and Urban Areas

Rural people make daily use of a system during the monsoon, while urban dwellers benefit only during excessive floods. Therefore, urban and industrial areas need only to be represented at system level by the Pourashava and Chamber of Commerce, if existing. The number of representatives depends on the number of beneficiaries and the benefits.

System Level WMC

This committee needs to be dominated by representatives from all sub-area committees. As for chairmanship the most practical would be to have the committee chaired by a lead agency official like a Project Director or Executive Engineer. To avoid that project officials dominate the beneficiaries, this committee should be officially placed under a District Council (when formed) chaired by District President or under a District or Thana Coordination Council chaired by DC or TNO.

Timing of Committee Formation

In order that beneficiaries can commit themselves officially to infrastructure construction and O&M, they should be formed before infrastructure decision making is done.

Numerical Composition

Sub-system committees should be kept smaller than 40 members and preferably below twenty members. Three representatives per Chawk of 200-300 ha should be enough to cover the diversity of the chawk and include women as well as fishermen, when needed. Each committee needs a small executive committee that can be convened within a day.

President, Vice President and Secretary represent the Sub-system at system level, but the system level executive system committee excludes Secretaries. A system level committee should also not exceed 50 members and its executive committee should be within 25 members in size.

Complementary Interest Group Platforms

For sizeable systems with important minority interest groups consultation platforms should be formed for such groups, as they will not be heard in general meetings. It concerns fishermen and maybe landless, women or boatmen. Their participation becomes more important in case it is found that the selected concept, i.e. option, has negative effects on either of these groups or if the project has specific water management objectives and measures related to any of these groups.

However, much more experience, in other projects, should be gained before it can be established whether their contributions are sufficiently different and useful to justify the extra effort and resources to reach them. More result will be booked by solving inequality and special interest issues; including mitigation and compensation, outside the committees or by designing infrastructure that can not be manipulated in favor of the powerful sections of the society.

For consultation outside the committee, only one platform per system, per group, should be formed as more cannot be maintained. Preferably, existing institutions are to be used like fishermen cooperatives and NGO groups. If existing groups are used, probably not all people might be represented, but it might sufficiently serve the purpose of obtaining feedback on plans and designs and of preparing their representatives for general meetings.

Consultation on Detailed Area Plans, Designs and O&M

In this stage, the project team will develop sub-area wise elaborated options on basis of earlier developed options and consultation rounds. They will include a plan and a design with clearly stated objectives, types, locations and size of infrastructure, costs, and an estimate of O&M requirement and costs for government and beneficiaries. The formed committees and platforms will be consulted on the options. After processing the consultation results, one option per sub-area will be chosen and elaborated. Subsequently the committees, government and donors will have to endorse the chosen option and commit to the consequences.

Strengthening Institutions

The Project Committee will need training on the system and on the objectives and functioning of the committee. The latter should include sensitizing the majority to the interests of special groups. These training should be given by project staff jointly with professional training specialists.

Further, the committees need formal recognition by the Executing Agency and by-laws describing the purpose, the regulations and the division of roles within the committee and between the committee and the government and the project.

Design & Estimate

Design should take institutional conditions in to account, as the success of infrastructure depends on whether it can be managed. Design should result in management units that are as simple and as independent as possible. Design should further result in O&M requirements that are technically and economically feasible for both beneficiary committees and Executing Agency. Construction and O&M cost share for Executing Agency and beneficiaries should be in accordance with earlier agreements.

220

O&M During Project

Operation Modes

The project will formulate operation modes on basis of its understanding of the system. This understanding is acquired through hydrological modeling and monitoring of operation by beneficiaries. The operation modes will be formulated in the form of do's and don'ts and mutual agreements between sub-areas. Towards the end of the project when understanding becomes more complete, the operation modes will be incorporated in an Operational Plan.

Water Management Committees

For O&M small committees are needed, consisting of few committed and skilled individuals, who can be assigned O&M field jobs. This is the Water Management Committee in the true sense. They can be sub-committees to the PCs. When after the project PC-roles in planning and implementation revert to the Union, they might move along and become sub-committees to the Union Parishad.

The WMCs should be formed as soon as the first manageable infrastructure is in place.

For operation and maintenance, committees are normally needed per structure, but in complex situations like Tangail, the committees should be formed per sub-area, dealing with more than one structure. Committees are only viable if there is sufficient work, if the involved number of households is too big for everybody to know personally, and if sufficient active leaders can be found. For Tangail this situation is found at sub-compartment and compartment level. Chawk level committees are not needed. There should however be chawk level meetings to elect or re-elect representatives to the WMC. These might be periodical (every few years) or as per the need.

Maintenance

For proper maintenance, it is helpful to make a maintenance plan. The maintenance plan should specify responsibilities, costs and possible sources of funds. Maintenance plans should be agreed between the parties involved.

Maintenance can best be specified according to the kind of work (earth work, structures and mechanical work), together with the kind of maintenance (preventive, periodic and emergency maintenance). On basis of the agreements about maintenance made in the feasibility study and implementation periods, a

Maintenance Plan is drafted, in which the final details about all pieces of infrastructure, the division of roles and the character of maintenance duties are given.

Strengthening Institutions

WMCs need to be trained on functioning as a committee, on system operation and on maintenance. The same training modules can be used as for those training given during CPP. By-laws much like those for PCs will have to be drafted, amended and adopted by WMCs. The operational and maintenance plans will be prominent in the by-laws.

As soon as operation of the first completed structures starts, the executive agency should have staff in place that is responsible for dealing with operation and the committees. Further, the executing agency staff equally needs training on system operation, maintenance and on committee mobilization and institutional development.

O&M during Project

Maintenance during the project should be the duty of the same party that is responsible for maintenance after the project ends. Only in that way the responsible party can build up maintenance skills and routine with the benefit of guidance and monitoring by the project, while it is still there. A project that is designed to continue one or two years after the last infrastructure is completed therefore has preference.

Agriculture

In the context of a water management and flood control project, it is important to make a clear distinction between general agricultural development goals and specific project goals, which are related to the changed conditions in a compartment. General agricultural development is the concern of existing national agencies, with or without compartmentalization. The more specific project-related goals will eventually also become their responsibility, but their capabilities to handle that responsibility need strengthening.

The tasks of the agriculture section can be considered from this angle. Two different classes of interventions can then be distinguished:

- Initial, temporary interventions, which are needed to set the change process in motion and for which temporary capabilities have to be created,
- Permanent interventions, which should continue after termination of the project under responsibility of the national agencies.

Since agricultural development during and after the project is the responsibility of national agencies, the agricultural section of a project should work as much as possible through these agencies and enhance their capabilities to implement interventions in support of agricultural development in the compartment. For permanent interventions, this is obvious, since the national agencies have to take them over. For the temporary interventions, it is also essential that they be carried out through the national agencies, to create the necessary sense of ownership.

Technically, the tasks of the agricultural section of a compartmentalization project are three-fold:

- Monitor the changes in land use and agricultural production occurring in the compartment as a result of project interventions,
- Contribute to the development of operational procedures for water management,
- Enable agricultural producers to adjust to improved water management conditions and exploit the new opportunities, through participatory on-farm technology testing and demonstration.

Monitoring Changes in Land Use and Agricultural Production

Agricultural practices and land use will change in response to changes in water management conditions, but with a time lag. Farmers will base their decision making

226

on their perception of the changes and their reliability. The CPP experiences show that changes did occur towards more productive monsoon cropping in response to the lowering of monsoon water levels and reduced flooding, but farmers returned to more conservative crop choices in 1999 in response to the floods of 1998. Compartment-wide monitoring of such changes serves two purposes:

- It allows verification of the assumed effect of water management on productive conditions in different parts of the compartment and provides a yard stick for the impact on agricultural productivity,
- It provides location-specific information which will improve the dialogue with farmers on water management operations they would prefer.

Land Use Mapping or Monitoring Plots.

CPP used two parallel approaches for land use monitoring:

- Detailed seasonal mapping of land use in the entire compartment by marking the areas planted to each crop in chawk maps (Land Use Survey, LUS)
- Choosing a large number of monitoring plots (MP), which were representative for the entire compartment, and recording the crop grown in each season

The LUS approach was very time consuming and involved all the Block Supervisors (BS) of the Department of Agricultural Extension (DAE). The reliability of the data was good in the Rabi and pre-monsoon seasons but less so in the monsoon, because a large part of the cropping area is not accessible and it is difficult to identify the different Aman varieties from a distance. A major advantage of the LUS is that the data can be presented in the form of detailed GIS maps, which allow visual assessment at a glance. The major disadvantages are (i) the requirements in skill and time for the field work, (ii) the need for fairly sophisticated tools (digitizing of the maps and GIS map manipulation), and (iii) the unreliability of the monsoon data.

The advantages of the MP approach are that (i) the data for each plot are precise, (ii) data collection is very simple, and (iii) changes in cropping patterns are obtained for each plot. The disadvantages are that (i) it is difficult to choose a priori a representative set of MPs and (ii) the visual presentation of the results is less appealing than for the LUS.

In a future compartmentalization project the MP approach should, in our view, be preferred, but with a sufficiently large number of plots to ensure that they are representative. The sample should be established after an initial land classification has been carried out based on an elevation map, combined with a map showing farmers' own land type classification. The number of MP in each land class should be proportional to the area covered by that class. A subset of the MP should also be used for the collection of data on inputs and crop yield. All observations should be carried out by regular DAE field staff.

Mapping Farmers' Land Type Classification

The way farmers themselves classify their land reflects their assessment of its capability and is closely related to actual land use. In fact, it is the outcome of many years of experience, integrating the effects of previous flooding and its variation. Mapping of farmers' land classification was done by CPP in an advanced stage of the project but should in the future be done right at the start of the project. It involves drawing the different farmer-defined land types into each chawk map, derived from the topographical map of the compartment. Comparison of the initial land type map with inundation maps generated in the course of the project provides a measure for the changes in water conditions as compared with farmers' own perception as reflected in their classification.

Apart from its use in the choice of MP and in relating changes in land use in different parts of the compartment to the base situation, the land type map will also be helpful in designing water management operations as discussed in the next section.

Development of Operational Procedures For Water Management

In CPP, no a priori assessment was made of the implications of different possible infrastructure designs for agricultural production. The project started after the infrastructure design had been completed. The design criteria were not clearly defined and the extent to which water control was possible was not clear. Farmers were observed to increase their area under T-Aman as compared with the pre-project situation, as well as the percentage under HYV in some areas and less in others. Otherwise, the agriculture section more or less groped in the dark as to the implications of infrastructure operation at the field level. This limited its effectiveness. During the third year of the final phase, modeling of the implications of various management scenarios gradually led to more clarity and towards the end, the project was better able to make predictions about the effect of management interventions.

In a future project under similar flood plain conditions, peripheral structures would be built right from the start, but internal infrastructure should be built gradually in the course of the project in close consultation with the beneficiaries, as argued in the institutional guidelines. At the start of the project, the agriculture section should map land types in the project area according to farmers' classification. Water management conditions and land use in the different land types should then be monitored across the project and farmers' assessment of the adequacy or otherwise of water management should be recorded. This information should be used for operation of the peripheral inlets and outlets in consultation with the water management committees. Systematic inadequacies in the internal water management situation, which cannot be corrected by operation of the peripheral structures, should be corrected by the construction of internal structures.

In the course of the project this process of observation, consultation and construction of internal structures should lead to the best possible infrastructure with flexible operational guidelines which optimize the internal water conditions for agriculture within the constraints set by other interest groups.

On-Farm Technology Testing and Demonstration

The analysis in the previous section implies that initially there will be little scope for experimentation and extension in relation to changed water management conditions. First, the implications at the field level of operating the water management structures must be known. Inputs from agriculturists are needed to design and supervise data collection in monitoring plots, contribute to the development of different water management scenarios and analyze their probable effects on crop production.

As soon as the operational plan for the compartment enters the implementation phase, agricultural experimentation and extension activities should start. The aim is to investigate on a pilot scale, together with farmers, how farming can exploit new opportunities and how possible negative effects can be mitigated. Participating farmers must be fully aware of the uncertainties inherent in the new situation and understand the risks involved. Findings from the on-farm tests and demonstrations should be disseminated compartment-wide by DAE. Whenever necessary, actions should be undertaken to promote the availability of the necessary inputs for intensified production, through line agencies, NGO's and the private sector.

Participatory Assessment of New Cropping Options

Changes in water control and management are expected to allow an increase in efficiency, variety and profitability of farming. These effects should, to some extent, be predictable, but there remains a considerable degree of uncertainty about year-to-year variation, especially early in the life of the compartment. Action research is therefore needed with strong farmer participation to explore new options in cropping practices, varieties, cropping patterns, crop diversification, fertility management, etc. over a sufficiently long period. The national agencies (e.g. BARI, DAE) supported by the project should establish a participatory on-farm testing and demonstration (OFTD) program in a number of representative pilot locations. Local NGO's should be associated with the program as actors on behalf of the farmers, providing the necessary grassroots mobilization. Prior to the OFTD program, Participatory Rural Appraisals may be conducted in the pilot areas. The purpose is mainly to launch the program and generate a common perception of problems and opportunities shared by all parties involved.

Farmers themselves must decide on the priorities for on-farm testing and demonstration in consultation with and with advice from the OFTD team. The tests and demonstrations may include improved crop varieties, alternative land use and cropping patterns, introduction of new (irrigated) rabi crops, fertility management through fertilizer, manure, compost, etc. With time, the choice of technologies is adjusted to the accumulated experiences. The program must be flexible enough to follow up on new questions that emerge during testing and address constraints to adoption of technologies that appear to be profitable. Once adoptable technologies have been identified, they should be demonstrated more widely in the usual way by the extension service.

Institutional Collaboration

Institutionally, a project is temporary, and meant to set a sustainable process in motion. Collaboration with national institutions is therefore essential. CPP did many things on its own, thereby creating insufficient sense of ownership by the national agencies. Projects like CPP should be embedded in national institutions, rather than setting up their own facilities in isolation. This would mean that the agriculture component be integrated to a large extent with DAE and the OFTD component with BARI. Project staff should ensure consistency of the approaches, contribute technical and organizational skills and assist in the coordination of the line agencies and the NGO's.

209

Fisheries and Water Management

One of the major lessons learned in the project is that before any design is made or water management is implemented there should be a clear policy on water and fisheries. The major question is what will be the minimum area of water bodies to be maintained after a project is implemented.

Policy makers and planners should set the criteria for this and a first step in this direction is the important statement in the National Water Policy: ***"that no dry season water body is to be depleted"***. The implication is that none is to be reduced in extent or depth of flooding at the height of the dry season and recently WARPO recommended using the mapped area of February/March 1997[1] as a baseline. This recommended criteria is essential as the results of the fisheries monitoring program of CPP indicated that floodplain fisheries is extremely vulnerable in the dry season and the extend of the water area and fishing pressure in the dry season are most likely more important then the extend of flooding during the monsoon period.

If this criteria is accepted as a national policy then the first steps in design and implementation becomes straight forward; Check all proposed scenario's against this criteria. This can be done with the following tools

- Satellite images
- Hydrological models, which include a dry season water balance
- Geographical Information Systems

The major bottleneck will be most likely not flood control or drainage but it will be ground water extraction and direct pumping of water from the beels for dry season *Boro* irrigation.

Once a scenario is found which meet this first criteria of not reducing the extend of perennial Beels in the dry season then in a second step the impact of this scenario on floodplain fisheries during the monsoon is analyzed. For this, the following tools are available:

- The floodplain fisheries model as developed by CPP.
- The National fisheries database developed presently by Fisheries department in co-operation with EGIS.
- The National Inland Water database of WARPO.
- The data base on subsistence fishing of the Helen Keller foundation in Dhaka.
- The FAP 17 and FAP 6 data base.

22X

In order to make a proper comparison of the different remaining options the distribution of the fish catch over the different social strata i.e. Landless, marginal farmers, etc should be known. First indication on this aspect can be found in the FAP 17 database but ideally a Catch and Effort survey is carried out during one flood season.

Secondly, it is strongly recommended to carry out a Rapid Fish Biodiversity Appraisal, which will give an idea of the pre-project status of the different water bodies.

If done properly the analysis will provide information on the overall positive and negative impacts of the proposed scenarios. In some cases only professional fishermen will be negatively impacted (CPP) or in other cases the overall impact on professional and subsistence fisheries outweighs the agriculture benefits (KJDRP) but in all cases mitigation measures should be developed.

A major direct impact of water management on fish is the impact of sluices/regulators on larval fish with about 40% mortality rates if the are operated in a "undershot mode" and where possible the design and operation of any scheme should try to avoid this and use "overshot" only.

Implementation and Mitigation of Negative Impacts

Negative impact can be expected at two levels: the professional fishermen and losses of subsistence fisheries. The social impacts of the two types are different and mitigation will need a different approach for each.

Professional fishermen are completely depending on fisheries for their livelihood when this is threatened, due to flood control or agriculture development schemes, the only way to mitigate the inverse impact is to provide an alternative source of income. Practically it means that the number of professional fishermen must be reduced so that the remaining fishermen still have a reasonable income from the reduced fisheries. The fishermen leaving the fisheries should be assisted in finding a new source of income.

Landless and marginal farmers mainly carry out subsistence and occasional fisheries. Fishing is an economic activity of the landless and marginal farmers but it is one of many sources, which becomes relatively more important during the flood season when all three of their main sources (agriculture labor, non-agriculture labor and self-employment) are at their annual low. Mitigation of this loss is difficult or even impossible as it impacts in most cases the majority of the rural population, the landless and the marginal farmers. Mitigation of the losses through traditional aquaculture extension programs or through the development of borrow pits, proved to be unsuccessful as the target group does not own land for fish ponds and the limited availability of *Khas* borrow pits. Therefore, mitigation of this loss should be looked upon in the general frame of poverty alleviation and any poverty alleviation scheme, which has proven it self could be implemented. Within this respect the "Homestead Catfish Program" as developed by CPP has proven itself as:

- It is a simple method which facilitate people to assess their own risk, and determine their own level of investment, use of external inputs and use of natural resources;
- It has low risks, low investments and low external input strategies;
- The investments are preliminary in human capital;
- It fits well in the numerous income earning activities and diversification of the livelihood of the rural poor;
- It can be carried out within the homestead and is becomes therefore accessible for the landless and marginal farmers.

General Remarks on Fisheries

One of the major results of the fisheries monitoring program of CPP is that fishing effort is the major driving force behind floodplain fish catches. Open water capture fisheries in Bangladesh is declining. In the discussion on the reason of the decline often flood control, construction embankments, habitat degradation, etc are mentioned. Without doubt they have contributed to the decline in inland fisheries but the results of the fisheries monitoring program of CPP indicate that over-exploitation due to the simple fact that there are too many people "hunting" the fish is another major player. The disappearance of the large size, slow growing, late maturing fish species such as the Indian carps from the inland catches was the first sign of this phenomenon and it can only be hoped that the remaining miscellaneous species will not have the same fate. Incorporation of this aspect of over-exploitation, especially during the dry season, in any fisheries development program is therefore of utmost importance as otherwise they are doomed to fail and we will end up with water bodies only containing small prawns and catfish.

220

Women and Development

It turned out that 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 hardly benefited from CPP interventions, because they do not have land.

It should therefore be recognized that a CPP-like project has a limited scope to improve the position of poorer women, who nevertheless constitute the major group of women in Bangladesh. For this purpose a totally different type of project would be needed, one 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.

Nevertheless the experience in CPP has shown that a number of successful economic and socio-political activities can be developed that have increased women's access to new technologies, productive resources and income, as well as the level of their information, knowledge and skills. These include the catfish program, the cultivation of modern varieties of summer vegetables, and women's participation in water management committees, as well as preventive maintenance of the embankments. These activities 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.

Women and Development in Project Design

During the identification and design of CPP women were identified as a 'disadvantaged group', who should be assisted though the creation of employment opportunities in operation and maintenance (O&M). No differentiation was made between the various categories of women (rich, poor, farm, fishery, landless) who would be affected by the project. As could be expected, the need for O&M work was strongest among landless women. During the implementation of CPP, it became clear that these needs for employment represented only a small part of women's interests in the project area. Further research during project implementation showed that:

- Farm women and fishery women are directly concerned by a project like CPP, whereas this is not the case with landless women,
- All categories of women (farm, fishery, landless) wanted to participate in project activities and decision making which was in line with the project objectives of 'people's participation',
- Women also wanted to benefit from changes and expected project results.

Women's interests related to water management and control were the same as those of the different categories 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 husband is employed elsewhere. 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, their lack of resources and rights, and the persistent patriarchal values. They are issues of gender inequality. Women's demand to participate in project activities and decision making, therefore, requires that a project create the conditions for women's participation and benefits. This implies the empowerment of women, and taking special measures to address the constraints that women encounter in their access to information, knowledge and resources.

Since no gender analysis was executed during project identification and design, the above issues did not come out, so that no concrete objectives could be formulated for women and development. This resulted in a limited allocation of resources for WID and a poor concept of 'women's involvement'. Without sufficient gender expertise and resources it has taken the project quite some time to identify relevant objectives for WID. Special attention to gender issues and to the identification of the needs and interests of different categories of women during project identification and design would have saved time and costs.

A water resources management project can avoid these problems through the inclusion of gender expertise in project identification and formulation. In addition, the execution of a Gender Assessment Study (GAS) is an effective method to design the gender component of a complex project like CPP. The GAS should be composed of:

- A stakeholder and target group analysis
- An institutional gender assessment
- An assessment of the project proposal to anticipate positive and/or negative effects on women's position and gender relations.

The results of the GAS allow the specification of gender/WID objectives, of target groups and of expected results. It would also indicate staff requirements for gender in the project team and propose a gender approach that includes measures to overcome constraints that women face. Finally, a GAS comes with options for an institutional setting that can deal with WID, which in the case of a CPP-like project would preferably be a combination of the BWDB, sectoral departments and NGO's. (For further information on a GAS, see the manual 'Gender Assessment Studies', The Hague 1997, written by A. Lingen on behalf of the Netherlands Ministry of Foreign Affairs).

Project Preparation

During project preparation baseline data were collected and a needs assessment was done, in which women took actively part. However, due to the definition of women as a 'disadvantaged group who need employment opportunities', mostly landless women were part of this process. These women do not have land that will be affected by CPP, though. Therefore, future projects like CPP should include all categories of the female (and male) population during base line data collection and needs assessments. Examples are:

- Women and men involved in local politics and decision making,
- Women and men of farming households of different classes,
- Women and men of fishery households,
- Landless women and men.

This will need special measures to ensure women's involvement such as:

- Participatory approach,
- The use of female (and male) staff with gender expertise,
- Gender training for staff,
- Meeting times and places that allow women's participation,
- Informing women and men about the need for women's participation,
- Special meetings with only women to inform them and to strengthen their self-image.

226

Type of gender data that are required:

- Gender division of labor in reproductive, productive and community activities
- Women's workload
- Gender inequalities in access to and control over resources
- Decision making process in the household and at community level
- Women's (self) image in society
- Constraints and opportunities for women's participation and benefits.

CPP has finally defined WID objectives that were relevant and can serve as example for a future comparable water control project. This holds true for both the overall WID objective as well as the specific WID objectives.

Overall WID objective:
The promotion of women's empowerment and equal participation in project activities and decision making, so that women will be able to benefit from project results to the same extent as men.

Specific WID objectives:

- To realize the active representation of women in decision making in project institutions, systems and O&M
- 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
- To assess the effects of the project on gender relations and women's socio-cultural, economic, political and physical position.

Project Implementation and Monitoring

The choice to combine a mainstream gender approach with a women-specific approach was a sound choice and can be replicated a next time. The mainstream approach focused on the incorporation of gender issues in all CPP programs and project sections, in order to ensure that women participate and benefit from the

228

interventions. This included the active representation of (all categories of) women in institution building (WMC), of women farmers in the on farm testing and demonstration program, in the catfish program, in environmental activities and of landless women in O&M (EMG activities). This approach is not a common strategy in the Bangladeshi context, but the experience has shown that a project like CPP can be successful in contributing to some improvement of women's economic and socio-political position. The approach is replicable, but should try to overcome a number of constraints that are primarily of an institutional nature, such as:

- The lack of gender awareness and commitment in relevant government institutions (BWDB, BARI, DAE)
- The long time that is needed to realize changes in gender relations
- The difficulty to find qualified female staff for technical project sections.

It will be important to undertake activities that address some of the above constraints. Examples of measures that have had a positive effect in overcoming some of the institutional constraints are:

- Regular gender awareness and gender planning training attuned to the needs and working circumstances of the various groups of stakeholders (staff of cooperating agencies, project staff, water committees, politicians, farmers, etc)
- Advocacy, publicity, lobbying and other measures that draw attention to the need for women's involvement
- The organization of section wise training which was a combination of gender awareness (for technical staff of e.g. the agricultural and fisheries section) and technical training (for WID staff). This allowed for institutional arrangements between the sections and improved the cooperation
- Specific activities for the empowerment of women.

In the context of Bangladesh, women-specific activities are easier to implement. Although a CPP-like project has limited scope to improve the position of poorer women, women-specific activities can empower women and create the conditions that would enable women to participate in project activities in particular in water management, institution building and agriculture. Activities that have been successful in this respect and that could be replicated elsewhere include:

- Literacy and health courses for women
- Network meetings with women

- Training sessions for women committee members, farmers, EMG women that increased their knowledge and skills in various domains (e.g. agriculture, organization, leadership, conflict resolutions, how to conduct a meeting, etc.)
- Gender training.

The activities have been successful, not only because they answered a need, but also because of the extensive inputs provided by the field staff of the WID section and their motivation and skills to assist the women in the project area.

The following recommendations can be given for the implementation of future compartmentalization projects:

- A target of 33% women in the WMCs 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% women constitute an entry point for further empowerment activities for women
- Farmwomen 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 NGO's can 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 NGO's 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 household in the area
- Monitoring forms should be made on the main issues that influence gender relations in the context of rural Bangladesh, i.e.: workload/division of labor, access to and control over means of production and services, income and expenditures, social status.

224

Institutional Issues

The major institutional gender issues at stake in a compartmentalization project like CPP, is 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. To achieve this multi-donor cooperation will be needed with a view to identify and discuss opportunities for institutional transformation and gender sensitization within the BWDB. It can be expected that it will take time before this will result in commitment to gender equality at the level of the BWDB. The existing male domination, values and culture, the lack of transparency and accountability, of female technical staff and the lack of resources for supervision, operation and maintenance constitute substantial constraints. Such a long-term approach should, therefore, not exclude short-term solutions, such as the involvement of NGO's and other institutions from civil society.

However, CPP experiences have shown that it is difficult to find NGO's that have the expertise, motivation and resources to develop activities in the field of women and water resources management. A future project in this domain should therefore pay ample attention to assess and identify potential institutional capacity and develop a project component that aims at institutional development and organizational strengthening of such institutions in general and in the field of gender and water management in particular.