Government of the People's Republic of Bangladesh

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

BANGLADESH ACTION PLAN FOR FLOOD CONTROL

COMPARTMENTALIZATION PILOT PROJECT (FAP 20)

TANGAIL CPP INTERIM REPORT MAIN VOLUME

(DRAFT)

September 1992

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

under assignment to

DIRECTORAAT GENERAAL INTERNATIONALE SAMENWERKING
Government of the Netherlands

and

KREDITANSTALT FÜR WIEDERAUFBAU
Federal Republic of Germany

COMPARTMENTALIZATION PILOT PROJECT
FAP 20

Ministry of Irrigation, Water Development and Flood Control

PROJECT OFFICE :
B.B. Girls High School Road, Akur Takur Para, Tangail

October 1, 1992

TO: The Chief Engineer of the
Flood Plan Co-Ordination Organization
72, Green Road
Dhaka-1215

Our reference : 1101/339
Regarding : **Tangail CPP Interim Report (including Annexes)**
Enclosures : 30 sets

Dear Sir,

We have the pleasure to herewith submit to you 30 sets of the FAP 20 Tangail CPP Interim Report, consisting a main report and seven Annexes with supporting subject-matter information. The Appendices of Annexes 1.1 and 1.3 will be submitted shortly.

A copy of the Tangail CPP Interim Report has been sent directly to the people and organizations mentioned on the attached distribution list. We understand that you will distribute copies to the POE, relevant FAP-projects, BWDB and others.

Yours sincerely,

Md. Obaidur Rahman,
Project Director

Mr. Hans Visser
Team Leader

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TANGAIL CPP INTERIM REPORT

TABLE OF CONTENTS
MAIN VOLUME

TABLES

FIGURES

ANNEXES

i SUMMARY AND CONCLUSIONS

Background

In the (revised) Inception Report (April 1992) a number of "likely options" were mentioned (Chapter 6, p. 80). These ranged from drainage improvement only to controlled floodwater management through gated inlets. During May a multi-criteria assessment of 8 development options was done which resulted in the short-listing of the following options:

A : improved drainage during pre- and post monsoon through re-excavation of existing *khals*,
B : option "A" plus throttled inlets to mitigate the danger of additional flooding under option "A",
C : option "B" plus gated inlets and additional embankment works to provide a higher degree of flood protection and the possibility of monsoon water level regulation,
D : option "C" plus strengthening of the southern boundary and placement of outlet regulators to provide full flood protection.

It was proposed to take these four options to all concerned into the consultation process. The aim of this next step in the process of people's participation was to give all concerned a chance to voice their opinion as to the desirability of each option. This step was considered essential because ultimately the people in- and outside the CPP area would have to live with the additional benefits and negative effects that each option brings. A difference of opinion developed between the FAP 20 Consultants and the Project staff on whether all the options proposed were in-line with the ToR. During a meeting at FPCO on June 29, FAP 20 was informed that only those options which included flood protection at the peripheral embankment could be presented into the consultation process.

The planning in this Interim Report calls for six implementation alternatives, all of which have a common starting base, very similar to option C, for the 1992/93 construction period. This means that the main question whether or not flood protection through (gated) inlet structures in general, and the *Lohajang* head regulator in particular, is a precondition **or** an option for Tangail CPP, has only to be answered by mid-1993. A final decision by the GOB and the donors is required as to how to reconcile the present direction with the ToR.

Adjusted approach

During an abridged consultation process, the Union Chairmen, NGOs and members of farmers, landless, fishermen and women's groups in the northern and external sub-compartments were informed about the planned interventions and their reactions solicited. About twenty-five meetings took place, around the locations of the major structural interventions. In general these meetings confirmed the need for some improved protection and embankments, but also the reservations concerning the operation and possible negative effects of of the main structures on navigation and fisheries. In sub-compartments 9, 10 and 11 meetings included discussions about various options for

internal water management. These meetings have been very helpful to refine the designs on internal water management measures to be included in the 1992/93 construction period. Consultations will continue for subsequent development of the sub-compartments.

Development targets

To comply with the overall objective of compartmentalization to provide, through water management, a more secure environment for intensive agriculture, fisheries and integrated rural/urban development, and thereby improve the economic security and quality of life of the floodplain population, a number of specific targets have been formulated for the development of the Tangail CPP. These targets concern both structural and non-structural project components and interventions.

Structural targets are related to flood protection at the boundary of the compartment and improved or adjusted water management for agriculture, fisheries, navigation and urban development respectively. The non-structural targets are related to the socio-economic, environmental and institutional aspects of the Tangail CPP.

Planning and design

Based on the conclusions of the various surveys, the outcome of the abridged consultations, the results of modelling, the engineering possibilities and the institutional requirements, plans and designs have been worked out. The core of the plans is related to the formulation of **six implementation alternatives** :

IMPLEMENTATION ALTERNATIVES TANGAIL (PLANNING)

IA	FULL COMPARTMENTALIZATION; ALL PERIPHERAL STRUCTURES GATED WITH THE EXCEPTION OF THE UNGATED OR PARTLY GATED, NAVIGABLE INLET STRUCTURES *LOHAJANG* AND *SADULLAPUR*; LIMITED PERIPHERAL ROAD (20 KM); SOUTHERN EMBANKMENT AS FEEDER ROAD WITH BRIDGES/UNGATED STRUCTURES; FLOW REGULATORS BETWEEN *LOHAJANG* AND SC'S 9, 10 AND 11 ONLY
IB	THE SAME AS IA, BUT ALSO GATED, UNNAVIGABLE INLET STRUCTURES *LOHAJANG* AND *SADULLAPUR*; INCLUDING MOORING FACILITIES (OR LOCK)
IIA	THE SAME AS IA, BUT ALSO INCLUDING FLOW REGULATORS BETWEEN *LOHAJANG* AND REMAINING SUB-COMPARTMENTS
IIB	THE SAME AS IB, BUT ALSO INCLUDING FLOW REGULATORS BETWEEN *LOHAJANG* AND REMAINING SUB-COMPARTMENTS
IIIA	THE SAME AS IIB, BUT WITH CLOSED/REGULATED STRUCTURES ALONG SOUTHERN EMBANKMENT, WITH EXCEPTION OF THE OPEN *LOHAJANG* OUTLET
IIIB	THE SAME AS IIIA, BUT WITH COMPLETE PERIPHERAL ROAD (60 KM)

They have in common that the implementation schedule for the coming year is virtually the same. In fact, the six alternatives together constitute one dynamic development scenario in which elements of the four options formulated earlier have been combined.

This approach has been followed to enable incorporation of test results into the ongoing decision-making proces concerning regarding possible next steps. Moreover, it has the advantage that remaining gaps in design criteria can be closed and that proper institutionalization can be realized simultaneously with the progress of design and construction.

The plans and designs call for:

- o measures to improve Peripheral Flood Control;
- o measures to improve water management within the Tangail CPP;
- o mitigation measures within and outside the perimeter of the compartment;
- o the establishment of institutions at compartment, sub-compartment and water users level;
- o a training programme aimed at government staff, local government officials and beneficiaries;
- o a monitoring programme of hydrological, environmental, socio-economic and institutional indicators;
- o a post-evaluation programme;
- o additional studies in fields of agriculture, fisheries, socio-economic, environmental and other related issues.

Implementation schedule

The implementation alternatives proposed require four decisions to be taken by mid-1993 through mid-1995. These decisions concern the possible installation of gates in the *Lohajang* inlet regulator, installation of flow regulators between the *Lohajang* and sub-compartments, other than 9, 10 and 11, the possible provision of outlet structures along the southern embankment and the construction of the peripheral road. All four decisions might also be deferred if it can be expected that results of testing, alternatives designs or availability of information on the implications for the Tangail CPP about the *Bhramaputra* Left Embankment and/or the *Dhaleswari* Mitigation Plan would increase the justification of the respective choices.

Structural measures

- o Construction period 1992/93

  - peripheral control by strengthening the horseshoe embankment including erosion protection works,
  - construction of relevant structures,
  - internal control in sub-compartments, 9, 10 and 11, including the development of the adjacent *Lohajang* floodplain,
  - mitigation measures for floodplain fisheries.

- o Construction period 1993/94

  - completion of peripheral control,
  - completion of sub-compartments 9, 10 and 11,

- internal control of sub-compartments 1-8, E1 and 15, including the development of the adjacent *Lohajang* floodplain,
- implementation of upstream mitigation measures,
- urban development,
- completion of bank protection and river training.

o Construction period 1994/95

- completion of sub-compartments 1-8, E1 and 15,
- completion of sub-compartments 12-14,
- completion of peripheral control at southern embankment (if this will be decided).

Non-structural measures

Socio-economic programme

The consultation process will precede detailed and final planning of the structural measures mentioned above. This involves meetings per sub-compartment with the different interest groups, i.e. farmers, fishermen, landless, women and the urban population.

The proposed development plan involves much re-excavation of existing khals as well as some embankment work. After the consultation meetings in an area are completed, landless contracting societies will be established to take up part of this work.

By the time implementation has, for started structures, embankment and channels maintenance groups will be formed. As in the Landless Constracting Societies disadvantaged groups will be given priority.

Moreover a number of workshops/seminars will be organized on topics related to the various development issues.

Institutionalisation programme

The proposed programme will improve the functioning of existing institutions and, to the extent required, establish new institutions that will facilitate comprehensive area based water management at the level of the compartment and sub-compartments. The major elements are:

- The gradual establishment of **Water Users Groups** at field level, composed of the various categories of interest groups and defined by location, socio-economic interest and water related activity.

- The establishment of **Sub-Compartment Water Committees**, composed of representatives of interest groups (different categories of farmers, fishermen, landless, women, urban dwellers), Union Parishad Ward Members and field staff of BWDB, BRDB and DAE. These committees will in due course become responsible for operation and maintenance of all water regulating structures that affect the sub-

compartment and will be the major channel for representation of people's interest to other institutions.

- The establisment of the **CPP Executive Committee** composed of District and Thana level staff of the 5 relevant line departments, local government officials, Tangail town representatives, representatives of benificiaries and NGO staff. This Committee will facilitate the implementation of CPP and will coordinate the inputs from the various agencies.

- Once full representation from the side of Sub Compartment Water Committees in the CPP Executive Committee will have been reached (mid 1994), this body will become the **(Provisional) Compartment Water Management Board.** This board, made up by representatives of line departments, beneficiaries, local government and, initially, CPP, will take up responsibilities for Operation and Maintenance for all structures that affect Tangail Compartment. It will guide the project and will, after its completion, assume responsibility for comprehensive water management, cost recovery and future planning according to the then prevailing national legislation.

Field-level organisation of beneficiaries and the establishment of Water Users Groups and Sub-Compartment Water Committtees will be undertaken by BRDB, DAE and a selected NGO. Union Parishad Members and Chairmen will play a central role at these levels, which will ensure integration of the various new structures into the fabric of local society. District and Thana level staff of the various departments will assume direct responsibilities for the execution of CPP activities.

Training

In order to create or strengthen the required skills an extensive **training programme** will be designed and executed. This programme will aim at the representatives of beneficiaries, field staff of BRDB, BWDB and DAE and technical staff of the various line departments at District and Thana levels as well as the BWDB. It will convey knowledge and skills related to integrated water management but also the skills and vision required for activities that cut across departmental boundaries and that will effectively involve people at the lowest possible levels.

The various activities aimed at institution building and training will result in a package of materials, guidelines and manuals that can be used for replication outside of this pilot project.

Studies

Studies are planned to improve insight in institutional arrangements for participation and area based water management and to elaborate the legal, fiscal and administrative arrangements required for successful functioning of the proposed institutions. Other studies to be undertaken are proposed in the fields of farm system research, fisheries, socio-economic impact, EIA, verification of topo-map and transport and markets.

Costs of implementation

The cost estimates of structural works of implementation alternatives IA, IIA and IIB are summarized below:

IA FULL COMPARTMENTALIZATION; ALL PERIPHERAL STRUCTURES GATED WITH THE EXCEPTION OF THE UNGATED OR PARTLY GATED NAVIGABLE INLET STRUCTURES *LOHAJANG* AND *SADULLAPUR*; LIMITED PERIPHERAL ROAD (20 KM); SOUTHERN EMBANKMENT AS FEEDER ROAD WITH BRIDGES/UNGATED STRUCTURES; FLOW REGULATORS BETWEEN *LOHAJANG* AND COMPARTMENT ONLY IN SC'S 9, 10 AND 11 ONLY				
	92/93	93/94	94/95	Total
Total Cost (Tk mln)	80	84	23	187

IIA THE SAME AS IA, REMAINING SUB-COMPARTMENTS BUT ALSO INCLUDING FLOW REGULATORS BETWEEN *LOHAJANG* AND REMAINING SUB-COMPARTMENTS				
	92/93	93/94	94/95	Total
Total Cost (Tk mln)	80	112	38	230

IIIB THE SAME AS IIIA, BUT WITH COMPLETE PERIPHERAL ROAD (60 KM)				
	92/93	93/94	94/95	Total
Total Cost (Tk mln)	82	166	55	303

The cost estimates of non-structural activities are as follows:

	1992-93	1993-94	1994-95	Total Lakh Tk
- establishing the Compartmentalization Pilot Project Executive Committee	2	3	4	9
- facilitating GOB inter-departmental cooperation	7.5	7.5	5	20
- training programme	30	20	10	60
- consultation process	1.5	2	1.5	5
- establishing and facilitating Water Users Groups and Sub-Compartment Water Committees	7	10	10	27
- establishing and facilitating Landless Contracting Societies	1	2	2	5
- establishing and facilitating Maintenance Groups	1	2	2	5
- special studies	p.m.	p.m.	p.m	p.m.
Total	50	46.5	34.5	131

Impact assessment

Implementation of the Tangail CPP will improve the economic security and quality of life especially of the rural farm households and urban population living within the CPP area.

It should be kept in mind, however, that the level of agricultural production and related activities is already quite high as compared to other areas in the floodplain.

Agricultural impact

The flood protection and improved water management measures will lead to higher crop security. The farmers, therefore, will shift from local varieties to high yielding varieties, this particularly holds true for the shift to transplanted Aman. This shift will result in a significant increase in cropping intensity from 203% at present to 215% in the future. Finally, the improved internal drainage situation in pre-and post-monsoon will allow for better growing conditions for Boro (HYV) and mustard.

Impact on fisheries

Improved water management for agriculture, will have some adverse effects on fisheries. Reproduction and nursing of both *"Beel"* fish and "River" fish will be reduced to some extent. The introduction of "fish-friendly" structures will only minimize losses but cannot prevent them. Mitigation measures, such as the integrated farming of rice/fish and culture based fisheries are a potentially beneficial measure, that would also restore some of the previously lost natural carp production.

Internal socio-economic impact

The larger, but also the medium and small farm households will benefit from the project, provided they will have access to the necessary credit facilities. Marginal farmers and pure share-croppers are less likely to benefit directly, other than by improved flood protection of their homesteads. They would, together with the landless and women, receive indirect benefits through additional employment opportunities. To offset the negative impact professional and occasional fishermen will be encouraged to effectuate some switch to culture-based fisheries. The population of Tangail town, including urban dwellers, are likely to be the main beneficiaries from the flood protection provided by the CPP.

External socio-economic impact

Farmers in the adjacent areas may face slightly higher levels of water during the monsoon. Overall, the impact on agricultural production is likely to be minimal. Fishermen of all types will benefit because of higher upstream water levels and availability of fish fry. In the downstream areas fishermen are likely to experience some negative impact. To some extent the landless and women will benefit from mitigation measures for improved navigation possibilities as well as from road communication. In general it can be stated (Ref. conclusion FAP 14) that people in unprotected areas would be better able to cope with flooding and thereby improve their general welfare by integration of specific flood response measures within structural and non-structural

projects. Well, Tangail CPP is a case in point, as it includes multi-purpose refuge areas alongside its peripheral embankment.

Operation and maintenance

The most important activities, in which the involvement of the beneficiaries is considered essential are operation and maintenance. Appropriate technical guidelines and institutional arrangements have been formulated to ensure the sustainability of the project interventions and, in turn, its development results. Moreover, it is proposed to include landless and women, wherever possible and relevant in the embankment- channel-and structures-maintenance groups, respectively.

Multi-criteria analysis

As part of the multi-criteria analysis an **indicative** cost-benefit calculation has been carried out. The total costs concern engineering, investment (both in structural works and non-structural activities) and recurrent costs. The benefits are only derived from an increase in agricultural output (Tk 20 mln), a decrease in fisheries (Tk 2 mln) and a modest amount reflecting a reduction of flood damage (Tk 6 mln).

The economic criteria used can be summarized as follows:

Criteria	Unit	Implementation Alternative					
		IA		IIA		IIIB	
		ECON	FIN	ECON	FIN	ECON	FIN
Investment cost	Tk mln	148	188	185	231	236	303
Foreign exchange	%	41	41	45	45	41	41
Engineering cost	Tk mln	19	28	24	35	31	46
Total investment	Tk mln	167	216	209	265	267	349
Recurrent cost	Tk mln	7	10	8	10	11	14
Total benefits	Tk mln	22	26	22	26	22	26
IRR	%	2.1	1.6	0.4	0.0	-3.2	-4
NPV	Tk mln	-125	-160	-167	-208	-239	-311

From this preliminary analysis of the direct impacts it is clear that the project is hardly justified from a strictly economic point of view, inspite of some tangible benefits which might be in favour of that part of the population most urgently in need of support. However, no attempt has been made so far, to quantify indirect benefits or to value other criteria, such as the pilot character of the project and the external socio-economic impact of flood protection itself. This will be done at a later stage of the Tangail CPP.

Justification

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 limited in regions which already have a relatively high degree of economic development, as is the case in the Tangail CPP area. Tentative calculations have shown that the same project, implemented in a region starting with a cropping intensity of, say 180 %, will attain break-even conditions in economic terms at a cropping intensity of about 210 %.

If farmers experience a more secure environment due to reduced flood hazards and improved water management, natural risk aversion, especially of marginal and small farmers, may be reduced in favour of more intensive and more efficient cultivation practices. These elements may result in intensified agricultural production and additional employment opportunities. These have been identified to be 133,700 man days per year.

Outside agricultural activities, new jobs will also be created in connection with operation and maintenance requirements of the water management system. It should however be kept in mind that in general there are good reasons for a region to be economically less developed compared to others. In Bangladesh, this is not only due to the lack of flood protection and effective water management but also to other well known distortions from which agricultural development is suffering, of which sub-optimal land-use systems and insufficient institutional support are only the most outstanding.

Providing flood protection and improved watermanagement by compartmentalization is considered a precondition for the elimination of most of the other distortions. This is where FAP 20 in general and the Tangail CPP in particular hopes to make a significant contribution as detailed in this Interim Report.

ii ABBREVIATIONS

AEZ	-	Agro-Ecological Zone
BADC	-	Bangladesh Agricultural Development Corporation
BARC	-	Bangladesh Agricultural Research Council
BARI	-	Bangladesh Agricultural Research Institute
BAU	-	Bangladesh Agricultural University
BBS	-	Bangladesh Bureau of Statistics
BETS	-	Bangladesh Engineering & Technological Services
BJRI	-	Bangladesh Jute Research Institute
BLE	-	*Brahmaputra* Left Embankment
BRAC	-	Bangladesh Rural Advancement Committee
BRDB	-	Bangladesh Rural Development Board
BRE	-	*Brahmaputra* Right Embankment
BRRI	-	Bangladesh Rice Research Institute
BS	-	Block supervisor
BWDB	-	Bangladesh Water Development Board
CPP	-	Compartmentalization Pilot Project
CT	-	Consultants Team
CWMB	-	Compartmental Water Management Board
CMG	-	Canal Maintenance Group
DAE	-	Department of Agricultural Extension
DC	-	Deputy Commissioner
DDP	-	Delta Development Project
DGIS	-	Directorate General for International Cooperation
DHI	-	Danish Hydraulic Institute
DMP	-	*Dhaleswari* Mitigation Plan
DTW	-	Deep Tube Well
DS(WL)	-	Downstream Water Level
EIA	-	Environment Impact Assessment
EIP	-	Early Implementation Projects
EMG	-	Embankment Maintenance Group
EIIR	-	Economic Internal Rate of Return
FA	-	Financial Assistance
FAP	-	Flood Action Plan
FCD/I	-	Flood Control, Drainage and Irrigation
FFW	-	Food for Work
FMM	-	Flood Management Model
FMMCC	-	Flood Modelling/Management Coordinating Committee
FPCO	-	Flood Plan Co-ordination Organization
FY	-	Financial Year
FIRR	-	Financial Internal Rate of Return
G-7	-	Group of Seven Industrialized Countries
GIS	-	Geographic Information System (FAP 19)
GOB	-	Government of Bangladesh
GTZ	-	Gesellschaft fuer Technische Zusammenarbeit
HA	-	Hectares
HH	-	Household
HYV	-	High Yielding Variety

ISPAN	-	Irrigation Support Project for Asia and the Near East
JPPS	-	Jamalpur Priority Pilot Study
KfW	-	Kreditnastalt für Wiederaufbau
LCS	-	Landless Contracting Society
LGEB	-	Local Government Engineering Development
LLP	-	Low-lift Pump
MDSC	-	Multi-Disciplinary Sub-Compartment (survey)
MIWDFC	-	Ministry of Irrigation, Water Development and Flood Control
MOA	-	Ministry of Agriculture
MPO	-	Master Plan Organisation (now WARPO)
NAM	-	Rainfall-runoff module of MIKE 11
NCA	-	Net Cultivable Area
NCRS	-	North Central Regional Study
NGO	-	Non-Governmental Organization
NWMB	-	National Water Management Board
NWRS	-	North West Regional Study
NPV	-	Net Present Value
O&M	-	Operation and Maintenance
PA	-	Participants Activities (matrix)
PD	-	Project Director
PHE	-	Public Health Engineering (department)
POE	-	Panel of Experts
PP	-	Project Proforma
PT	-	Project Team
PWD	-	Public Works Department
R&H	-	Roads and Highways
RWMB	-	Regional Water Management Board
SDE	-	Sub-Divisional Engineer
SRDI	-	Soil Resources Development Institute
SRP	-	Systems Rehabilitation Project
STW	-	Shallow Tube Well
SMG	-	Structure Maintenance Group
TA	-	Technical Assistance
TADP	-	Tangail Agricultural Development Project
TAPP	-	Technical Assistance Project Proforma
TL	-	Team Leader
ToR	-	Terms of Reference
TP	-	Technical Proposal
UNDP	-	United Nations Development Programme
USAID	-	United States Agency for International Development
US(WL)	-	Upstream Water Level
WARPO	-	Water Resources Planning Organisation

iii GLOSSARY

Aquaculture	-	Artificial and commercial cultivation of aquatic products.
Aus	-	A group of photoperiod-insensitive rice varieties sown during March-April and harvested during June-August.
Baseline survey	-	A survey with the aim to provide and verify data on hydrological, engineering, agricultural, socio-economic and environmental aspects prior to, during and on completion of the pilot project.
Beel	-	Small lake, low-lying depression, a permanent body of water in a floodplain or a body of water created by rains or floods.
Boro	-	A group of photoperiod-insensitive but fairly cold tolerant rice varieties transplanted in December-January and harvested in April-May.
Braus	-	In between Aus and Boro. Rice varieties planted between February 15 and March 15.
Compartment	-	An area in which effective water management, particularly through controlled flooding and controlled drainage, is made possible through structural and institutional arrangements. A compartment can be subdivided into sub-compartments.
Compartmentalization	-	The spreading of the flood water over the flood plains by establishing interlinked compartments, with the objective to provide a more secure environment for agriculture, fisheries and integrated rural and urban development through water management (controlled flooding and drainage) .
Controlled drainage	-	The control of the water flow out of a (sub)compartment according to the local or regional requirements.
Controlled flooding	-	The spreading of the flood over the land in a (semi) controlled way with the help of provisions incorporated in compartments, embankments, roads, etc.

Deepwater Aman	-	A group of photoperiod-sensitive varieties adapted in water depth ranging from 1 to 3m and above. These are either direct seeded in February-May or transplanted in July-August and harvested in October-December.
Fully-controlled structure	-	A structure through which the water flow can be fully regulated.
Khal	-	A natural channel.
Mauza	-	Revenue village with a separate Jurisdiction List Number, area and a map.
Multi-criteria analysis	-	An analysis and display of the impacts of proposed structural and non-structural works in which a wide range of criteria are 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 will be dealt with in a descriptive way.
Pagard	-	A small water body, generally excavated near a home stead, which is used for fish stocking as well as for household activities.
PA-Matrix	-	A relational matrix, depicting links between participants and activities in a certain process.
Parishad	-	Elected Council
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 on, and new hypotheses for integrated rural development.
Semi-controlled structure	-	An ungated structure that can not be regulated.
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 provided with (semi)controlled structures.
Transplanted Aman	-	A group of photoperiod-sensitive rice planted in July-August in non-flooded areas and harvested in November-December.

Union	-	Smallest electoral unit of areas outside municipalities comprising several mauzas (or villages), and generally divided into three wards. It has an Union Parishad (council).
Thana (previously *Upazila*)	-	Local administrative unit, comprising about 10 Unions, and mainly staffed by delegated central government officials.

iv SELECTED BIBLIOGRAPHY

AGRICULTURAL PRODUCTION SYSTEM, TR-14, MPO, Dhaka, 1987

BANGLADESH ACTION PLAN FOR FLOOD CONTROL; ACHIEVEMENT AND OUTLOOK (DRAFT), FPCO, Dhaka, 1992

CAN DEVELOPMENT BE FINANCED FROM BELOW?: LOCAL RESOURCES MOBILISATION, H.W. Blair, UPL, Dhaka, 1989

DHALESWARI MITIGATION PLAN; DRAFT FINAL REPORT, Jamuna Bridge Authority, Dhaka, 1991

FCD/I AGRICULTURAL STUDY, DRAFT FINAL REPORT, SUMMARY AND RECOMMENDATIONS, FAP 12, Dhaka, 1991

FISHERIES AND FLOOD CONTROL, DRAINAGE AND IRRIGATION DEVELOPMENT, TR-17, MPO, Dhaka, 1987

GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENT (draft), FAP 16, Dhaka, 1992

GUIDELINES ON PROJECT ASSESSMENT, FPCO, July 1991, Dhaka

INSTITUTIONALIZATION OF BENEFICIARY PARTICIPATION FOR PROJECT SUCCESS (DRAFT), UNDP/FPCO, Dhaka, 1992

JAMALPUR PRIORITY PROJECT STUDY, INTERIM FEASIBILITY REPORT, Main report, FAP 3.1, Dhaka, 1992

REGIONAL WATER RESOURCES DEVELOPMENT PLAN, DRAFT FINAL REPORT, FAP 3, Dhaka, 1992

LAND ACQUISITION AND RESETTLEMENT STUDY; SUMMARY OF FINDING AND RECOMMENDATIONS, FAP 15, Dhaka, 1992

LANDLESS CONTRACTING SOCIETIES (Draft), EIP/BWDB, Dhaka

MANUAL FOR ENVIRONMENTAL IMPACT ASSESSMENT, VOLUME-1, FAP 16, Dhaka, 1992

MISSION REPORT ON INSTITUTIONAL ASPECTS TECHNICAL REPORT 9 (DRAFT), SRP/BWDB, Dhaka, 1992

PROJECT WITH PEOPLE; PRACTICE OF PARTICIPATION IN RURAL DEVELOPMENT, Peter Oakley et al, International Labour Office, Geneva, 1990

RAPID RURAL APPRAISAL (RRA); CONCEPTS,METHODS AND APPLICATIONS, BARC, Dhaka, 1990

RAPID RURAL APPRAISALS, overview, FAP 12, 1991, Dhaka

RAPID RURAL APPRAISAL OF SILIMPUR-KARATIA REGULATOR CUM BRIDGES, FAP 12, Dhaka, 1991

RECOMMENDED ORGANIZATION FOR IMPROVED OPERATION AND MAINTENANCE AT SUB- PROJECT LEVEL (Draft), SRP/BWDB, Technical Report No 11, Dhaka, 1991

RECONNAISSANCE SOIL SURVEY, TANGAIL DISTRICT, Directorate of Soil Survey, 1967, East Pakistan, Dacca

SEMINAR ON SYSTEMS REHABILITATION PROJECT AND USERS PARTICIPATION BWDB/SRP, Dhaka, 1992

SMALL AREA ATLAS OF BANGLADESH, MAUZAS AND MAHALLAHS OF TANGAIL DISTRICT, BBS, Dhaka. 1986

THE BANGLADESH CENSUS OF AGRICULTURE AND LIVESTOCK: 1983_84, BBS, Dhaka, 1988

1 INTRODUCTION

1.1 Water management in historic perspective

Over the centuries the farmers in the delta area of Bengal organized themselves to cope with their environment. They did this without much support or interference from a central government. They built embankments in which they cut openings to irrigate their land and which they closed again before the next flood. Together they maintained the embankments and the channels. One can say that the people were engaged in a sort of integrated water management in which flood protection, drainage and irrigation were handled in a balanced way. The rivers and *khals* brought fish fry to the fields. The farmers profited from the positive influence of the flooding of their land because it increased the fertility. At that time Bengal was apparently a rich country in which the people made full use of its position at the lower reach of major rivers.

This situation has changed in such a way that the major attention was diverted from monsoon irrigation to flood protection. The first national water master plan (1964) gave major emphasis on flood protection. A foreign concept - the polder - was introduced. Quite a few projects were carried out based on this idea. However, by going for full protection, the negative effects of floods were reduced within the polder, but also the beneficial effects of the floods. Isolated polders give solutions for the enclosed areas, but often they create problems in the surrounding, because of higher water levels. Furthermore, the polders require a high level of management capacity of Government agencies and effective concensus about balancing the various interest that are involved. These conditions are not always met. As a consequence, people from outside the polders frequently cut the embankments.

Following the disastrous floods of 1987 and 1988 several studies were undertaken to investigate how to protect the country better against the devastating effects of the floods. The results showed alternatives, with on the one side 'full protection' and on the other side 'living with the floods'.

1.2 The Flood Action Plan

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

The FAP comprises a number of studies and pilot projects which are expected to lead to water resource management and related projects, with an emphasis on flood control and drainage. In the first two years of the Plan, 1990-92, Regional Water Resource Development Planning Studies are being undertaken to identify alternative water resource management strategies for different regions of the country. These will be followed by

feasibility studies for priority investment projects. A number of complementary socio-economic and environmental studies are being carried out in order to improve understanding of the impact of flooding and of Flood Control, Drainage and Irrigation (FDC/I) projects, and to recommend economic, social and environmental guidelines and criteria appropriate for use in planning and implementing such projects. While the emphasis of the Regional Studies is on flood control and drainage, other problems such as saline intrusion will also be addressed.

The main focus of the Flood Action Plan is defined by the Government of Bangladesh in the well-known Eleven Guiding Principles. Emphasis is given on 'controlled flooding' and 'controlled drainage'. Floods would be controlled in such a way that maximum profit can be achieved from the beneficial effects of river water flooding, while minimizing the disadvantages. The Action Plan comprises twenty-six components and supporting activities. The Compartmentalization Pilot Project - FAP 20 - is one of them.

1.3 Controlled flooding and drainage

Many outsiders classify all flooding as undesirable and flood mitigation often gets political support and foreign assistance. Yet, the rural population perceive normal flooding as a very positive factor in the seasonal cycle. The mechanisms behind the positive influence of the normal flooding on agriculture (silt deposit and/or nitrogen fixation through blue-green algae growth) and on fishery is the subject for many academic discussions and research. Lately there is a growing realization among scientists that the floodplain population may well have a more comprehensive view of flooding than most outsiders. Therefore a cornerstone of the approach is to involve the intended beneficiaries, and those likely to be adversely affected by works of the Compartmentalization Pilot Project. This involvement applies to all stages of Project planning, design, construction, operation and maintenance and monitoring and evaluation.

It will be necessary to make a distinction between flooding which originates from overflow of the river banks and flooding from local rainfall. Control of flooding from high water levels in the river can be achieved through the construction or rehabilitation of river embankments with control structures. One of the main issues here is to consider the effect of flood control on the neighbouring areas. Control of flooding inside the embankment (compartment) from local rainfall is basically a matter of (temporarily) flood retention within the operational units to avoid that flood water will accumulate in the low lying areas. The realization of this objective is more a matter of improving the internal drainage system, but is bound by downstream water level conditions.

1.4 The concept of compartmentalization

The concept of compartmentalization is introduced in the GOB/UNDP study "Bangladesh Flood Policy Study" (May 1989). According to the Flood Action Plan, which resulted from this study, the areas at the right and left bank of the *Brahmaputra* would be subdivided into compartments.

The flood water will flow into the compartment and spread over the area in a (semi)-controlled way by means of regulating structures in the primary embankments along this river and the gated or ungated openings in the secondary embankments between the compartments. The structural and non-structural measures to achieve this can be called the macro (main) system.

The way the flood, as well as the drainage of excess rainfall, has to be controlled will be determined by the demands from inside the compartment. The required structural and non-structural measures for water management within the compartments can be called the micro (minor) system.

The concept of compartmentalization is instrumental for the implementation of water management interventions.

The following definition will be used:

> *A compartment is an area in which effective water management, particularly through semi-controlled flooding and controlled drainage, is made possible through structural and institutional arrangements. Compartmentalization is linked to area development with sound water management as the main agent. A compartment will be sub-divided into sub-compartments and operational water management units.*

It is obvious that a compartment can be a large area and that hydrology, topography, existing infrastructure, landuse and administrative boundaries are important factors to consider. In analogy with an irrigation system, it is possible to make a distinction between the macro (main) system and the micro (minor) system. Clearly, to make the participation of the beneficiaries in Project planning, design, construction, operation, maintenance, monitoring and evaluation successful, it will be necessary to subdivide the compartment into rather small units.

The criteria to design a compartment and its subdivision into operational units or (a combination of) sub-compartments are subject of the CPP study. It goes without saying that it will be advantageous to design units that are homogeneous in many ways, as well as manageable as a distinct unit. The following factors have been considered at an early stage for the Tangail Pilot Project:

- **Physical parameters**; an operational unit should preferably have its own facilities for controlled flooding and drainage; assuming that it will be convenient from a management point of view that each unit has its own water level and associated management mode within the unit; the topography and hydrology of the area will have a significant effect on the size of the units.

- **Landuse patterns**; different landuse patterns require different water management modes; in order to simplify the management of the units, landuse within a particular unit should preferably be uniform;

In the future also other factors may have to be taken into account:

- **Administrative boundaries**; in the design and management of irrigation systems, it can often not be prevented that administrative boundaries and the boundaries of the water management (tertiary) unit do not coincide. This complicates the functioning of the Water User Groups. A compartment is not the same as an irrigation system but, certainly, there are some lessons to be learned from experience with the management of irrigation systems in the design of water management systems for compartments;

- **Social homogeneity**; operational units should also, from a social point of view be as homogeneous as possible. Using landuse as a criterium for the design of the operational unit may in itself result in some homogeneity of the group within the unit. By aiming at rather small units, social homogeneity will also be enhanced.

- **Manageability**; O&M of the smaller operational units should as far as possible be the responsibility of the beneficiaries themselves (Water User Groups). In the design of irrigation systems, it is generally accepted that service units should not be much larger than 50 hectares. Another criterium that is often used is that the size of the group should not be much larger than 30 to 40 farmers. For Bangladesh, with an average land holding size slightly less than 1 ha, this leads to an unit size of 25 ha on average.

Finally, sub-compartments may be combined for economic or operational reasons.

1.5 The Compartmentalization Pilot Project (CPP-FAP 20)

1.5.1 The objective

The overall objective of FAP 20 is:

> "*....to establish appropriate watermanagement systems for the development of protected areas so that criteria and principles for design, implementation and operation can be made available for the Action Plan.*" [ToR, page 4].

Specifically this will entail the

> "*...testing of the compartmentalization concept in the field under real operating conditions, addressing all relevant socio-economic, institutional and environmental issues and trying out water control works and water management systems.*"[ToR, page 4].

FAP 20 has to produce not only the structural works and an institutional set-up for the compartments Tangail and Sirajganj, but also criteria, guidelines, manuals and a training and demonstration programme for the establishment of other compartments.

1.5.2 Water management

Water management projects must not only take the needs of agriculture into account, but also:

- the needs of the non-crop sectors such as fisheries, livestock, transport and industry (rural as well as urban);

- the conflicting interests, such as between low- and high- land farmers, between farmers and landless people and between those inside and outside the boundaries of the project; and

- the need for widespread popular support through people's participation, so as to facilitate input into design, planning, operation and maintenance of structures, including embankments.

Water shortages should be minimized by water supply, and excess of water should be minimized by improved flood control and drainage.

In FAP 20 water management is therefore defined as follows:

> *Water management is the controlled quantitative and qualitative usage of water, including early, late and deep flooding, rainfall and ground water in agriculture, fisheries, transport, sanitation and for domestic and industrial purposes.*

Water management ideally is a continuous process in which the people concerned participate in a decisive way. It starts with the identification of the existing water related problems and possibilities, followed by planning, design, construction, operation and maintenance, but also monitoring and evaluation of the results. Water management includes reconciling competing interests and it should lead to sustainable development.

It is, therefore, necessary to institutionalize the people's participation in water management. This will not be easy after decades of centralized state control.

This water-management-related institutionalization will have to be initiated at the local level, but will ultimately have to extend all the way up to the national and even the international level. It will also have to include legislation, including the formulation of bye-laws, defining rules and regulations about the privileges and duties of the people and organizations concerned. Here again it is necessary that these are sustainable, and accepted as legitimate by the people.

1.5.3 People's participation

The FAP 20 ToR puts much emphasis on people's participation and its institutionalization;

> "*The compartment is basically a management unit in which the involvement of beneficiaries is considered essential for its success.*" [ToR, p. 3]

> "*The non-structural output which constitute the basic objectives of the Pilot Project will cover the following:*
>
> .....

2. *Social Aspects*
Policies and Guidelines of involving the scheme beneficiaries and disadvantaged groups in the planning and implementation of physical works and their management
...
4. *Institutional Arrangements*
Policies and Guidelines for strengthening existing institutions and/or establishing new ones for the management of compartments or sub-compartmental development with the emphasis on local government and beneficiary participation .... [ToR page 6, 7)

This emphasis on the non-structural aspects of compartmentalization has strongly been reconfirmed by evaluations of existing FCD/I projects (see particularly FAP 12/13). These have highlighted that success and sustainability requires people's participation in all phases of such projects and close collaboration between and within the various government organizations.

FAP 20 has therefore designed a comprehensive programme to involve all concerned in the process of designing, operating and testing compartmentalization. As mentioned in the Inception Report (April 1992) people's participation can be anything between genuine grassroots development and the "selling" of a programme (designed by others) to the people concerned. FAP 20 proposed not follow either of these extreme approaches. Within the limits set by the specific objectives of FAP 20 ("testing the compartmentalization concept in the field under real operating conditions"), a "bottom-up" approach is emphasized.

1.6 Objectives of the report

The objective of this Tangail CPP Interim Report is to outline the progress and planning of the various required project outputs. The costs and benefits are estimated and a multi-criteria analysis is carried out.

The report should contribute to a balanced approach as to the further planning, design and implementation of both the structural and the non-structural components of the Tangail CPP. It goes without saying that the real outputs will be only known after testing the results of the various interventions. Therefore, quite an ambitious programme has been proposed for the coming year to enable evaluation of the intended measures at an early stage.

As far as possible use has been made of the "Guidelines for Project Assessment" (FPCO, May 1992).

The next Tangail Interim Report will be submitted in September 1993. If so required the planning and programme for the remaining project period will be amended and adjusted.

1.7 Organization of the report

The **Main report** is organized in such a way that a logical sequence of past, present and future project activities has been described. All on-going and planned interventions are based on the results, interpretation and analysis of the various surveys carried out as

described in Chapter 2. In Chapter 3 the targets for structural and non-structural elements are outlined.

The core of this report is Chapter 4, in which the planning and design of the various project activities have been discussed and further studies have been proposed. The time frame in which the outputs should be realized and the related cost estimates are presented in Chapter 5.

An assessment of the impacts of the proposed measures are elaborated in Chapter 6. In Chapter 7 technical and institutional aspects of operation and maintenance have been discussed. Finally, a multi-criteria analysis, including an analysis of the direct and indirect costs and benefits and of other qualitative, impacts has been described in Chapter 8.

The **Annexes**, including their Appendices, contain all supporting data, detailed sectoral analysis, engineering design assumptions and criteria and of course proposals for institutionalization of all measures.

1.8 Acknowledgements

Without the contributions from a number of other FAP projects this report could not have been completed in time. Especially we are grateful to FAP 3 (regional information); FAP 12/13 (evaluation of existing FCD/I projects); FAP 16 (environmental issues); FAP 17 (fisheries); FAP 19 (GIS-generated basic info) and FAP 25 (modelling aspects).

The cooperation received from the Office of the Deputy Commissioner and from Government Departments and Institutions represented in Tangail have emphasized the inter-departmental and multi-disciplinarity character of FAP 20. In Dhaka, especially the BWDB's Design Office has been very helpful to the CPP staff. A number of NGO's and individual persons have contributed, often at short notice, to the preparation and organization of the consultation meetings in the field.

2 PRESENT SITUATION

2.1 Tangail CPP area

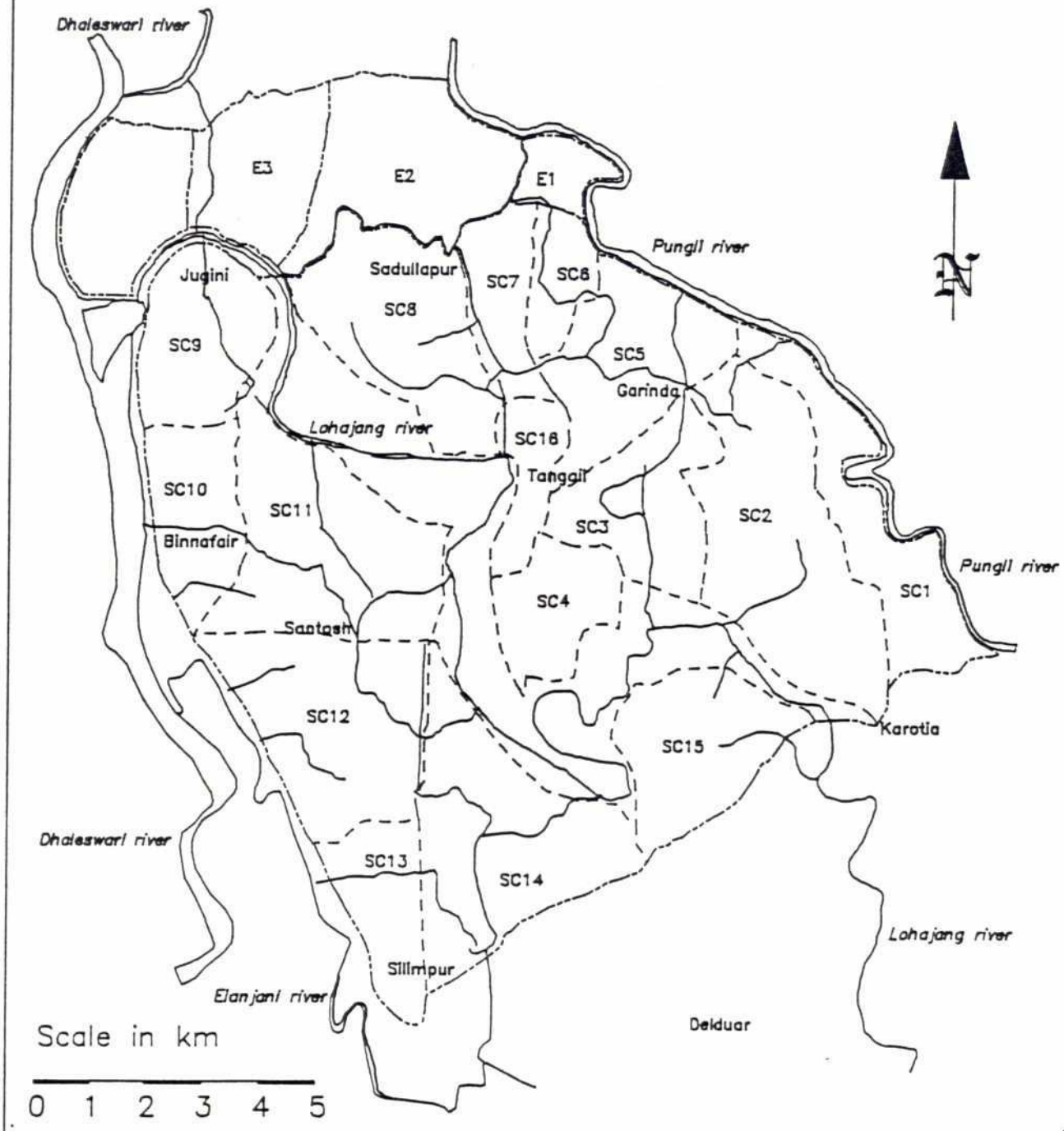
The Tangail Pilot Project area is located on the left bank of the *Brahmaputra*, enclosing Tangail town (Figure 2.1). The area is bounded by a horse-shoe embankment along the *Dhaleswari* and *Elanjani* rivers in the West, the *Lohajang* and *Gala khal* in the North and the *Pungli* river in the East. The southern boundary is formed by an earthen road between *Silimpur* and *Karatia*. The project area comprises 13,169 ha, divided over three Thana's of Tangail District: Tangail (83%), *Delduar* (14%) and *Basail* (3%). Homesteads, roads, markets, *beels*, rivers etc. make up 29% of the area and 71% is cultivable land. The population is around 260,000 out of which about 105,000 live in Tangail town (mid-1992).

The pilot area occupies part of the Young *Brahmaputra* Floodplain. Overall drainage is away from the *Brahmaputra* (Jamuna) and *Dhaleswari* rivers towards low-lying land in the South-East. Overall land elevation is rather flat with contours varying between 12.5 and 7.5 m +PWD. However, in detail, the relief comprises a complex network of ridges, basins *(beels)* and old channels.

Most of the land goes under water in the monsoon season. Flooding is by rainwater (mean annual rainfall 1550 mm) and by river water. Flooding of depressions normally begins in May-June with the onset of the pre-monsoon rainfall. Flooding becomes more extensive during the monsoon, normally reaching its peak in July-August. In 'normal' flood years depressions are submerged 1-2 m deep. In years with high river floods, ridges are submerged and depressions are flooded up to 3 m and more. Surface flood water enters the area through intakes at four locations and 3 intakes/breaches in the West; through the *Lohajang* river and several branch channels, entering the project area in the North; through overland flow from the North and through an unstructured inlet from the *Pungli* river in the East. The main outflow is through the *Lohajang* river and through overland flow in the South. Most of the land becomes free from flood water by mid-November, but drainage channels are silted up and depressions stay wet, some throughout the dry season.

Agriculture in the project area is dominated by rice crops. Irrigation within the project boundary has a high intensity. As a result, irrigated Boro HYV is the main rice crop, producing 50-60% of the total rice production. Aus and deep water Aman (B.Aman) produce 15-20% each; T.Aman takes care of 10% of the production. Other relatively important crops are jute, wheat, mustard, sugar cane and pulses. A considerable part of the cultivable area is triple cropped. The overall cropping intensity is over 200%. Floods from rain and river water and impeded drainage are the major limitations for agricultural development. Much of the lower land presently remains fallow in the rainy season because of the risk that rapidly rising floodwater in June might drown Aman seedlings.

Livestock lacks sufficient qualitative and quantitative supply of fodder. The number of draught animals is no longer sufficient. As far as providing draught power is concerned, power tillers are filling up the deficit.



LEGEND

Compartment boundary
Sub-compartment boundary
Waterway

Note: Source for geo-data: FAP19.

MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION

COMPARTMENTALIZATION PILOT PROJECT
FAP 20

TANGAIL CPP AREA

Consultant: Euroconsult, Lahmeyer Intl, Beta Ltd, HCL

Drawn by	Checked by	Figure/Drawing No
Date	Date	2.1.

The average farm size is slightly less than 1 ha. The marketing margin of agricultural produce is in the order of 20% on average, but because 40-45% of the population live in an urban setting, the area technically faces a food deficit.

Fisheries activities and productions are determined by the seasonal fluctuation of the flood regime. In the dry season, professional fishermen are operating with seine and cast nets mainly in the *beels* and *pagards*. Based on existing "traditional rights", the professional fishermen share their catch with the owners of the *beels*. Subsistence fisheries, using scoop nets, traps, baskets and hand picking, can be carried out freely in all the *beels*. The majority of the fish caught this way belongs to the so called "miscellaneous" or "small" fish. During the flood period the segregation disappears and both professional and subsistence fishing is carried out freely over the floodplain. The regional blockage of migration routes for major carps through silted-up channels, embankments, regulators, etc. resulted in a serious decline of the production of the species.

Culture of the high valued carps has expanded within the last decade. However, production levels are low (500-900 kg/ha/yr) due to the use of sub-optimal culture techniques.

2.2 Reconnaissance and preliminary survey

Shortly after starting to operate, the FAP 20 staff conducted a preliminary survey of the Tangail CPP area. The findings of the preliminary survey of the Tangail CPP area were summarized in the *SUMMARY OF PRELIMINARY SURVEY OF TANGAIL COMPARTMENT* and presented for discussion at the FAP Team Leaders meeting on 29 August, 1991.

A few of the main conclusions of that survey were that:
- the area was much more heterogeneous in hydrological, agricultural and socio-economic conditions than expected,
- official data were available but followed administrative boundaries and those did not coincide with the compartment boundaries,
- official figures needed verification and had to be supplemented by qualitative data on underlying causes and relationships between the water management needs of the different interest groups.

On the basis of these findings the household baseline survey was designed and conducted. The preliminary survey also provided the basic information for designing the topographical and hydrological survey. The heterogeneity of the area called for detailed and location specific information as a basis for planning and design of structural and institutional measures. For that reason a multi-disciplinary sub-compartmental survey (needs assessment) was developed and conducted in each provisional sub-compartment. A summary of the findings of each of these surveys is presented below.

2.3 Baseline surveys framework

The Tangail CPP baseline survey comprises the following four surveys, each with specific aims and objectives;

- The **household survey** is designed to provide statistically valid baseline data mainly covering social, economic and agricultural matters. The survey is of the questionnaire type. These data are to some extent used in the planning process, but the main use of the data is in the multi-criteria analysis of development alternatives, and the post-project evaluation (Ref. Annex 1.1).

- The **topographical and hydrological survey** provides vital information for the planning, the mathematical modelling and the post-project evaluation. This survey includes levelling, recording water levels and discharge measurements (Ref. Annex 1.2).

- The focus of the **Multi-Disciplinary Sub-Compartmental (MDSC) survey** is the interrelation between all the relevant facets of life in each sub-compartment. Typical items are history of the area, environment, transport, fisheries, rural industry, hydrological situation, agricultural status etc. Data were collected using an adjusted Rapid Rural Appraisal approach. The main use of the information has been in planning and design of the structural and non-structural interventions. At the post-project evaluation stage the data will again be used as qualitative descriptive baseline information (Ref. Annex 1.3).

- Through the **institutional survey** information has been gathered at the compartmental level regarding the institutions relevant to water management. The information was gathered using open ended checklist questionnaires. The data have been used to design a strategy for institutional development (Ref. Annex 5; Appendix 2).

2.3.1 Household survey

The data collection of the Household Survey took place from mid-December 1991 till the end of March 1992. From April till July 1992 the data have been processed and analyzed. The areas surveyed comprised, besides the compartment itself, the adjacent areas and a control area *(Kalihati Thana)*. The work has been performed by Development Planners & Consultants (DPC), a firm which is specialized in this type of work.

Some of the conclusions of the survey are:

- of all the rural households 30% operate a farm of 0.2 ha. or more, implying that over 70% of the households depend on selling their labour in one way or another;
- over 50% of the net cultivable area is irrigated, and this indicates how at present the farmers are rather dry season oriented;
- the 5 major cropping patterns are: T.Aman/-/Boro (19%), /-/-/Boro (15%), T.Aman/Oilseeds/Boro (14%), /Jute/-/Wheat (6%) and -/Oilseeds/Boro (5%), again highlighting the importance of the dry season;

- just over 50% of the net operated area is cultivated during Kharif-2 and only about 2 % of the T.Aman grown in the area is HYV, signifying the insecurity felt by the farmers about monsoon crop production;
- the distribution of households over the different farm size categories is: pure share cropper 5 %, marginal farmers 23 %, small farmers 52 %, medium farmers 15 %, large farmers 5 %;
- the fish epidemic peaked in 1988 and the situation has improved since then;

For more information see Annex 1.1 and for more details its Appendices.

2.3.2 Topographical and hydrological surveys

2.3.2.1 Topographical survey

All topographic data are based on the available 1964 8" : mile maps, complemented by 1:50,000 spot maps and 1:20,000 aerial photographs of recent date. In addition to this a detailed topographic survey has been carried out in the Tangail compartment during the 1991/1992 dry season. More recent topograhic data are being prepared by FAP 18.

The principle aim of the survey under FAP 20 was the assessment of longitudinal and cross-sections of *khals* and embankments throughout the compartment. The location of the sections are given in Figures 1 and 2 in Annex 1.2. The actual data are available in the CPP office.

A secundary objective of the survey was to assess whether the 1964 map corresponds with the survey data. A comparison along the southern boundary gave matching data for about half the observed points. It is therefore proposed to verify the validity of the '64 map in an undisturbed area in the near future (see also 4.6).

Since no other data are as yet available it is suggested that the 1964 map be used for overall planning; for detailed planning topographical surveys are indispensable.

2.3.2.2 Hydrological survey

For the hydrological survey, rainfall data from Tangail Atia station (1961-1991) have been collected and used. A summary of these data is presented in Table 1 of Annex 1.2.

For an estimate of the potential evapotranspiration in Tangail, the data from Mymensing have been used (mean data per month, see Table 1.2 in Annex 2).

Annual lowest groundwater levels at different locations within the compartment have been monitored by the Department of Public Health Engineering. The status of these levels during the past 6 years is given below. A trend towards lower water levels can be observed which indicates that the use of groundwater is close to its maximum potential.

Water level at *Jugini* in m+PWD	Percentage of area flooded in the subcompartments
10.3	20 %
10.9	50 %
11.6	80 %

During the 1992 flood season a total of 35 gauges have been installed. The additional number includes gauges in the floodplain. The available gauges are indicated in Figure 4 of Annex 1.2.

In addition 3 automatic water level recorders (press-logs) have been installed in the Tangail compartment.

In order to get an impression of morphological characteristics of the waterways within the compartment the silt factor and the particle size distribution curve have been assessed. A summary is presented in Table 6 of Annex 1.2. For Tangail a siltfactor of 0.4 has been used.

2.3.3 Multi-Disciplinary Sub-Compartmental survey

The aim of the Multi-Disciplinary Sub-Compartmental (MDSC) survey was to get qualitative baseline data from the people in each sub-compartment. Farmers, landless, fishermen, women and urban dwellers were interviewed to find out their perception about the present water related situation in their area, the existing problems and potential improvements.

The survey team, made up of specialists from FAP 20 received special training for this survey. Based on the general principles of the Rapid Rural Appraisal methodology the team was specifically trained in using non-leading questions and in gathering the perceptions of the local people about water related issues. The MDSC survey fieldwork started mid-January 1992 and was completed 4 months later.

The three main conclusions of the MDSC survey were that;

- the normal monsoon flooding is appreciated because it brings fish-fry into the floodplain, allows cheap navigation and enhances soil fertility, but floods like 1988 are problematic to all;
- early drainage in the post-monsoon (as well as pre-monsoon), to facilitate dry season crop production, is an almost unanimously expressed need, and detailed suggestions were made as to which channels to be re-excavated;
- the inhabitants of the area appreciated embankments/roads but, for various reasons, the existing regulators were mostly seen to be negative.

depth in ft	1986	1987	1988	1989	1990	1991	1992
Baghil	17	17	19	19	17	19	19
Silimpur	16	19	19	19	17	18	19
Danya	15	16	19	20	16	18	18
Gala	17	17	19	19	16	20	20
Gharinda	18	17	19	19	16	22	23
Karotia	12	18	17	19	16	23	24
average	15.8	17.3	18.7	19.1	16.3	20.0	20.5

Groundwater flow characteristics are analysed in the WARPO (formerly MPO) Technical Report No 5. The following data have been used:

- specific yield: 0.038 -0.06
- infiltration rate 2 mm/day.

For the predominant soil types the "groundwater depth for the unit capillary flux" in meters and the "Water Holding Capacity" (WHC) in volume percentage have been used:

Soil type	WHC	Flux
Silty loam	37	2.8
Silty clay loam	19	1.8
Clayey loam	16	1.0

With respect to river stages there is only one permanent gauging station available within the Tangail area: at *Jugini* (from 1952 onwards).

During the 1991 flood season a total of 14 staff gauges have been placed in the Tangail compartment (see Figure 3 in Annex 1.2). Data measured at the stations have been used as a basis for the calibration of the mathematical model.

In order to estimate the probability of flooding within the compartment at different decades the mean maximum daily and maximum 3-day flood levels for *Jugini* station have been analyzed with a Gumbel-I distribution. The waterlevels at *Jugini* station during relevant decades for a 1:2, a 1:5, a 1:10 and a 1:20 year return period are shown on Annex 1.2 (Table 2.1). This table is complemented by the maximum rise in a three day period which is an important criterium for crop suitability.

An effort to correlate the flooding levels within the sub-compartments and the flood level at *Jugini* is presented in Tables 4 and 5 of Annex 1.2. As a rough guideline the following can be concluded:

Many detailed observations, suggestions etc. have been incorporated into the designs (Chapter 4).

For more details see Annex 1.3, as well as its Appendices.

2.3.4 Institutional survey

The aim of the institutional survey was to find out what institutions of the GOB and NGO's, formal and informal, exist in the area and how they function in relation to water management. The information was collected mainly through interviews with the different institutions as well as through the MDSC survey (informal institutions).

The main findings of this part of the baseline survey are:

- the different GOB departments function vertically and there is much room for improving their horizontal functioning at Thana and Union level;
- a wide variety of local as well as national NGOs work in the Tangail CPP area but there is little coordination among them;
- the boundaries of the compartment and the sub-compartments do not coincide with the Thana, Union and Mauza/Ward boundaries, thus complicating the institutionalization of water management;
- currently the links between BWDB and other relevant departments are weak;
- existing institutional arrangements for input by users in design and operation and maintenance of water-related structures are weak;
- there are no effective mechanisms for cost-recovery or cost-sharing for water-related facilities;
- there is no institutional platform for comprehensive water management.

Of the GOB Departments DOF, DAE, BRDB and the Union Parishad's were visited and interviewed. For more information and details see Annex 5: Appendix 2.

2.4 Mathematical modelling

A model is developed to appraise the external as well as internal river system and rainfall-runoff of the Tangail Compartment. The model is based on the Danish Hydraulic Institute (DHI) software package MIKE11 which contains a number of process modules. The Tangail Compartment model consists of two modules; the hydrological model NAM and the hydrodynamic model.

The model requires a set of data covering topography, boundary data (water level or discharge) and climatological data. River sections were surveyed and a water level measuring programme was initiated to collect the water levels at 14 locations throughout the CPP area.

The rainfall-runoff model was calibrated against the groundwater level. The CPP area is divided into 16 sub-compartments considering the existing infra-structure such as roads and embankments. The *Lohajang* floodplain is treated separately. The overland flow

factor which is the main parameter has been adjusted during the calibration. The model is calibrated for the 1991 situation and compared with measured groundwater levels. For detailed description of the parameters reference is made to Annex 4.

The main channels of the Tangail model are the rivers *Dhaleswari*, *Pungli*, *Elanjani* and the *Lohajang* and the *Gala khal*. The floodplain area is included as an extension of the channel cross-sections. Major *beels* or depressions were also included in the model.

The hydrodynamic part of the model is also calibrated against the 1991 measured water levels. The calibration shows in general good agreement with the measured values. Details are given in Annex 4. For hydraulic and hydrologic design of structures, channels and embankments usually the statistical analysis is based on data of a number of years. As the modelling has not been performed for a range of years for statistical analysis, the assessment of the most relevant years for the modelling is based on the probability analysis of certain hydrological events and on the probability of damage to crops related to these events. Considering both, it is found that 1987, 1989 are exceptionally wet and dry years respectively. Hence with these three years (including 1991), the modelling is carried out to determine the operational rules for the structures.

The main sectors for interaction of the model are agriculture and fisheries.

Inclusion of probable interventions

The basic purpose of the hydrodynamic model is to investigate the hydrological effects of the implementation of various engineering interventions such as embankments, drainage channels and hydraulic structures. The calibrated model is used to simulate the behaviour of the various engineering interventions. The 'with project' situation is compared with the 'without project' situation. Details of this comparison are given in Annex 4.

The 'with project' situation includes a number of implementation alternatives including peripheral control. Also the improvement of the existing structures along the *Dhaleswari-Elanjani* embankment and the internal interventions, such as improvement of main drainage channels, are included in the implementation alternatives.

The capacity and dimensions of the various structures are based on the duration and depth of flooding allowed in the different sub-compartments.

Post-processing of results

The output of the model, a series of hydrographs, will be used to estimate the effect of flooding on agricultural and fisheries output. The period from the 1st of May upto the 30th of November were divided into decades and maximum 3-day mean values for each decade were calculated. The resulting flooding depth per sub-compartment has been subsequently expressed according to the F0 to F4 classification.

Future Development

At present the model is sufficiently developed to simulate the peripheral control structures with internal drainage channel improvement. But to study into detail the water management per sub-compartment, the smaller channels have to be included as well. It is

the eastern and southern parts, occupying 46% of the area. Almost all soils are poorly drained and seasonally flooded. Both chemically and physically the soils appear to be among the best in Bangladesh. The relief of the flood basis is mainly smooth with some depressions and *beels*. The upper parts of the ridges are occupied by silt loams, the lowerparts by silty clay loams and the basins and *beels* by silty clays. Three major soil associations can be identified in the area, each one with its own potentials and limitations. (Further reference is made to Annex 2).

Agro-climate

The climate in the area, as everywhere in Bangladesh, is dominated by the monsoon and has three distinctive periods, the rabi season from November till February, the *Kharif-I* season from March to June and the *Kharif-II* season from July till October. Temperatures range from a minimum of 12°C in winter to a maximum of 34°C in the *Kharif-I* season (Table 2.1). Average annual rainfall is about 1550 mm, but the average for a period of the last 7 years is 2014 mm of which about 60% is falling in the monsoon season and even 88% if one includes the months of May and June of the *Kharif-I* season.

Table: 2.1 Climatological parameters of three seasons in the CPP Area, Tangail

Altitude: 9.8m	Longitude: 90-90.25E		Latitude: 24-24.25N		
Season	Temperature (0C) Max.	Min.	Rainfall* (mm.)	Sunshine hours/day	Humidity (%) 9 a.m	6 p.m
Kharif-I (March-June)	34	18	732	7.7	80	65
Kharif-II (July-Oct.)	31	24	1196	6.1	86	81
Rabi (Nov.-Feb.)	29	12	86	9.0	76	74

For source and details ref Table 1.2 in Annex 2.

The critical aspects of climate in relation to crops are:

- o the occurrence and reliability of the early monsoon rains and the onset of the monsoon.
- o the occurrence of storms that damage standing crops (Boro and Aus HYV rice).
- o the reliability of the monsoon rains, and the rise, duration and recession of floods associated with the monsoon rains; and
- o the reliability, amount and distribution of the late monsoon rains.

The crop environment during the *Kharif-II* season is not favourable for achieving full potential yields because of uneven distribution of rainfall, flooding at variable depths, insect attack, low solar radiation and high temperatures and humidity. In contrast the *Rabi* season has favourable conditions for achieving full potential yields: high solar radiation, low humidity and a wide variation in day and night temperatures.

2.6.2 Present agricultural situation

Crops and cropping system

Cropping patterns are to a great extent determined by seasonal floods. Cropping systems and practices are adapted to the local flood regimes and the availability of irrigation water.

With the introduction of tubewell irrigation cropping patterns have changed, the use of HYVs increased and production risen considerably. A total of 9197 ha. of the project area is cultivable (NCA). The cropping intensity in 1991-92 was 203%. The main crop is rice, planted to 115% of the area. Other important crops are jute, wheat, sugarcane, vegetables, potatoes and mustard (Table 6.2). The most important rice crop is Boro producing 56% of the total production of more than 28000 tons (1991). The Aman crop grown in the *Kharif-II* season (monsoon) produces 30% and the aus crop in the *Kharif-I* season the remaining 13% of the total rice production.

Inputs

Input supply as fertilizers, pesticides, irrigation equipment, tools and seeds is improving since trade of most items has been privatised. With the expansion of the area planted to HYVs, fertilizer use especially Urea, is increasing. The irrigated area is estimated at about 40% of the NCA using STWs and DTWs. Groundwater supply and recharge do not yet seem to be a constraint.

Hired labour is used in peak periods. The use of animal power is quite common in agricultural operations and in local transport. Fodder supply is not sufficient to keep the draught animals in a good condition, reducing the quality of land preparation. A small but growing number of 2 wheeled power tillers is now employed to satisfy the growing demand for draught power.

Credit to finance inputs has become an essential facility for most farmers especially when growing HYVs. Institutional and non-institutional credit is prevalent in the project area. Landless and marginal farmers have to go for the latter form of credit because they cannot put up any collateral.

Marketing

Marketing of agricultural produce in the project area is predominantly an individual business. State procurement of paddy and wheat is done in harvesting seasons at fixed prices. Jute is procured by special jute cooperations at prevailing market prices.

Constraints

Constraints to agricultural development are mainly related to flooding and impeded drainage. Other constraints are: the illiteracy among farmers, causing contact problems with research and extension staffs and heavy pressure of population leading to a shrinking land/man ratio which impedes farmers to generate surplus for investment.

Livestock

In the context of the overall planning the role of livestock is not very great in the Tangail CPP area. As already mentioned, one of the important limiting factors is the lack of a sufficient qualitative and quantitative supply of fodder. Since the introduction of the short stemmed rice HYVs, which are less palatable for cattle, there is growing shortage in fodder supply. The number of draught animals in Tangail is no longer sufficient, as the quality and stamina are rapidly decreasing. Like in other regions, power tillers will increasingly be used to supply the traction needed for land cultivation. A negative impact will be the reduced production of manure, used as a source of fuel and as organic fertilizer.

Forestry

Natural forests in the project area are non-existent. Expansion of tree planting using fast growing species is only possible at homesteads and along roadsides.

Further details of the present agricultural situation are mentioned in Annex 2.

2.7 Fisheries

The fish species in Bangladesh can be divided into two major groups, considering their reproductive behaviour:

River fish, such as the major carps, spawn upstream in the major rivers at the beginning of the rainy season. The eggs, larvae, fingerlings and some adults of these species flow with the water current downstream, finally entering the floodplain, where they find all the nutrient for survival and growth. These species migrate back to the rivers as soon as the water recedes from the floodplain.

Beel fish, such as snakeheads, catfish, etc, can survive the harsh condition of the floodplain. They reproduce in the pre-monsoon as the water levels in the *beels* rise. Nursing takes place in the inundated floodplain. With the receding waters this group migrates back to the rivers or gets trapped in the *beels*.

The difference between both groups has been a key point of attention in the fisheries study due to the fact that water management regulations affect both groups in a different way.

In Bangladesh, the Department of Fisheries is monitoring fisheries and aquaculture, through the Fisheries Resources Survey System. This monitoring system indicated that from a base of 488,000 ton/year there is a decline of 44,000 ton/year in fish production obtained from rivers, floodplain and *beels* during the period 1983-1989. Within the same period the inland aquaculture output of Bangladesh increased with 48,000 t/year, making up for the losses of inland fisheries.

The present production of 1000 kg/ha/year obtained from managed ponds could be increased to a maximum of 2000 kg/ha/year through improvement of the methods used. This would give a maximum aquaculture output of 100,000 t/year. It can be concluded

that there is not much scope left for a continuing making up of captured fisheries losses by aquaculture.

The total fish production of Tangail district increased from 5,500 t/yr in 1983 to 7,000 t/yr in 1989, mainly due to an increased floodplain fisheries output. It is however assumed that this increase is caused by errors in data collection, as these figures are in contradiction with the general trend in Bangladesh and with the findings of the MDSC-survey. Both riverine and *beel* fisheries declined substantially within the last decade.

The main reasons for this decline of the inland capture fisheries output are:

- Blockage of migration routes of carp species.
- Reduction of fish breeding and nursing habitats.
- The massive capture of fry for aquaculture purpose.
- The increased fishing intensity.
- The increased use of agro-chemicals.
- The disease known as Epizootic Ulcerative Syndrome, which spread over South East Asia in the last decade, especially attacking *beelfish*.

Within the CPP-project area the general trend of reduced fisheries output was reported by the professional fishermen during the MDSC-Survey. However, reliable data on the past and present situation could not be compiled from the Fisheries statistics. The total fisheries output of the CPP area was estimated at 420 t/year, using the data from the Fisheries Household Survey. The distribution over the different habitats is presented below.

HABITAT	CATCH IN TON/YEAR
RIVER	44
BEEL	127
FLOODPLAIN	183
PITS & DERELICT PONDS	26
AQUACULTURE	40
TOTAL	420

Fishing activities in the project area can be divided in:

Professional fishermen, their main occupation is fishing throughout the year; and their number in the CPP area is estimated at 460.

Occasional fishermen, these fishermen have next to fishing an alternative occupation; approximately 930 are active in the CPP area.

Subsistence fishermen, the majority of the fish, in Bangladesh and in the CPP area is caught by this group. The catch is mainly meant for home consumption. In the Fisheries Household Survey their number is estimated at over 17,000.

A survey executed by FAP 20 indicated the existence of approximately 350 culturable ponds within the CPP area. The main species cultured are: Major or Indian carps, Silver carp, Common carp, Tilapia and Grass carp. Fry is mainly obtained from natural sources, except for the chinese carp. The actual aquacultural production is estimated at 40 t/year, with an average pond size of 0.1 ha and a production level of 1,200 kg/ha/year.

Tangail district and the CPP area are among the lowest inland fish producers of Bangladesh, providing approximately 1% of the total inland fisheries production. As a consequence the per capita availability of fish is 1.83 kg only. The average consumption rate in the project area is 7 kg/capita/year, which indicates that a substantial amount is obtained from outside the project area. The major part (85%) of the fish consumed in the rural area of the CPP area consists of the so called "small" or "miscellaneous" species, most of them originating from the *Beel* areas.

A fivefold increase, or 1970 t/year of fisheries output is needed in the CPP area, in order to secure the future demand (year 2020) at the present average consumption rate. With the present situation, such an increase can not be obtained and the CPP area will become even more dependent on outside resources.

2.8 Navigation

Navigation has traditionally been important in the Tangail CPP area. The location of Tangail along the *Jamuna* river, opposite *Sirajganj* on the other bank of the river, and the good road connection with *Dhaka* are the main reasons for this. Over the last few decennia navigation has however slowly declined. This seems partly due to "push" factors such as silting up of channels and building of embankments. The main "pull" factor is the improvement of road transport.

In the recent past much navigation took place via the *Binnafair khal*. This was the main route for navigation between *Tangail* town and the area between it and *Sirajganj*. Siltation of this *khal* reduced navigation possibilities, but this route was completely blocked when in 1983/84 a regulator was built in the *khal* where it crosses the *Dhaleswari* embankment.

Most recently, external navigation mainly used the *Jugini* and *Sadullapur khals*. There is also some external navigation to and from *Karatia* but this is much less important than navigation to the north-west of the area.

External navigation involves mainly cargo. Incoming goods are mainly agricultural produce (including cattle) while the outgoing flow is both agricultural inputs and consumer goods. Passengers also make use of this navigation route, but cargo is the mainstay.

Internal navigation is particularly relevant in the southern and eastern sub-compartments. Here communication is mainly with *Karatia* and involves both cargo and passengers.

Further details are presented in Table 4 in Annex 6.1.

2.9 Road transport

The road transport system connecting the area with other parts of the country is well developed. The *Dhaka-Jamalpur/Mymenshingh* road runs through the area and is used extensively for passenger and cargo transport. There are also metalled road connections to the area immediately South of the project (*Delduar*) and to the North. During the dry season a non-metal road connects the area with the area between the river *Dhaleswari* and the main channel of the river *Jamuna*. An all-season non-metal road, including a ferry, connects the project area with the area to the East.

In addition to the above, there are quite a number of non-motorable village roads and paths that provide for movement of people and limited amounts of goods in and out of the project area.

The internal road system is also well developed, and still expanding. There are quite a few metalled roads as well as non-metalled feeder roads (Union Parishad/CARE). The village road that constitutes the southern boundary of the compartment is being upgraded by building a number of culverts/bridges.

Normal flooding does not interfere with road transport. Severe flooding, such as in 1988, however, results in many roads being damaged and becoming unusable until repaired.

2.10 Urban area; Tangail town

Tangail town sub-compartment is located in the center of the compartment on the eastern bank of the *Lohajang* river. The total area of this sub-compartment is about 260 ha. Most of the land is high or medium high with some lower spots.

The population of the town, which at 105,000 (mid-1992) is about 40% of the population of the total compartment, is mainly involved in non-agricultural earning activities like services, handicraft and business.

Main problems are relating to the river erosion of the *Lohajang* river, the insufficiency of the surface drainage system, especially in the central part of the town and the occasional river flooding.

Further details are presented in the MDSC summary report in Annex 1.3, Appendix 2.

3 DEVELOPMENT TARGETS

3.1 General

According to the FAP 20 ToR the overall objective of compartmentalization is:

> *"... to provide, through water management, a more secure environment for intensive agriculture, fisheries and integrated rural/urban development, and thereby improve the economic security and quality of life of the floodplain population."* [ToR, p. 3]

This objective can be reached through a combination of structural and non-structural targets. The structural elements enable water management while the non-structural elements are to ensure the use of the structural elements in such a way that maximum social benefit can be derived. In the next two sections both these elements are covered in more detail.

3.2 Structural Targets

3.2.1 General

Structural targets related to the water management system concern the following areas:

- Flood protection at the compartmental boundary.
- Improved water management for agriculture.
- Improved water management for fisheries.
- Improved water management for navigation.
- Improved water management for urban development.

The possible technical solutions that are envisaged in order to reach these targets have to take into account the hydrological cycle, deviations from the expected hydrological situation and among others, different landtypes.

3.2.2 Flood protection at compartmental boundary

Extreme flood events only occur during the full monsoon season from July to September, although earlier, lower floods - can have quite some impact as well. Of particular concern are the habitat areas that become flooded both in the urban and rural areas, due to an exceptionally high river water level mostly in combination with abundant local rainfall.

If prevention of flood damage has a high priority then a flood proof peripheral embankment and in-and outlet structures are prerequisites.

3.2.3. Water management for agriculture

There are 4 distinct agro-hydrological periods; pre-monsoon, monsoon, post-monsoon and the dry season.

Pre-monsoon (March to June)

During this period the Boro is harvested. It is cultivated from lowland up to high land areas. This crop may be damaged by water logging caused by excessive early rainfall or an early high stage of the river.

Damage can be reduced by providing an effective drainage system and by water retention on higher lands (F0, F1 and F2). An early high stage of the river can possibly be semi-controlled by installing and operating the peripheral/internal structures.

Monsoon (July to September)

A variety of crops is grown that can resist different levels of flooding. A long-term aim of the project is to increase the area planted to T.Aman (HYV). Due to the risk of high waterlevels from mid-July onwards, the existing situation does hardly permit the cultivation of HYV Aman. In order to improve this situation, the waterlevels within the compartment should be lowered considerably. Optimum waterlevels per crop are mentioned in Table 6.1. The highest level of water after the end of August will determine on the optimum area potentially planted to T.Aman.

In order to get lower waterlevels during monsoon within the compartment, the following elements will be considered:

- Peripheral control.
- Control between the *Lohajang* and the sub-compartments (controlled flooding and drainage).
- Control between the sub-compartments (controlled flooding and drainage).
- Water retention on the higher grounds especially highland and medium highland

"Control" may assume various levels, including "semi-control" by ungated structures.

These measures may effectively "control" a high flood situation. The high rainfall situation can not be dealt with so effectively because after mid-July the outside areas may have a higher waterlevel than the inside areas.

In case of a period of too low rainfall during several weeks, controlled flooding of lower lands and supplementary irrigation with surface water on higher lands may be considered. If a high flood occurs during this period, irrigation inlets through the peripheral embankment can be used. If the waterlevel in the rivers is low then tubewells could be operated, which is not the case as yet.

Post-monsoon (October)

During this period the land should be drained as early as possible in order to permit the cultivation of oil-seeds from November onwards. The required water management element is the drainage of the low lying areas (not the permanent *beels*). This can be effected by improving the drainage system.

Dry-season (November to February)

The dominant activity during this period is the irrigation of the Boro crop by means of shallow and deep tube wells. Early drainage will enable timely sowing of Boro and a slight increase in the potential area. The actual recharge of the groundwater in the Tangail compartment area (13,000 ha only) does not affect the availability of groundwater during the dry season in the future (see Section 2.3.2.2).

3.2.4 Water management for fisheries

The existing situation is favourable for floodplain and *beel* fisheries. There is free access from the major rivers into the *khals*, floodplains and *beels* and there is prolonged inundation of these low lying areas. Controlled flooding and drainage will drawback on this situation in two manners:

- the migration of fish is hampered by (gated) structures between the major rivers and the flooded areas.

- the inundated area within the compartment where the fish can feed and spawn is reduced.

A slight compensation for the generally negative effect for *beel* fish can be obtained if the highest waterlevel after August can be maintained throughout the monsoon season by controlled drainage, thus partly maintaining the feeding ground for *beel* fish. This may also be beneficial in years with a very modest river flood.

The water management elements as required for agriculture will be adjusted in order to minimize the negative impact for fish. Especially, the gated regulating structures should be considered in this respect (see 4.1.3.2).

During the dry season the levels in perennial *beels* decrease. It may be considered to excavate specific *beels* in order to improve the survival rate of mature *beel* fish for the next fish season. This should be verified by the on-going special fisheries study.

3.2.5 Water management for navigation

Also for navigation the existing situation is the most favourable one. From late June to mid-October (3.5 months) there is free passage for all kinds of smaller country boats. Beyond this period navigation is not possible in the Tangail compartment. Gated structures will hamper the movement of even the smallest boats during most of the wet season. Some major structures may be adjusted in order to minimize the negative impact for navigation. It is targeted that, even if the main inlet structures are gated, in 60-70% of the time navigation would be possible as compared to the present situation.

3.2.6 Water management for urban areas

In the existing situation Tangail town and other urban areas may get flooded occasionally from high river stages, intensive rainfall or a combination of the two. The water management elements as required for the safety of the compartment and for agriculture will improve this situation, especially with respect to the river flooding.

The flooding from rainfall may require an improved sewage/stormwater system, possibly in combination with a pumping station. The supply of drinking water for Tangail (deep tube well) will not be influenced by the project. All these elements are considered to be beyond the present scope of the project although they should be monitored. It will be investigated whether the peripheral flood protection for the compartment is sufficient for the urban areas. If not, a secondary embankment for Tangail town may be justified.

3.3 Non-structural targets

3.3.1 Socio-economic

FAP 20 aims at the following socio-economic targets;

- involvement of beneficiaries and those negatively affected in planning, design, construction and operation,
- creating of employment opportunities for disadvantaged groups during construction as well as in on-going operation and maintenance work,
- protection and compensation of groups that are adversely affected,
- special emphasis in all activities on minorities and women.

The above mentioned aims are worked out in different ways throughout the project life cycle. Beneficiaries and those negatively affected are involved in all stages of the project. Of all earth moving work 30-50% has been reserved for Landless Contracting Societies. Half of that quota is reserved for women. Those potentially negatively affected by the project, mainly those living up-stream and North-West of the Tangail CPP area, are the first to qualify for such employment opportunities.

All turfing and regular earth work maintenance has been reserved for destitute women. If insufficient women groups are available male LCS might temporarily be given such work. In all institutional arrangements proposed by the project special emphasis is given to genuine representation of the weaker sections of rural society.

3.3.2 Environmental

All environmental issues will be dealt with as follows. The first target is to preserve the environment and where possible enhance it. One example of such improvement is the flushing of water logged areas. Next, potential negative effects should be prevented or minimized. And another example is the construction of "fish-friendly" structures.

If this is not possible then mitigation measures are proposed. Examples are the development of *Jugini beel* by not allowing compartmentalization to drain out the whole of the adjacent flood plain, but only part. Another example is the proposed multi-purpose extension of parts of the embankment around the project area. Such extensions can then be used by those living outside the embankment as places of refuge during extreme floods.

If neither prevention nor mitigation is possible then compensation will be offered to those affected. The most obvious example of this is quick and fair compensation of those whose land will be acquired for construction purposes.

3.3.3 Institutional

The main aim of institutionalization is to develop mechanisms for operating and maintaining the compartmental water management system. Such institutionalization should allow for genuine representation of all concerned, including those living outside the project area and (potentially) negatively affected.

The institutionalization aimed for will have to be such that it will allow for changing requirements inside the compartment to be taken into account as time goes by. The whole system must therefore be seen as a dynamic process which will allow the inhabitants of the area to manage their water system to the maximum extent possible.

This requires that the institutional arrangements allow decisions to be made at the lowest possible level and that those who bear the immediate consequences should be directly represented in such decision making. This implies effective decentralisation and integration of this proces at the level of sub-compartments and, where needed, at the level of the compartment. For this at present no arrangements exist and the project will test, fine-tune and consolidate the organisational options designed for this purpose.

The institutional arrangements need to meet three other requirements as well:

- **Facilitating direct involvement and close coordination between the various line departments whose work relates to water management.** As multi-disciplinary water management is a task that at present does not belong to any of the existing departments, a mechanism needs to be established that draws on the strengths of the various departments without being dominated by any of them. The project can not aim at working at a final solution, as this is an issue at the level of national policy making, to be explored by FAP 26. However, the project will put in place and test arrangements that bring the relevant departments together in developing guidelines and instruments for comprehensive water management, but it will also directly involve field staff in implemention. This will help to clarify options for long-term incorporation of responsibilities into existing or new governmental institutions.

- **Testing strategies for cost-recovery and cost-sharing for improved water management.** While the initial investments in this project will be born by the GOB and donors, the recurrent costs for operation and maintenance should, to the extent possible, be covered locally. Partly this will happen by way of direct contributions made by users, in the form of providing labour and materials for structural works and by providing managerial capacity in supervising and operating structures. But the project will also investigate the possibility and modalities for cost-recovery by way of purpose-related taxation and fee-systems. This should assist in understanding options for local sustainability of project initiated investments.

- **Establishing how and to what extent others than the usual governmental agencies can play an effective role in establishing and maintaining arrangements for comprehensive water management at a compartmental and sub-compartmental level.** Extensive use will be made of Non Government Organisations (NGO's), in order to determine what their contribution can be in mobilizing, training and supporting water users. But the project will also systematically involve the Union

Councils, the lowest level of elected government and a potential resource in this context. Finally, the project will test in what way the various categories of water users themselves can assume long-term responsibilities and how this can be consolidated in organisational arrangements.

The purpose of FAP 20 is not only to test different approaches under real field conditions, but also to develop and consolidate manuals, training materials, procedures and guidelines that can be used for replication elsewhere. Special emphasis will be placed on the generation of training packages for water users, field staff of government agencies, members of the various institutions charged with water management and district level government staff (see Annex 7). This will increase the effectiveness of individuals and institutions at these various levels and provide tested instruments for future replication of the positive results of this pilot project.

4 PLANNING AND DESIGN

4.1 General

In this Chapter the various aspects of planning and design of the structural and non-structural elements of the Tangail CPP have been described. The proposed plans and designs are based on the results of the various surveys, the outcome of the abridged consultations, the engineering possibilities and the institutional requirements. First, details of the peripheral flood control works have been worked out, followed by a description of the water management features within the Tangail CPP. Section 4.4 explains the non-structural plans and section 4.5 the institutional requirements. In the next sections environmental issues and a programme for monitoring and evaluation have been discussed. A selection of possible special studies related to FAP 20 is proposed in section 4.8. Throughout this Chapter reference is made to the proposed implementation alternatives (Figure 4.1).

4.2 Peripheral flood control

From the outset of FAP 20, various interpretations have been given of the extent to which the Tangail peripheral embankment should provide protection against floods, especially whether Tangail CPP would now have to include flood protection to simulate the same type of protection which would have otherwise been provided by the BLE. The same applies for the required "controllability, fish-friendlyness and navigability" of the related structures (gated, partly gated, ungated).

The existing situation provides for some peripheral flood control for the Tangail Compartment. However, in case of a major flood the whole compartment becomes inundated and the level of flooding can not be controlled.

The aim of the peripheral control at compartmental level is that normal (semi-)controlled flooding will continue whereas in case of a major flood the flood water can be kept out (gated structures), or will be reduced (partly ungated structures). Peripheral control is further a prerequisite for controlled drainage from the compartment into the *Iohajang* river.

All **six implementation alternatives** referred to in this chapter (see Figure 4.1) have in common that the implementation schedule for the year 1992-93 is virtually the same. This has the advantage that remaining problems concerning design issues can be solved in time. The basis of each of the alternatives reflects the concerns of the higher authorities, the needs expressed by the beneficiaries and the ideas of the designers.

Figure 4.1 IMPLEMENTATION ALTERNATIVES TANGAIL (PLANNING)

IA	FULL COMPARTMENTALIZATION; ALL PERIPHERAL STRUCTURES GATED WITH THE EXCEPTION OF THE UNGATED OR PARTLY GATED, NAVIGABLE INLET STRUCTURES *LOHAJANG* AND *SADULLAPUR*; LIMITED PERIPHERAL ROAD (20 KM); SOUTHERN EMBANKMENT AS FEEDER ROAD WITH BRIDGES/UNGATED STRUCTURES; FLOW REGULATORS BETWEEN *LOHAJANG* AND SC'S 9, 10 AND 11 ONLY
IB	THE SAME AS IA, BUT ALSO GATED, UNNAVIGABLE INLET STRUCTURES *LOHAJANG* AND *SADULLAPUR*; INCLUDING MOORING FACILITIES (OR LOCK)
IIA	THE SAME AS IA, BUT ALSO INCLUDING FLOW REGULATORS BETWEEN *LOHAJANG* AND REMAINING SUB-COMPARTMENTS
IIB	THE SAME AS IB, BUT ALSO INCLUDING FLOW REGULATORS BETWEEN *lohajang* AND REMAINING SUB-COMPARTMENTS
IIIA	THE SAME AS IIB, BUT WITH CLOSED/REGULATED STRUCTURES ALONG SOUTHERN EMBANKMENT, WITH EXCEPTION OF THE OPEN *LOHAJANG* OUTLET
IIIB	THE SAME AS IIIA, BUT WITH COMPLETE PERIPHERAL ROAD (60 KM)

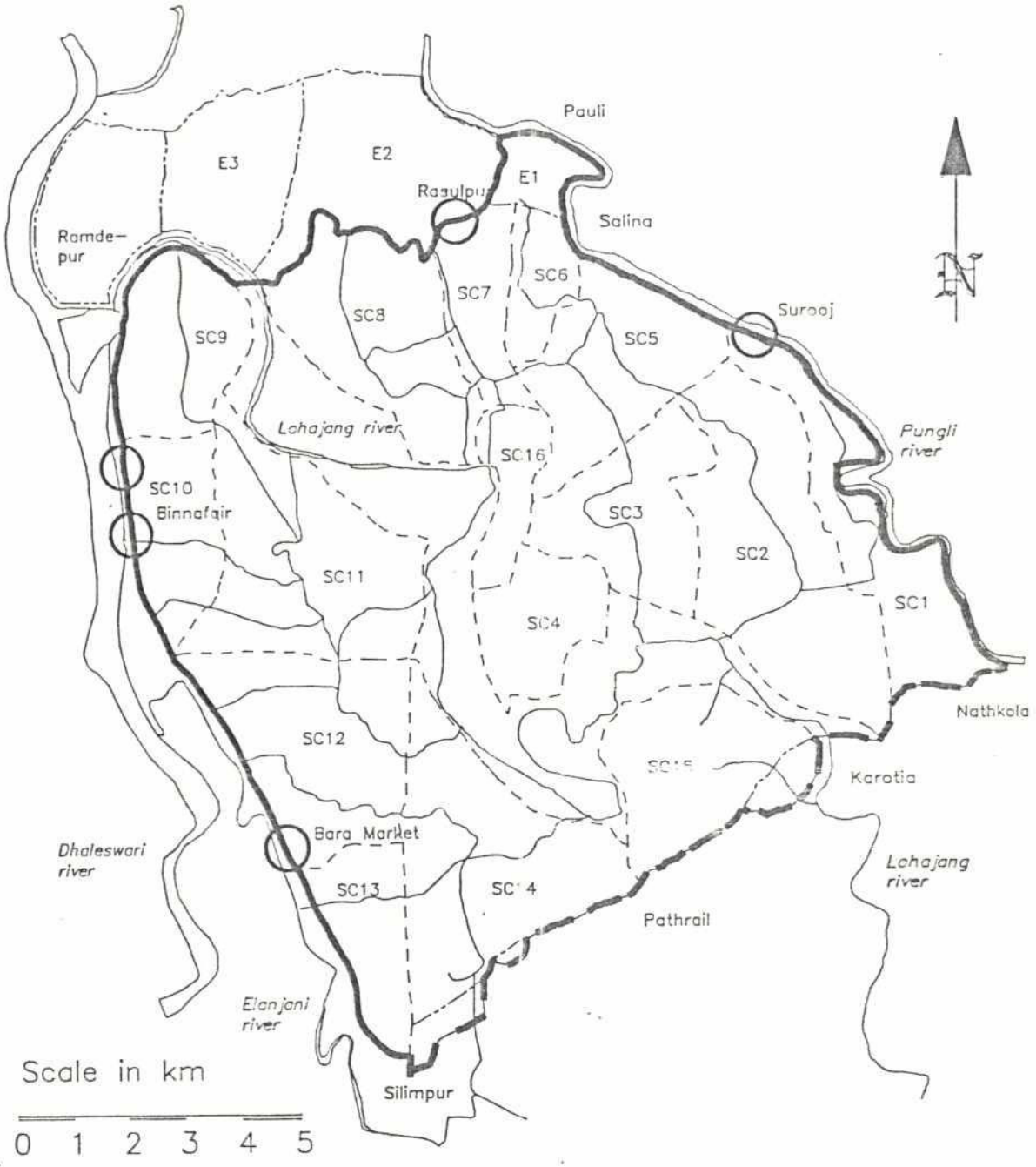
Each implementation alternative includes most of the following construction elements:

- Horse-shoe embankment (4.2.1)
- Emergency spillways (4.2.2)
- Main inlet regulator (4.2.3)
- Medium size inlet regulators (4.2.4)
- Existing inlet structures (4.2.5)
- Closure embankment on the southern side (4.2.6)
- Main outlet regulator or control structures along the *lohajang* (4.2.7)
- Medium and small size outlet regulators (4.2.8)
- Erosion protection works along adjacent rivers (4.2.9)

In the following paragraphs planning and design criteria for these elements have been described.

4.2.1 Horse shoe embankment

The existing peripheral embankment (horse shoe embankment) around the Tangail compartment provides some protection against flooding but it is by no means a secure embankment. Neither will this security be given by the BLE for the years to come (FAP 3). It has also a function for flood free housing and transport (road transport). For that reason it is envisaged that in the future the embankment may function even more as a multi-purpose utility. Road transport and planting of trees on the berm of the embankment will be planned. Further elements are scheduled, such as constructing emergency "bulge" areas along the riverside of the embankment to accommodate people and livestock from outside the embankment during high flood periods. A lumpsum for implementation under the interior water management and mitigation measures has been included (see Figure 4.2).



LEGEND

- Compartment boundary
- Sub-compartment boundary
- Waterway
- Peripheral embankment
- Spillway

Note: Source for geo-data: FAP19.

MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION

COMPARTMENTALIZATION PILOT PROJECT
FAP 20

PERIPHERAL EMBANKMENT

Consultant: Euroconsult, Lahmeyer Intl, Bets Ltd, HCL

Drawn by	Checked by:	Figure/Drawing No
Date:	Date:	4.2

Alignment

The alignment for the upgraded peripheral horseshoe embankment mainly follows the alignment of the existing embankment. Only for the reach where the existing embankment excludes the area E1 and passes straight from Rassulpur to Salina a different alignment as requested by the people is in order to include this area E1 (Pauli) (See Figures 1 in Annex 6). Some realignment might be required.

It is anticipated that a future compartment upstream of the Tangail compartment will be bordered by the *lohajang* river upstream of the main inlet regulator and the *Gala khal* from *Jugini* to Pauli. This border thus provides a connection between the *Dhaleswari* and Pungli rivers. The area E1 can not be managed by this future upstream compartment.

The natural drainage pattern from E1 flows intc sub-compartment 6 which is now blocked by the existing embankment and is giving rise to social problems (ref: MDSCS). See Figure 1 in Annex 6 for more detail.

Minor deviations occur at erosion sites where a retired embankment is suggested.

The peripheral embankment for the Tangail compartment area is divided into the following 4 reaches:

- The reach from Ramdepur in the North to *Silimpur* in the South along the *Dhaleswari* and *Elanjani* rivers. The length of the existing embankment is 70.925-54.300 = 16.625 km

- The reach from Ramdepur in the West to Rasulpur in the East along the *lohajang* river and the *Gala khal*. The length of the existing embankment is 9.600 km

- The reach from Rasulpur via Pauli to Salina along the *Gala khal* and the Pungli river. The length of the existing embankment is 3.600 km (new alignment).

- The reach from Salina to Nathkola along the Pungli river. The length of the existing embankment is 15.530 km.

Details are presented in Figure 4.2

As far as crest levels are concerned it is standard BWDB practice to design interior embankments for floods with a 1:20 years return period with a 90 cm freeboard.

Since at present the embankment also serves for housing this design level would mean the removal of all houses. In this light it has been decided to upgrade only those sections during the 1992/93 construction period which are considered weak. It is proposed to prevent against a **1988 flood with a 30 cm freeboard**. This level corresponds with a 1:7 year return period flood with a 0.90 m freeboard *(Jugini* 13.73 m+PWD).

It is not intended to dislocate the families in existing houses during the 1992/93 constructions period located on the embankment. Realignment or resettlement at a later

stage, however, should not be excluded. Sections that are above the 1988 flood level will not be upgraded, unless required for improving the multi-purpose use of the embankment. Sections that are at imminent danger from river erosion will also be upgraded. (Mainly by means of a retired embankment.)

Sections that are above the design level will be maintained as such. If required the cross-section may be improved.

The gradient (slope level) of the maximum flood level along the *Dhaleswari/Elanjani* has been assessed by FAP-3 as ((13.43 m+PWD - 12.30 m+PWD) / 16.6 km) = 6.8 cm/km embankment. Taking a safety margin into consideration, a slope of 5 cm/km will be adopted for the range along the *Dhaleswari, Elanjani* and Pungli rivers, because a 30 year peak level record *(Jugini)* is only available for the Ramdepur site.

For the reach along the *Lohajang* and the *Gala Khal* from Ramdepur via Rassulpur to Pauli a slope of 0 cm/km will be adopted to account for the extreme flow conditions where the whole floodplain acts as a waterway. This will also account for the expected backwater curve from the location of the main inlet *Lohajang*.

The required design levels in m+PWD at specific locations can be summarized as follows:

LOCATION	1988 FLOOD LEVEL (m+PWD)	FREE BOARD (m)	DESIGN LEVEL (m+PWD)
Ramdepur	13.43	0.30	13.73
Silimpur	12.60	0.30	12.90
Rassulpur	13.43	0.30	13.73
Pauli	13.43	0.30	13.73
Salina	13.31	0.30	13.61
Nathkola	12.53	0.30	12.83

Locations of the borrowpit

The embankment along the *Dhaleswari* and *Elanjani* rivers will possibly be part of the *Brahmaputra* Left Embankment (BLE) for which a design level of 1:100 years may be anticipated. For the *Lohajang* and Pungli rivers and the *Gala khal*, an ultimate design level of 1:20 years may be anticipated. Therefore, the minimum distance between the toe of the embankment and the borrowpit should be more than the standard BWDB berm (6.10 m).

The designs are based on following data:

- 1988 flood level at *Jugini* station: 13.43 m+PWD
- 1:20 years flood level at *Jugini* station: 13.15 m+PWD
- 1:100 years flood level at *Jugini* station: 13.70 m+PWD
- berm as per BWDB standard: 6.10 m.

The following table summarizes the minimum distance between the toe of the embankment and the borrowpit:

River	Minimum Distance	
	River side	Country side
Dhaleswari/Elanjani	9.0 m.	8.0 m.
Lohajang/Gala/Pungli	7.4 m.	6.9 m.

The borrowpit should preferably be located on the river side.

The construction material for the embankment will be mainly nearby available natural material; preferably sandy silt or sandy clay, excavated from the river side of the embankment to prevent loss of agricultural land.

The existing embankment will form a basis for the upgraded embankment unless the first has a highly unfavourable foundation which might exist in closed off *khals*. In this case excavation may be required.

Due to the short duration of high waterlevels sealing is not considered necessary.

The remaining design criteria will comply with standard BWDB practice; so:

- crest width : 4.25 m
- R/S slope : 1:3
- C/S slope : 1:2
- Compaction : 80% of compaction, allowing for 20 % shrinkage of construction height.

It is assumed that the total width of the embankment as per BWDB standard does provide sufficient stability, protection against seepage (1.6 seepage line) and permit road transport without weakening of the embankment. Also new sections of the embankment will follow the standard design criteria.

4.2.2 Emergency Spillways

It is proposed that emergency spillways be integrated in the peripheral embankment for the following reasons:

- They help control the waterlevel within the river during an extreme flood event with a probability that is close to the design event.

- Locally they provide a higher downstream (country side) waterlevel when overtopping of the embankment occurs thus reducing damage during an extreme flood that surpasses the design flood.

These spillways will function only properly if the embankment is maintained upto standard.

The floodplain (of which the Tangail compartment is a part) has an active role in flood management during peak discharges by providing storage and participating in the flow towards the Bay of Bengal. The emergency spillways provide an inflow during extreme floods. The outflow from and/or retention of this flood water within the compartment will be considered as well.

To calculate the total capacity of the spillways it is assumed that in total 10 % of the river discharge would flow into the compartment. An estimate of the 1988 peak discharge serves as a basis.

In summary this would mean the following discharges and capacities:

RIVER	EST.RIVER DISCHARGE 1988 m^3/Sec	REQUIRED SPILL CAPACITY m^3/Sec	SPILL CAPACITY AVAILABLE m^3/Sec	ADDITIONAL SPILL CAPACITY NEEDED m^3 sec
Dhaleswari	1500	150	90	60
Pungli	1000	100	40	60
Elanjani	600	60	30	30

During extreme floods all planned and new inlet structures will be opened. (*Lohajang* main inlet: *Jugini*, Rassulpur, *Sadullapur* and Baruha medium inlet regulators: and the 4 existing structures).

The *Lohajang* river will be controlled by a main inlet regulator. This inlet regulator does provide a spilling capacity for the *Dhaleswari* during extreme floods (see also 4.2.3).

The maximum discharge as depending on the height of the spilling section in relation to the upgraded embankment (1988 flood level plus 0.3 m freeboard) for a width of the spilling section of 100 m. is shown below. The spill section is flowing full and the embankment is just not overtopping. Further more the return period in years is shown when the section will start spilling over:

H SPILL BELOW CREST OF EMBANKMENT (m)	FLOW DEPTH SPILLWAY IN (m)	MAX. DISCHARGE IN m^3/sec/100m	RETURN PERIOD IN YEARS
0.30	0.30	27	45
0.40	0.40	42	35
0.50	0.50	59	25
0.60	**0.60**	**77**	**19**
0.70	0.70	97	14
0.75	0.75	108	12
0.80	0.80	119	10

With a high return period of 35 or 45 years, it is doubtful whether the construction of these sections makes any sense, people will not understand the need for these structures; besides they tend to become more expensive. With a lower return period the construction cost decreases but damage from spilling will increase, in some cases without any real need since the embankment would not have been overtopped anyway. A return period of 20 years is proposed. This issue should be considered at national level. The results may be incorporated in general guidelines for full compartmentalization.

To comply with the capacities for each river along the compartment the following length of spill section is required (with a sill level of 0.60 m below adjacent embankment section):

Dhaleswari : 80 m
Elanjani : 40 m
Pungli : 80 m

For the location of these structures a reasonable distance between the main river channel and the embankment must be maintained.

The following appropriate locations have been identified (see Figure 4.2).

For the **Dhaleswari** river:

- 1.2 km North of the *Binnafair* inlet structure, a reach of about 40 m length has been identified *(Goalpur)*. The water spills into the floodplain at SC10.

- Just North of the *Binnafair* inlet structure, a reach of 40 m length has been identified. The water spills into the Binnafair *khal*.

For the **Pungli** river:

- 0.5 km West of *Rasulpur,* a reach of 40 m length has been identified. The water spills into the floodplain at SC7.

- Just North of the *Suruj khal*, a reach of 40 m length has been identified. The water spills into the *Suruj khal*.

For the ***Elanjani*** river:

- Just North of *Bara* Market a reach of 40 m length has been identified (between SC 12 and SC 13).The water spills onto the floodplain at SC 12.

The emergency spillways will be constructed on the existing embankment as far as its cross-section does not disrupt the required section.

The outline design drawing of the emergency spillways is shown in Figure 9 in Annex 6.1.

4.2.3 Main inlet regulator

4.2.3.1 General

The function of the main inlet regulator is to provide more security and protection for the Tangail compartment during high floods. Maintaining an appropriate waterlevel in the *Lohajang* river, which would facilitate controlled flooding and drainage in the compartment is also possible. Moreover, the main inlet regulator should be controlled and operated, in such a way that it should not be detrimental to fish migration from the main rivers into the floodplain. The actual navigation should also be considered and mitigation measures will be provided if needed. Alternatives are being discussed with the Design Department of BWDB.

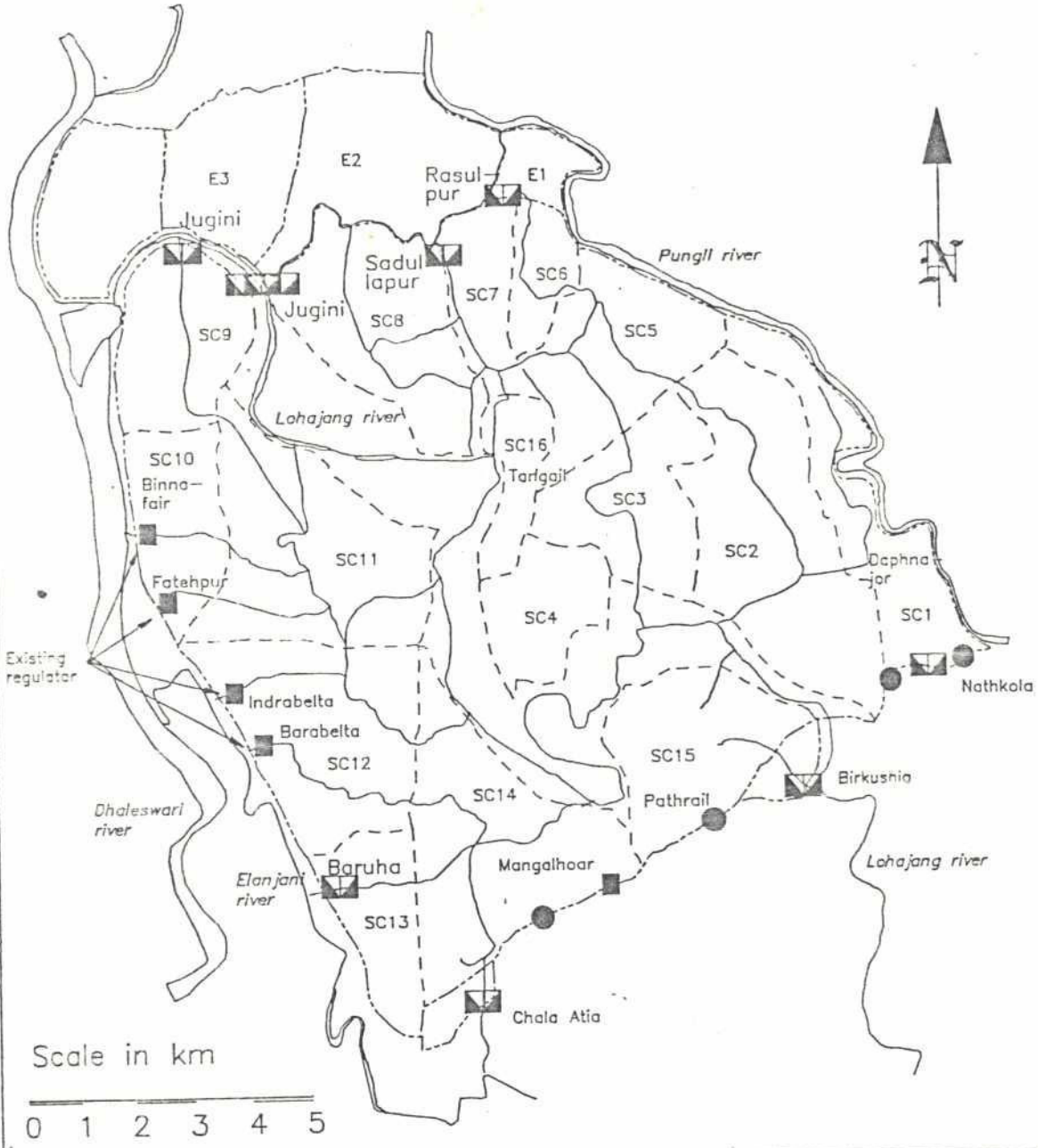
The structure is located 4.5 km downstream from the mouth of the *Lohajang* river just downstream of the *Gala khal* inlet (see Figure 4.3). It will be constructed in a pit on the right bank of the river to permit a 2 year construction period if needed.

The main inlet regulator in the *Lohajang* has a regional function. The head-loss from the discharge through the structure should not be too high for a typical peak flow in the *Lohajang* which is estimated at about 80 m3/s. An 8 vent structure with 1.5 m by 3.0 m vent size, gives this discharge with a headloss over the structure of 0.7 m.

Trial runs with the MIKE11 mathematical model have shown that an increased number of vents does not yield a substantial rise in the downstream waterlevel except for temporary peak discharges. With a smaller number of vents the throttling effect becomes substantial even for the normal discharge (20-50 m^3/sec).

The sill level of the structure has been assessed at 9.5 m+PWD, which corresponds with the bottom level of the *Lohajang* river at the site.

The top-level of the structure is based on the 1 in 50 years return period (13.47 m+PWD at *Jugini)* plus a margin for the ponding effect (0.5 m) and a freeboard for wave action. The BWDB normally adopts 1 m for the latter. An outline design drawing for the main inlet is shown in Figure 10 of Annex 6.1.



LEGEND

- Compartment boundary
- Sub-compartment boundary
- Waterways
- Main inlet structure
- Medium inlet regulator
- Minor inlet regulator
- Controlled drainage outlet

Note: Source for geo-data: FAP19.

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BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION

COMPARTMENTALIZATION PILOT PROJECT
FAP 20

PERIPHERAL STRUCTURES

Consultant: Euroconsult, Lahmeyer Intl, Beta Ltd, HCL

Drawn by	Checked by	Figure/Drawing No
Date:	Date:	4.3

4.2.3.2 Criteria for fish-migration

The following findings are based on the work presented in the preliminary report on design of fish-friendly structures by FAP 17:

- Even ungated structures will have an impact on the migration of fish
- Overshot flow is considered to be more fish-friendly than undershot flow; the latter being especially harmful to fish fry
- Turbulance from undershot gates will be more intensive in comparison with overshot gates. A combination of these two flow types in one structure calls for a down-stream extension of the piers upto a length where uniform sub-critical flow has been established
- Downstream control will be finer and more easily by means of undershot gates
- Control of a downstream water level by means of a combination of fully retracted and fully open gates, may lead to problems of energy dissipation due to unsymmetrical flow downstream
- Gradual downstream energy dissipation is considered less damaging to fish. This will require extensive downstream bed and bank protection.

Combining these findings and pending the outcome of further study, the following lay-out is proposed for the 8 vent main inlet in the *Lohajang* river:

The 6 central vents are undershot gates, the two outer vents are run as free surface vents since there is reason to suppose that fish fry mostly migrate via the slower streams near the banks. The side vents would be the last to be closed and it is proposed that flow in these side vents should be controlled by two part gates. The lower part, 1.5 to 2.0 m high, would be lowered to the bed as a first stage of control so that overshot flow was established. The upper part of the gate would normally be brought down for full closure only. The divide piers for the outer vents are extended to reduce interaction with the turbulence of the undershot gates.

With these conditions, the gate operation can be developed to give the required control of the downstream waterlevel throughout the monsoon season while the impact on the migration of fish fry is limited.

The criteria for navigation may lead to a larger vent/gate size with a reduced number of vents. The concept indicated above will not differ.

4.2.3.3 Criteria for navigation

The *Jugini* market close to the proposed inlet location is a very important landing site. However, navigation of motorized country boats beyond this market is only permitted up to the *Chillabari khal* which is closed (5 km from *Jugini* Market). Therefore, a lock in the main inlet is does not seem to be feasible, but should not be excluded. Further study is needed.

Another possibility would be to combine the middle two openings to allow for continued navigation in about 60-70% of the time. This and other options are being discussed with the BWDB Design Office. Further study is needed on the technical and economic feasibility of various possible solutions.

Proposed mitigation measures for the possible restriction in navigation would be:

- A mooring place at the inlet location where both passengers and goods can be transferred, construction would be in 1993/94;

- Improvement on the existing road between *Jugini* Market and Tangail town.

A detailed assessment of navigation is and around the compartment area is presented in Table 4 of Annex 6.1.

4.2.4 Medium inlet regulators

There are 4 new inlet regulators proposed for peripheral control:
- at *Khorda Jugini*
- at *Rassulpur*
- at *Sadullapur*
- at Baruha

Except for the Baruha regulator these sites are presently open throughout the monsoon season. The function of these medium inlet regulators is to secure the waterlevel inside the compartment and, by maintaining an appropriate waterlevel in the major *khals*, facilitating controlled flooding and drainage in the compartment. The Baruha regulator has been included because it is a prominent *khal* which flooded sub-compartment 13 until recently. According to the local population, both fish migration and navigation should be considered for all these structures.

The location of the regulators is as follows:

- *Sadullapur*: 350 m from the mouth of the *khal*.
- *Rassulpur*: 25 m from the mouth of the *khal*.
- *Jugini*: 250 m from the mouth of the *khal*.
- *Baruha*: 100 m from the mouth of the *khal*.

The location of the structures is given in Figure 4.3.

The capacity of these structures is related to the water requirement within the sub-compartments. Because of the predominantly dynamic flow it is difficult to determine the required capacity of the regulators directly. An estimate has been obtained by assuming the following. The command area must be flooded from zero to 50 % within a three day period with a head-loss over the structure of 0.4 m. This assessment is based on the area elevation curve as presented in Annex 4.

The dimensions of the existing *khals* have also been considered for the assessment of the required capacity. Both for the *Sadullapur* and Baruha regulators a double vent is required to flood the command area according to the criterion indicated above.

The higher capacity of the *Sadullapur* regulator may also be useful because it provides a direct connection from the *Gala khal* and the *Pungli* river via *District khal* to the *Lohajang*. Thus it may be useful for the drainage of the area upstream of the compartment during the post monsoon period.

The sill-level, approximate command area, vent number and size, the approximate 1:50 years highest waterlevel at the structure site (upstream) and an estimate of possible ponding effect are shown below:

location of regulator	sill level (m+PWD)	command area	nr. of vents	vent size (m x m)	1:50 YRS HWL (m+PWD)	ponding (M)
Rassulpur	9.22	SC5&6	1	1.5*3.0	13.47	0.3
Sadullapur	9.50	SC7&8	2	1.5*3.0	13.47	0.3
Jugini	10.62	SC9*0.8	1	1.5*1.8	13.47	0.3
Baruha	9.70	SC13&12*0.5	2	1.5*1.8	12.84	0.1

In line with the design for the main inlet it is proposed that the vents are run as free surface vents and that flow should be controlled by two part gates. The lower part, 1.0 to 1.5 m high, would be lowered to the bed as a first stage of control establishing overshot flow. The upper part of the gate will only be brought down for full closure.

Baruha *khal* is closed, so no navigation takes place at the moment. Both *Jugini* and Rassulpur *khals* have little navigation. However, some non-motorized country boats do use the *Sadullapur khal* and the local population expressed considerable interest in continued navigation. It is therefore suggested to include alternative solutions in the study mentioned in 4.2.3.3 (meanwhile the BWDB Design Office of considers a double opening to allow navigation). If continued navigation will prove to be impossible, the following mitigation measures are proposed:

- A mooring place can be provided at the *Sadullapur* inlet regulator for the transfer of goods from one boat to another.

- A mooring place can be implemented at the bridge at *Gala* Bazar for unloading of goods; the road to Tangail is in good condition.

4.2.5 Existing inlet regulators

There are 4 existing inlet regulators at:

- *Binnafair khal*
- *Fatehpur*

- *Indra Belta*
- *Belta Sarai*

(see Figure 4.3).

The function of these structures is safety during extreme flood events and controlled flooding of the agricultural land. Drawbacks of these structures are as follows:

- The regulators are provided with stop-logs for closure. These are difficult to operate and also tend to disappear which makes the functioning of the structures during extreme floods less secure.

- In the present set-up they do not control the flooding since the lowland is flooded anyway via the *Lohajang*.

- The capacity of the regulators in the *Binnafair khal* and the *Belta Sarai khal* does not meet the requirement as stated in Section 4.2.4. The *Belta Sarai* regulator requires about 12 days and the *Binnafair* regulator about 20 days for the flooding of the command area up to 50 %.

- Fish migration is limited because of the small vent size with an undershot flowtype when high river stages prevail.

- Navigation is impossible whereas formerly the Binnafair *khal* was an important navigation channel.

The capacity of the Fatehpur and Indra Belta regulators is sufficient.

Relevant data of these structures are:

regulator name	sill level m+PWD	command area in ha	vent number	vent size in mXm	1:50 YEARS HWL m--PWD
Binnafair	9.33	1000	1	0.9*1.2	13.12
Fatehpur	9.24	250	1	0.9*1.2	13.07
Indra Belta	9.82	250	1	0.9*1.2	12.92
Belta Sarai	9.82	1000	1	0.9*1.2	12.87

The following actions are proposed for upgrading:

- All existing regulators will be provided with a gate.

- The structures fit in with the proposed structural management measures for compartmentalization. The insufficient capacity of the Binnafair regulator can be compensated by the Kagmari regulator (Section 4.3.1.). The required capacity of the Bara Belta regulator can be compensated by the Baruha regulator.

Unfortunately, the existing structures can not be transformed into regulators with free surface vents. This would benefit both the capacity and the passage of fish.

Re-establishment of the navigation is not considered at this stage.

4.2.6 Southern closure embankment

The function of a southern closure embankment is safety during extreme floods as well as the controlled drainage of the compartment in a south-eastern direction. It remains to be seen whether the southern embankment should be provided with closed/regulated structures. Further consultation and modelling analysis is needed to make a sound judgement.

The southern embankment of the Tangail compartment as defined in the ToR is formed by the unmetalled road between *Nathkola, Karotia, Pathrail* and *Silimpur*.

The following minor deviations in the alignment are proposed

- West of the *Lohajang* river near Karotia it is proposed to include the *Birkushia* chalk. If both the Kumuli *khal* and the *Birkushia khal* can be controlled at the confluence with the *Lohajang* river, then the control of the water level of SC15 will be improved.

- At Atia village three breaches have been repaired by a new embankment section just south of the old embankment. It is proposed to follow this new alignment.

- At *Silimpur* the *Chal Atia khal* flows out of the compartment to enter it again 1 km downstream. This is difficult to control and it is therefore proposed to change the alignment in a southern direction to include the *Atia Hinganagar khal*.

Details are given in Figure 4.2

Crest level

The crest level of the southern embankment is related to the crest level of the horse shoe embankment, the level of the proposed emergency sections and the expected backwater level in the *Lohajang* with the main inlet fully closed. This simulates a flood situation with a higher probability than 1:20 years.

The following levels are relevant:

	Design level m+PWD	Spilling level m+PWD
Ramdepur:	13.73	13.13
Silimpur:	12.90	12.30
Nathkola:	12.53	11.93

In order to assess the influence from the back water curve at Karotia, the 1987 flood data have been used. The highest level at Ramdepur was 12.95 m+PWD in 87. With the main inlet regulator closed, the highest waterlevel at Karotia was 10.8 m+PWD as based on model data. It is estimated that when the waterlevel at the main inlet reaches 13.13 m+PWD (spilling level of the emergency sections) the waterlevel at Karotia will be around 11.00 m+PWD. Taking the same margin between the spill level and the design level the embankment height at Karotia should be 11.00 + 0.60 = 11.60 m+PWD.

The southern embankment can be devided into 3 reaches:

- From Nathkola to Karotia; the waterlevel is fully dependant on the waterlevel in the Pungli. A zero gradient is assumed over the downstream floodplain. The required design level will be 12.53 m+PWD over the whole section.

- From Karotia to *Pathrail* up to the road from *Pathrail* to *Delduar* the water level is dependant on the waterlevel in the *Lohajang* river. A zero gradient is assumed over the downstream floodplain. The required design level is 11.60 m+PWD over the whole section. The crest level from *Pathrail* to *Karatia* can be lower because flooding from the Pungli is controlled by the road. *Tangail/Karatia/Dhaka* and flooding from the *Elanjani* is controlled by the road *Tangail/Pathrail/Delduar*.

- From *Pathrail* to *Silimpur* the waterlevel is dependant on the waterlevel in the *Elanjani* river. A zero gradient is assumed over the downstream floodplain. The required design level is 12.90 m+PWD over the whole section.

The drop in the embankment level between *Karatia* and *Pathrail* is justified by the main road Tangail, *Karatia, Mirzapur* which protects against flooding from the *Pungli* river and by the road Tangail, *Pathrail, Delduar* which protects against flooding from the *Elanjani* river.

The possible upgrading of this embankment will be taken up during the 1993/94 construction period, pending further surveys, consultation and studies.

The construction of emergency sections is not considered necessary. It would apply to the sub-compartments 1 and 2, 14 and 15. These are most efficiently flooded by the *Suruj* emergency spillways and the *Lohajang* main inlet regulator.

The berm will comply with standard BWDB practice: 6.10 m on either side of the embankment.

It is proposed that the slope of the embankment will be 1:2 on either side. With a compartment at Tangail only, the "riverside" will be in the South; when a compartment will also be constructed in the South, then the "riverside" will be north of the embankment. The steeper slope may save valuable agricultural land.

Further design criteria will be identical to the horse shoe embankment as assessed in section 4.2.1.

- crest width : 4.25 m
- compaction : allow for 20 % shrinkage.

The embankment does also serve as an non-metalled feder road.

4.2.7 Main outlet regulator

The principal function of the main outlet regulator would be safety during extreme floods. It may also serve to store water in the compartment when closed but this function is not considered relevant for the Tangail CPP.

Drawbacks of this structure are as follows:

- The structure must be very wide, and will be very costly, if it has to be designed to not have a back water effect. That effect would partly nullify the purpose of the main inlet regulator.

- Navigation will be hampered.

- Fish migration will be hampered.

The safety during exteme floods may also be provided by a series of regulators between the *Lohajang* and the sub-compartments that have to be provided anyway for control of the waterlevel within the compartment. This will not reduce the effect of the inlet regulator.

It is therefore proposed that the main outlet regulator be replaced by a series of medium regulators between the *Lohajang* river and the adjacent sub-compartments. This implies that the embankment along the *Lohajang* downstream of the inlet regulator has to be upgraded partially. Since the *Lohajang* embankment has not yet been surveyed, approximate data will be used for costing purposes. Design criteria will be prepared in the coming year.

4.2.8 Other outlet structures

The function of medium and minor outlet regulators is safety during extreme flood events and controlled drainage of the compartment into the southern adjacent areas.

Possibly, only a series of bridges and culverts have to be implemented. Otherwise, the following elements are considered necessary:

- **Structures in the embankment along SC 1**

  Three bridges are planned of 30, 15 and 25 m width respectively. The maximum discharge from the upstream area is about 2.3 m^3/sec (ref section 4.2.2.; based on 79 mm/day during the monsoon).

  The outlet just west of the road to Daphnajor must be closed with a 1 vent gate with vent size 1.5x1.80 m^2. The sill level will be 8.00 m+PWD.

  The other outlets will be controlled with a 0.60 m diameter controlled drainage outlet.

- **Structures in the embankment along SC 15**

  The outlet of the *Birkushia khal* will be regulated by a 1 vent gated structure with vent size 1.50x1.80 m^2; sill level will be 8.26 m (ref section 4.1.2.; based on 79 mm/day or 3.2 m^3/sec).

  The outlet at *Pathrail*/Nalsanda will be controlled with a 0.60 m diameter controlled drainage outlet.

- **Structures in the embankment along SC 14**

  One culvert and a breach just west of the road to *Delduar* will be replaced by a regulator. The drainage area is about 110 ha with a design runoff of 79 mm/day during full monsoon; the design discharge will be 1 m^3/sec. A standard 1 vent regulator (vent size 0.90x1.20 m^2) is necessary.

  A culvert at Mangalhor/Atia will be replaced by a 0.90 m diameter controlled drainage outlet.

  A breach in the embankment at Atia will be closed.

  A standard 1 vent regulator (vent size 1.50x1.80 m^2) is needed on the new alignment of the southern embankment at the outflow of Chala Atia *khal* into the adjacent SC 6 at Chala Atia.

All the proposed structures should be able to pass flow in two directions (drainage-cum-flushing sluices).

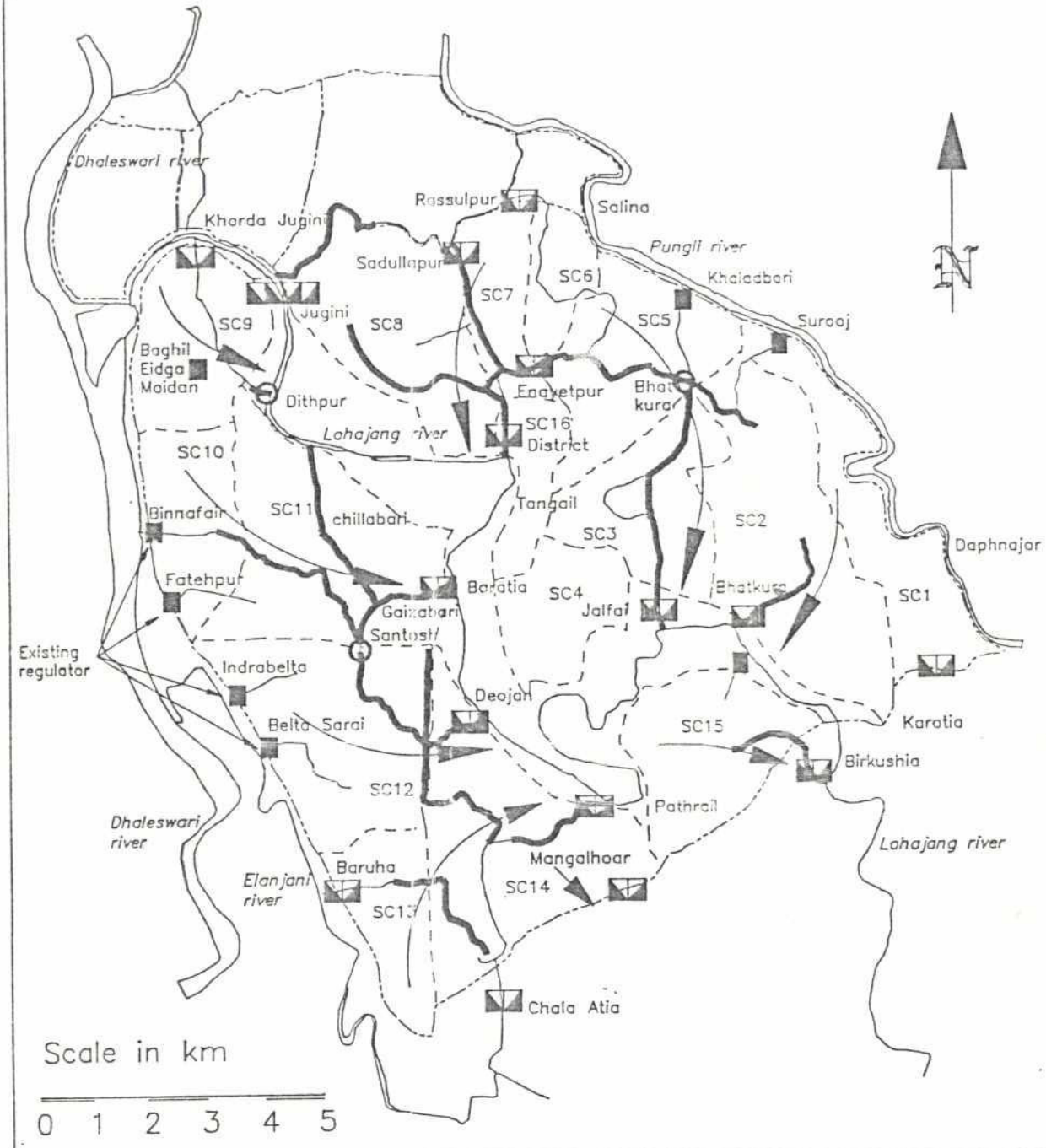
The potential location of the proposed structures is presented in Figure 4.4.

Details of all planned structures are presented in Table 2 of Annex 6.1.

4.2.9 Erosion protection measures

At the following sites erosion protection works at the peripheral embankment have been studied. At all sites a retired embankment with eventually a milder slope of the embankment with simple protection works have been proposed and are now being processed for tendering.

- *Dhaleswari* river.
  - Sibpur.
- *Elanjani* river.
  - Guni Kishore.
  - Baruha.
  - Bara Belta.
- Pungli river.
  - Salina.
  - Passbetor.
  - Khalat bari.
  - Birnahali.



LEGEND

- Compartment boundary
- Sub–compartment boundary
- Waterway
- Khal excavation
- Main inlet structure
- Medium inlet regulator
- Minor inlet regulator
- Weir/outlet

Note: Source for geo–data: FAP19.

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FLOW REGULATION

Consultant: Euroconsult, Lahmeyer Int'l, Beta Ltd, HCL

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Date:	Date:	4.4

4.2.10 Mitigation measures

Upstream areas

The areas upstream of the compartment will only be affected during peak discharges of the river system. During the pre-monsoon the *khals* and rivers are dry and any rainfall discharge can drain out via the *Gala khal*, the *Lohajang* and the *Sadullapur khal*. During the post-monsoon the same waterways can be used for drainage.

During peak discharges of the river system the ponding effect at the *Lohajang* main inlet and at the *Sadullapur* inlet is expected to be around 30 cm when these inlets will be closed during extreme flood events (4.5 km 0.06 m/km being the mean gradient in the *Lohajang*) when the inlets can not be closed, the ponding effect will be less.

This will mostly effect the areas E2 and E3 close to the compartment (region *Gala* and *Failar Ghona*). At *Malancho* along the *Dhaleswari* river and at *Bara Basalia* along the Pungli, this ponding effect will be greatly reduced because of vicinity to the rivers.

The area E1 will be included in the compartment. The area E4 is not protected and is part of the *Dhaleswari* flood plain.

It is proposed that the need for mitigation measures as induced by the compartmentalization project will be further discussed with the local population in the areas E2 and E3. These mitigation measures may include the raising of house plinths for affected households or the provision of shelter areas with a safe water supply for larger communities as well as raising the crest level of roads.

During the consultation process local people asked for the *Gala khal* to be re-excavated. It is expected that the peak water level in E2 & E3 will be even higher with this measure. However, drainage will be more efficient. It may further be beneficial to prevent sedimentation upstream of the main inlet in the *Lohajang* at *Jugini,* by excavation. This proposed excavation needs a very careful examination before actual implementation.

For costing purposes a lumpsum has been proposed.

Downstream areas

It is not expected that the downstream areas will be negatively affected by the Tangail compartment by the occurrence of higher water levels. Because mitigation might be required for other aspects (e.g. marketing, navigation, fisheries environment) a lumpsum has been included.

4.3 Water management within the compartment

4.3.1 General

For the planning of the water management inside the compartment the input from the MDSC survey has been most helpful. The majority of suggestion has been taken into account in the planning.

The peripheral flood control system does provide increased security during high flood situations and permits a lowering of the waterlevel in the sub-compartments closest to the main inlet by lowering the waterlevel in the *Lohajang* river. The water level in the sub-compartments 1, 2, 3, 4 and 15 is hardly reduced by the main inlet as indicated by the mathematical model (Ref. Annex 4).

The aim of the interior water management system is that the water availability can be influenced (within certain limits) to match the water requirements more satisfactory. These requirements differ in time and per area as well as per water users group.

The water availability differs through the season as well as from year to year. It will not be possible to maintain optimum waterlevels within the sub-compartment to its full extent. However, the interior watermanagement system should be such that it can cope with different situations and optimize water availability. To test this is one of the main objectives of the CPP. This would also include the possibility that the existing situation be more or less simulated within the pilot area through the opening of all gates.

There are some general principles that have been applied to support controlled flooding and drainage:

- reduce the length of the channels within the compartment,
- control the flow at the outfall of the channels,
- improve the capacity of the channels (if so required),
- improve management capacity and consistency with regard to flood control and drainage.

These four principles have been taken into account in the next sections.

4.3.2 Flow regulators

The existing situation is such that flood or rain water at SC 9 will flow via *khals* and *beels* into SC 14 before it may be drained into the *Lohajang* river. The same applies for the eastern compartment part where water from SC 8 will ultimately drain out via SC 2.

In order to improve on this situation the following general measures are proposed:

- **Eastern part of the compartment (SC 8 & E1)**

  The long drainage pattern from SC 8 onto SC 2 and 3 will be interrupted at *Enayetpur* by a regulator. It is possible to force the flow from the *Sadullapur khal* and from SC 7 and 8 out into the *Lohajang* river via the District *khal*.

  The outflow of the District *khal* into the *Lohajang* will be regulated by a 2 vent regulator (this capacity is based on the 2 vent inlet regulator at *Sadullapur*, see section 4.2.4).

  The flow from the areas E1 and SC 6-1 can not be re-directed towards the *Lohajang* river or the non-controlled *Pungli* river and has to be drained via the SC 2 and 3 via 2 regulators at *Jalfai* and *Bhatkura*.

At a later stage it may be considered to provide controlled drainage outlets at the interface of E1 with SC 6 at *Salina* and at the interface of SC 5 with SC 2 and SC 3 at *Garinda*. These should be submersible weirs that maintain a higher water level during the monsoon while drainage during pre- and post-monsoon may pass at a lower waterlevel.

Details are given in Figure 4.4.

- **Western part of the compartment (SC 9 15)**

The long drainage pattern from SC 9 onto SC 14 may be interrupted as follows:

SC 9 will have a medium inlet regulator at *Jugini* (ref section 4.2.4) and an outlet regulator at *Dithpur*. Flow into SC 10 will be controlled.

SC 10 has 2 existing inlet regulators at *Binnafair* and at *Fatehpur* (ref section 4.2.4). The outlet from SC 10 and SC 11 into the *Lohajang* will be regulated at *Kagmari*. The flow into SC 12 will be regulated by a submersible weir that retains water during monsoon while drainage during pre-and post- monsoon may pass at a lower level.

The SC 12 has existing inlets at *Indra Belta* and at *Belta Sarai*; SC 13 will have an inlet regulator at *Baruha*. Outlet from the SC 12, 13 and 14 will be regulated at *Baratia (Binnafair khal)* and at *Deojan (Deojan khal)*.

SC 15 is isolated from the other sub-compartments. Proper control may be achieved by an inlet regulator at *Kumuli* and an outlet regulator near the *Lohajang* at *Birkushia*. The outlet into E7 will be controlled at *Pathrail/Nalsanda*.

The required capacities, sill levels etc. will be based on the calculations made for the drainage channels as presented in the next section.

The relevant design data are summarized in Table 2 of Annex 6.1.

4.3.3 Channel capacity

The channels within the compartment will be used for both controlled drainage and flooding. The channel capacity is determined by the drainage requirement.

There are 3 distinct periods for drainage:

- **Pre-monsoon**; this period is typified by runoff from rainfall with low riverstages. The aim is that the fields, especially the low lying ones, do not inundate till after the Boro harvest which is finished by early to mid June.

  The 10 day maximum rainfall for the pre-monsoon period with a return period of 5 years may cause a flooding of 3 days duration. Allowing for a storage on the field of 150 mm (Boro crop cultivation), the drainage criterium will be 27 mm/day; maximum rise will be 165 mm.

NOTE: The standard design run-off rate for drainage systems in Bangladesh indicates a run-off rate of 25 mm/day (1.0 inch/day) for the Tangail area.

- **Monsoon**: this period is typified by overland flow from rainfall and riverspilling. With compartmentalization, the situation of excessive rainfall over a partly flooded compartment must be better controlled. The drainage is dependant on downstream river stages and the capacity is determined by the cross-sections and gradients of the *khal* and its structures. In case of overland flow through a *beel* area, the capacity of culverts/breaches will limit the discharge.

  Due to the higher outside riverstages the criterion as mentioned above) is not considered relevant for the low lying areas. The drainage should aim at a more or less stable waterlevel within the compartment regardless of the extreme rainfall. The three day max monsoon rainfall 1 in 5 years without additional surface storage gives a drainage criterium of 238/3 = 79 mm/day. Actual drainage is dependant on the waterlevel in the *Lohajang* river. The lowest monsoon waterlevel that still satisfies this criterium with channel dimensions as required for the pre-monsoon discharge will be indicated (ref Table 1 in Annex 6).

- **Post-monsoon**; this period is typified by low river stages. This period is not critical if the drainage criterium during the pre-monsoon is met.

For channel design, a first assessment of regime channel dimensions has been determined and is presented as follows:

Q	f	ss	D	B	s
15	0.4	1.5	2.12	10.75	4
12.5	0.4	1.5	2.03	9.51	4
10	0.4	1.5	1.92	8.10	4
7.5	0.4	1.5	1.79	6.55	5
6	0.4	1.5	1.72	5.43	5
4	0.4	1.5	1.60	3.73	5
3	0.4	1.25	1.41	3.71	5
2	0.4	1.0	1.24	3.21	6

In which:

Q: discharge in m3/s
f: Lacey's silt factor.
ss: side slope.
D: water depth in m.
B: channel bottom width in m.
s : gradient in cm/km.

These dimensions have been used as a reference only. The existing channel dimensions have also been considered. (ref. Annex 1.2). The channel dimensions as required during the three different periods are summarized in Table 1 of Annex 6.1. Approximate waterlevels in *beel* and char areas during pre-monsoon in combination with the limiting outflow section, mostly *khals*, form the basis for this assessment.

The excavation of the required bottom level of a *khal* should not extend into the *beel* area itself since this would drain the *beel* proper which is not intended. Only the flow over the rim of the *beel* shall be collected by the *khal*.

4.3.4 Water retention

It has been indicated in section 3.2.3 that water retention will be useful both during a situation of excessive rainfall as well as during a situation of too little rainfall.

On the compartment level there are some areas that are distinctly higher than the adjacent areas. A marked example is SC9 for which the separation from SC10 has already been proposed in section 4.3.2.

Further areas that are higher than the adjacent land are:

- the northern part of SC 8,
- the northern part of SC 1,
- the northern part of SC 7,
- the western part of SC 10,
- the western part of SC 12,
- the south-western part of SC 13.

The problem with water retention at this scale is that the land close to the retaining embankment/structures will be inundated too deep before any effect may be achieved in the higher land.

Water retention is therefore only effective if marginal bunds of a height of 20 to 30 cm are constructed and maintained on all non-flooded farmland. Because most farmland is cultivated under irrigated Boro during the dry season, these water retention works are potentially available.

These existing bunds however, are not completely satisfactory for the wet season for the following reasons:

- the height of the bunds is very limited (modest irrigation gift)
- there is hardly any provision for run-off from the fields.

Because of the annual flooding of the compartment the need for water retention is hardly recognized at present and consequently there is no maintenance of this system in the wet season.

In order to make these bunds effective during the wet season they should be higher (30 cm) and stronger and overflow facilities (e.g. overflow at 20 cm inundation level depending on crop status) should be provided on the farm level.

It is proposed that these works are taken up as extension services activities based on actual field trials in SC 9, 10 and 11 during 1993, in which the DAE will be involved.

4.3.5 Irrigation

Irrigation is required both during the dry and the wet season.

The 4 out of 5 year 3 day maximum waterlevel at *Jugini* during this period is (m+PWD):

Month Decade	1st	2nd	3rd
August	11.48	11.25	11.24
September	11.09	11.19	11.04

A waterlevel of about 11.00 m+PWD may be considered (neglecting the obvious correlation between low rainfall and low waterlevels).

A head loss of 0.50 m only between the river and the field permits to irrigate those areas under gravity that are lower than 10.5 m+PWD at SC 9.

Assuming a slope of 5 cm/km along the *Dhaleswari* and Pungli rivers and no slope along the *Gala khal,* the field level at *Silimpur (Elanjani)* must be lower than 9.67 m+PWD and the level at Nathkola (Pungli) lower than 9.60 m+PWD.

It is not possible to irrigate any of the high areas indicated in Section 4.3.4.

However, there are several relatively lower areas along the *Dhaleswari, Elanjani* and Pungli rivers that may be irrigated. The areas along the *Dhaleswari* and *Elanjani* rivers are already served by the existing and newly planned regulators (Existing structures 1 to 4 and *Jugini* and Baruha regulators).

Along the Pungli river, four sites have been identified with approximate command area:

- in E1 just upstream of Salina (50 ha).
- in SC 5 at *Khaladbari* (100 ha)
- in SC 1 at Suruuj for the irrigation of SC 2 (400 ha).
- in SC 1 at Daphnajor (200 ha)

Based on a water requirement of 15 mm/day (ETc + percolation losses + conveyance losses), the required capacity is about 0.2 m^3/sec/100 ha.

A detailed assessment of costs and expected benefits for these structures is needed before implementation.

Wet season tubewell irrigation

For the higher areas the temporary installation of tubewells for supplemental irrigation seems a good alternative for the irrigation inlets. The tubewell pumps can be reinstalled within a day. There are no investment costs required and it may be expected that the groundwater will be recharged during the wet season. However, it has been found that irrigation by tubewells during the wet season is not practised. The main constraints for the implementation of wet season tube-well irrigation are apparently related to contracts with the electricity supplier.

In the future development of the Tangail CPP, the introduction of low lift pumps might be an alternative for supplementary irrigation. This possibility needs further investigation.

4.3.6 Water management in sub compartments 9, 10 and 11

For the water management requirements within the sub-compartments, the waterlevels at which spilling from *beel* areas starts during the pre-monsoon period and during the monsoon period have been assessed. These are presented in Figure 4.5.

A marked difference can be observed between the level of the *beel* areas from SC 9 (10.1 m+PWD) and SC 10/11 (mostly 9.4 to 9.0 m+PWD). Apart from the differentiation between the SC 9 and the SC 10/11 there is no obvious reason to differentiate the waterlevels within these sub-compartments since the water levels represent a natural gradient in the land between the *Dhaleswari* and the *Lohajang*.

The following problems have to be solved:

- The natural outflow from the *Dithpur beel* (SC 9) into the *Singarkona beel*. This is blocked. A new channel reach from the *Dithpur beel* towards the *Lohajang* is needed, including a stepped outlet regulator near the *Lohajang* and a new embankment section just along the *Lohajang* from *Dithpur* to *Jugini* gath. These have already been proposed in Section 4.3.2

- There is no provision for the pre-monsoon drainage from the *Singarkona beel*. An existing channel of about 900 m length towards the *Lohajang* should be excavated with seperate a 0.60 m diameter drainage outlet just downstream of the *Dithpur* regulator.

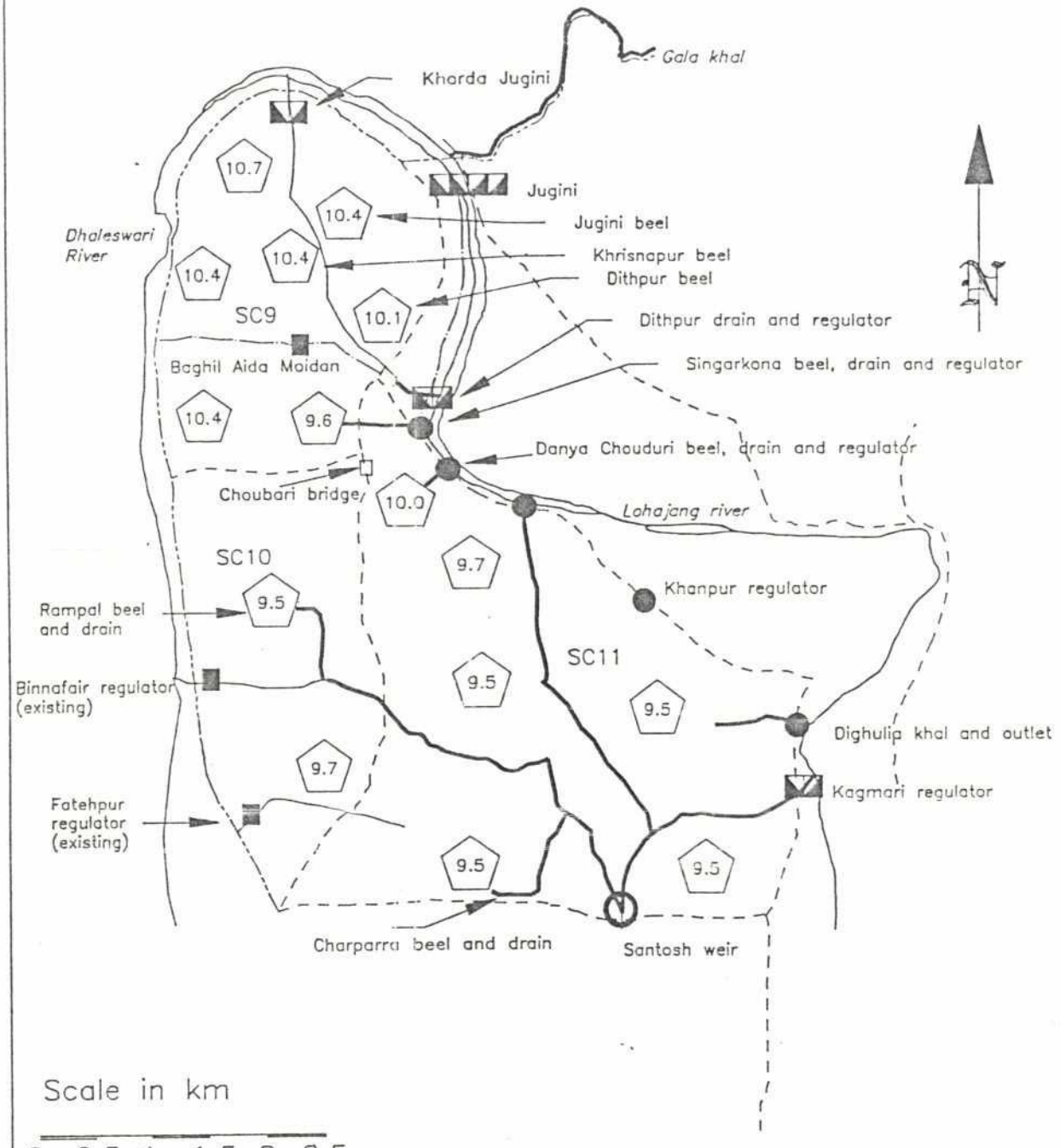
- The connection between SC 9 and SC 10 can be re-activated by means of a regulator at *Beel Baghil Eidga Moidan* in order to flood the *Singarkona beel* area during drought. A 0.30 m diameter drainage regulator is proposed. The sill level should be below 11.0 m+PWD.

- The drainage of the *Rampal beel* passes via a minor channel *(Rampal khal)* into the *Binnafair khal*. This *khal* should be reexcavated. The length of the *Rampal khal* is about 940 m, the bottom level should be 8.85 m+PWD and the bed width is 3 m.

- The drainage of the *Charparra beel* at *Chota Binnafair* passes onto SC12 at *Rackit Belta* (overland flow). The land level is too high for pre-monsoon drainage. It is proposed that a connection be made between this *beel* area and the *Binnafair khal* via the borrowpit of the *Santosh* road. The length of the channel is 850 m, bottom level will be 8.75 m+PWD and channel width 4 m.

- The *Danya Chowdury khal* is a minor channel that drains the *Danya Chowdury beel* towards the *Lohajang* river. The outlet should be regulated by a 0.60 m diameter drainage outlet.

- The *Dighulia khal* is a minor *khal* connected with the *Lohajang* just upstream of the *Gaziabari khal*. Since the *Gaziabari* outlet will be controlled, the *Dighulia* outlet will be controlled as well. A 0.60 m diameter drainage outlet is proposed.



LEGEND

- Compartment boundary
- Sub-compartment boundary
- Waterway / (re)-excavation
- Embankment/road
- Main inlet structure
- Medium regulator
- Minor regulator / irrigation inlet
- Controlled drainage outlet
- Weir/outlet
- Bridge
- Beel area & pre-monsoon waterlevel

Note: Source for geo-data: FAP19.

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IMPLEMENTATION LAY-OUT
SC 9, 10 AND 11

Consultant: Euroconsult, Lahmeyer Intl, Beta Ltd, HCL

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Date:	Date:	4.5

- One bridge culvert is proposed at *Choubari* on the *Danya Choudury* road which formes the divide between SC 10 and SC 11.

- There are 5 culverts in the *Santosh* road between SC 11 and SC 12. It is proposed to raise the sill level of three culverts to enable flow between SC 11 and 12, only during extreme rainfall or floods.

- There are 6 culverts between SC 11 and the *Lohajang* serving overland flow. It is proposed that these culverts will be closed.

4.3.7 Water management in sub-compartments 12, 13 and 14

The waterlevels of the *beel* areas within sub-compartments 12,13 and 14 are quite uniform with a natural gradient from sub-compartment 13 and 12 towards 14. (See also Figure 4.6).

After the implementation of structures along the periphery of sub-compartments 12, 13 and 14, the following problems remain to be solved:

- There is no link channel from *Panibanda beel* and the *Santosh* chalk to the *Binnafair khal*. For pre-monsoon discharge a channel of 300 m length is required; further details are given in Table 1 in Annex 6.1.

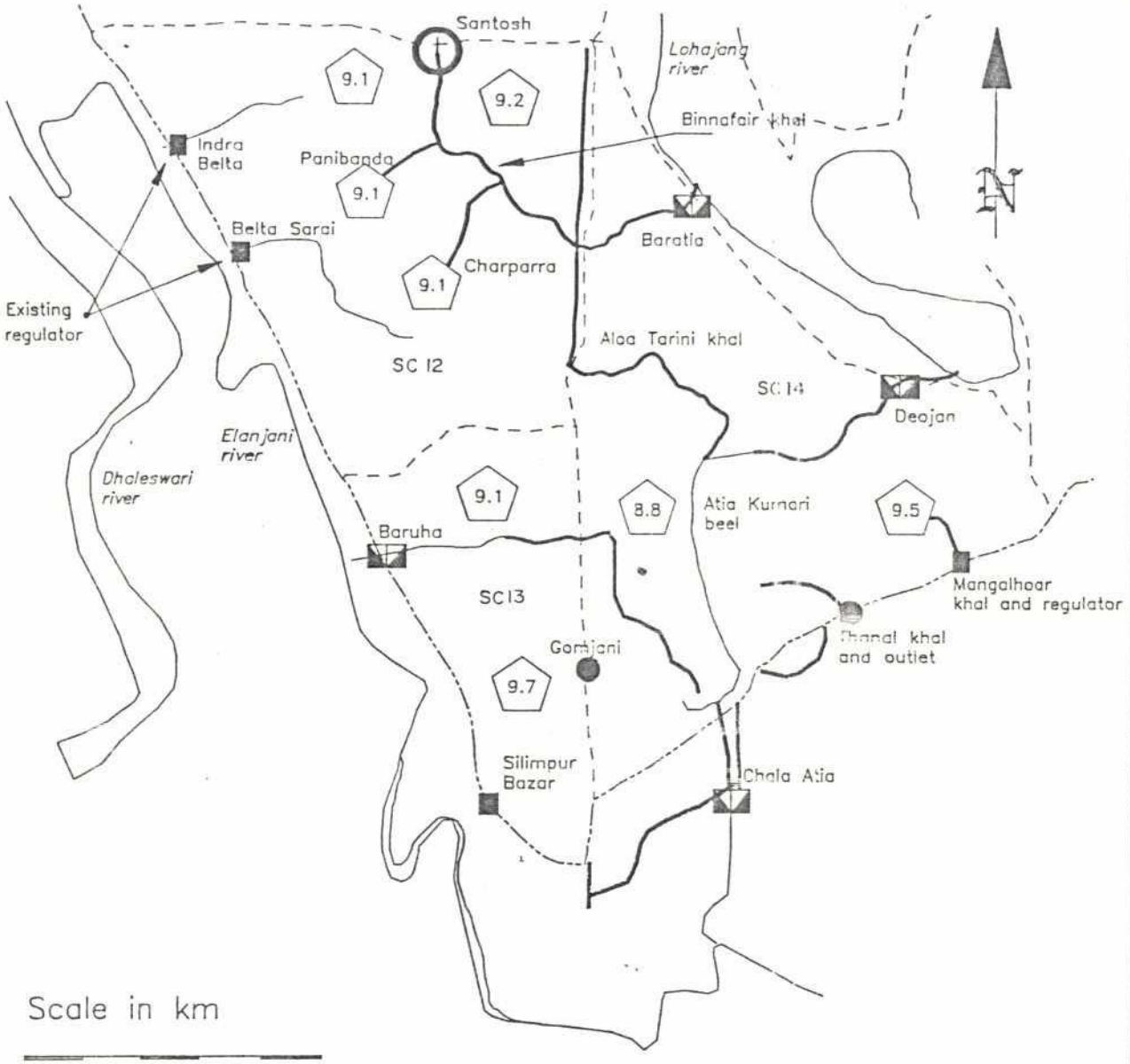
- There is no link channel from *Charpara beel* to the *Binnafair khal*. A channel of 800 m length is required; details are presented in Table 1 in Annex 6.1.

- During the peak monsoon, overland flow from SC 14 enters into the low pockets of SC 13 through the pipe culvert on the main road near the *Gomjani* Primary School. Though it is expected that high flood levels will be reduced, the culvert may eventually be replaced by a controlled drainage outlet.

- The existing culvert near *Silimpur* bazar is proposed to be replaced by a 0.60 m pipe culvert for proper control of flood water.

- SC 14 drains partly on the Nanduria *beel* in SC E6 through the *Thanal khal, Chala Atia khal* and the *Mongalhaor khal* passing through *Dosaiga*. These *khals* need re-excavation. This work will be postponed until proper planning is finalized for area E6 which is outside of the project area.

- The drainage problem in the southern part of SC 14 is related to the construction of roads without provision for culverts or bridges. A total of 4 bridges is needed in the *Bandarbari-Kumari* road and the *Mongalhaor* to *Dosaiga* road.



LEGEND

- Compartment boundary
- Sub-compartment boundary
- Waterway / (re)-excavation
- Embankment/road
- Main inlet structure
- Medium regulator
- Minor regulator / irrigation inlet
- Controlled drainage outlet
- Weir/outlet
- Bridge
- Beel area & pre-monsoon waterlevel

Note: Source for geo-data: FAP19.

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IMPLEMENTATION LAY-OUT
SC 12, 13 AND 14

Consultant: Euroconsult, Lahmeyer Intl, Betz Ltd, HCL

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Date:	Date:	4.6

4.3.8 Water management in sub-compartment 15

SC 15 is isolated from the other sub-compartments (see Figure 4.7). The area is relatively high. The drainage is mainly directed into the *Lohajang* at *Birkushia* in the South-East. Part of the surface runoff is directed towards area E7 at *Pathrail*. Apart from the measures proposed under peripheral control the following interventions are also required:

- In order to drain the *Akendapara* area, a link channel to *Birkushia* through *Gopalpur* is required; the length is 600 m.

- In order to regulate the waterlevel at *Khagjani* a seperate link canal from *Khagjana* to *Fusuki* of 750 m length is required. This canal should be complemented with an irrigation inlet at *Fusuki* to take in water from the *Lohajang*.

- The existing culvert at the outfall of *Pathrail khal* near the *Lohajang* river, should be replaced by a 1 vent regulator.

- To enhance road transport, 5 bridges are planned.

4.3.9 Water management in E1 and sub-compartments 1 to 8

The water levels at which spilling starts in the *beels* within the areas E1 and SC 8 towards SC 2, 3 and 4 show a natural gradient. (See Figures 4.8 and 4.9).

By means of a regulator at *Enayetpur*, the discharge from SC 8 and SC 7 can be re-directed towards the *Lohajang*. At the intersection of E1 and SC 6 and at the intersection of SC 5, SC 3 and SC 2 some water retention during the monsoon season will be provided by means of a combined weir/drainage outlet.

The following problems will be tackled as well:

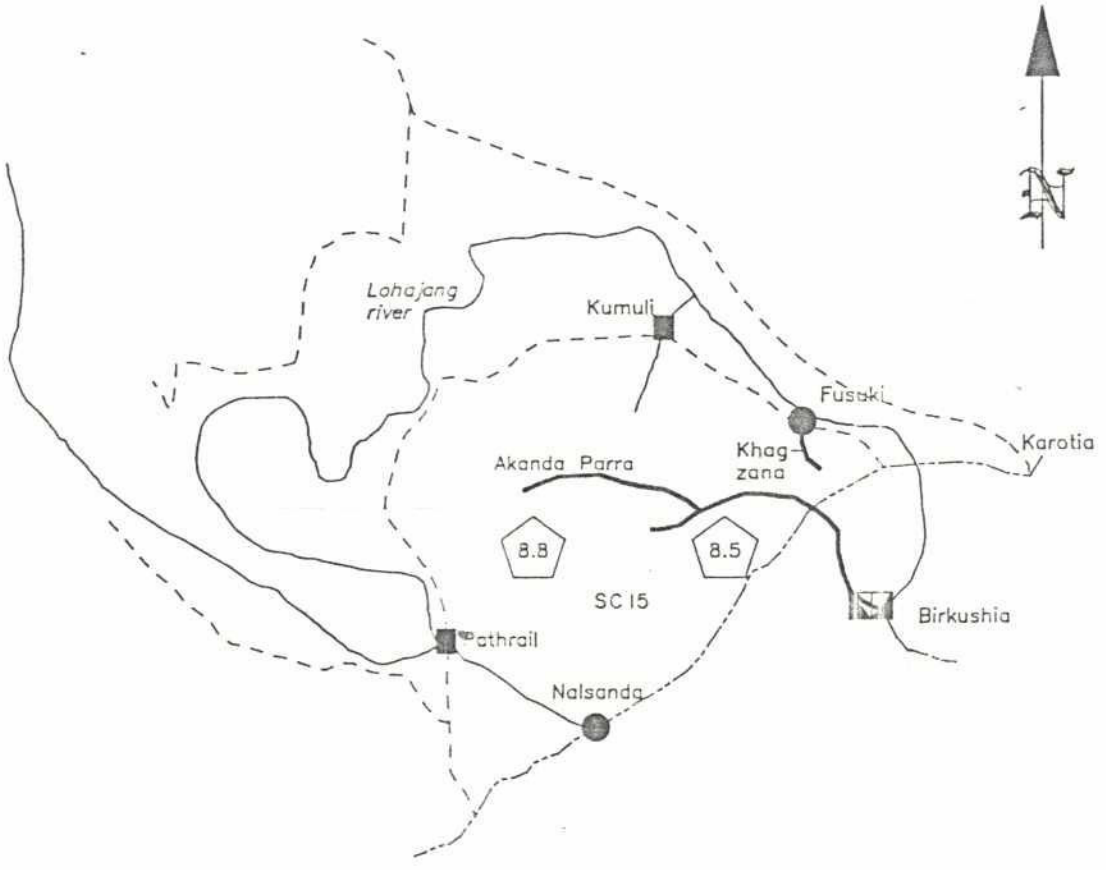
- During high river stages, the *Lohajang* river bank is overspilled and flood water enters SC 8 through 3 breaches in the western embankment of the sub-compartment.

  In order to prevent drainage congestion in the *Lohajang* floodplain at Bamail, it is proposed that the alignment of the embankment will follow the road from *Kagmara* via *Laujana* and *Konabari* to Pichuria. This section will be upgraded.

- One bridge will be constructed in the *Baniabari* road near *Batenda* school to safeguard proper flow of water and road communication in SC 8.

- A link canal is needed in SC 5 from *Sibpur* chalk to the *Barshilla beel* of (0.5 km) for reventing drainage congestion.

- A link channel is required in SC 5 from Ag *Bikramhati* to *Borai-lake* of (1 km) for preventing drainage congestion.



Scale in km

0 0.5 1 1.5 2 2.5

LEGEND

- Compartment boundary
- Sub-compartment boundary
- Waterway / (re)-excavation
- Embankment/road
- Main inlet structure
- Medium regulator
- Minor regulator / irrigation inlet
- Controlled drainage outlet
- Weir/outlet
- Bridge
- Beel area & pre-monsoon waterlevel

Note: Source for geo-data: FAP19.

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IMPLEMENTATION LAY-OUT
SC15

Consultant: Euroconsult, Lahmeyer Intl, Bats Ltd, HCL

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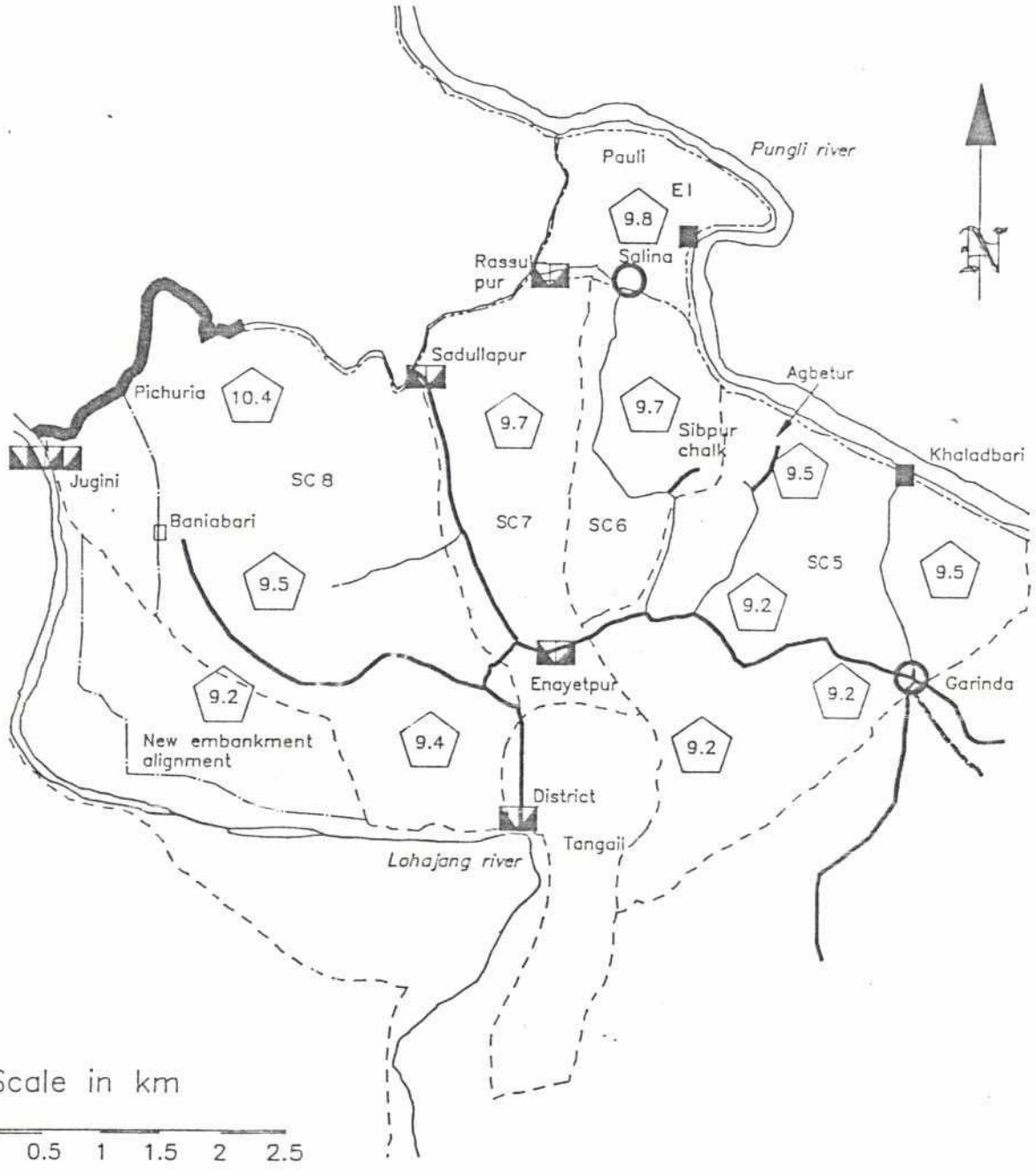

LEGEND

- Compartment boundary
- Sub-compartment boundary
- Waterway / (re)-excavation
- Embankment/road
- Main inlet structure
- Medium regulator
- Minor regulator / irrigation inlet
- Controlled drainage outlet
- Weir/outlet
- Bridge
- Beel area & pre-monsoon waterlevel

Note: Source for geo-data: FAP19.

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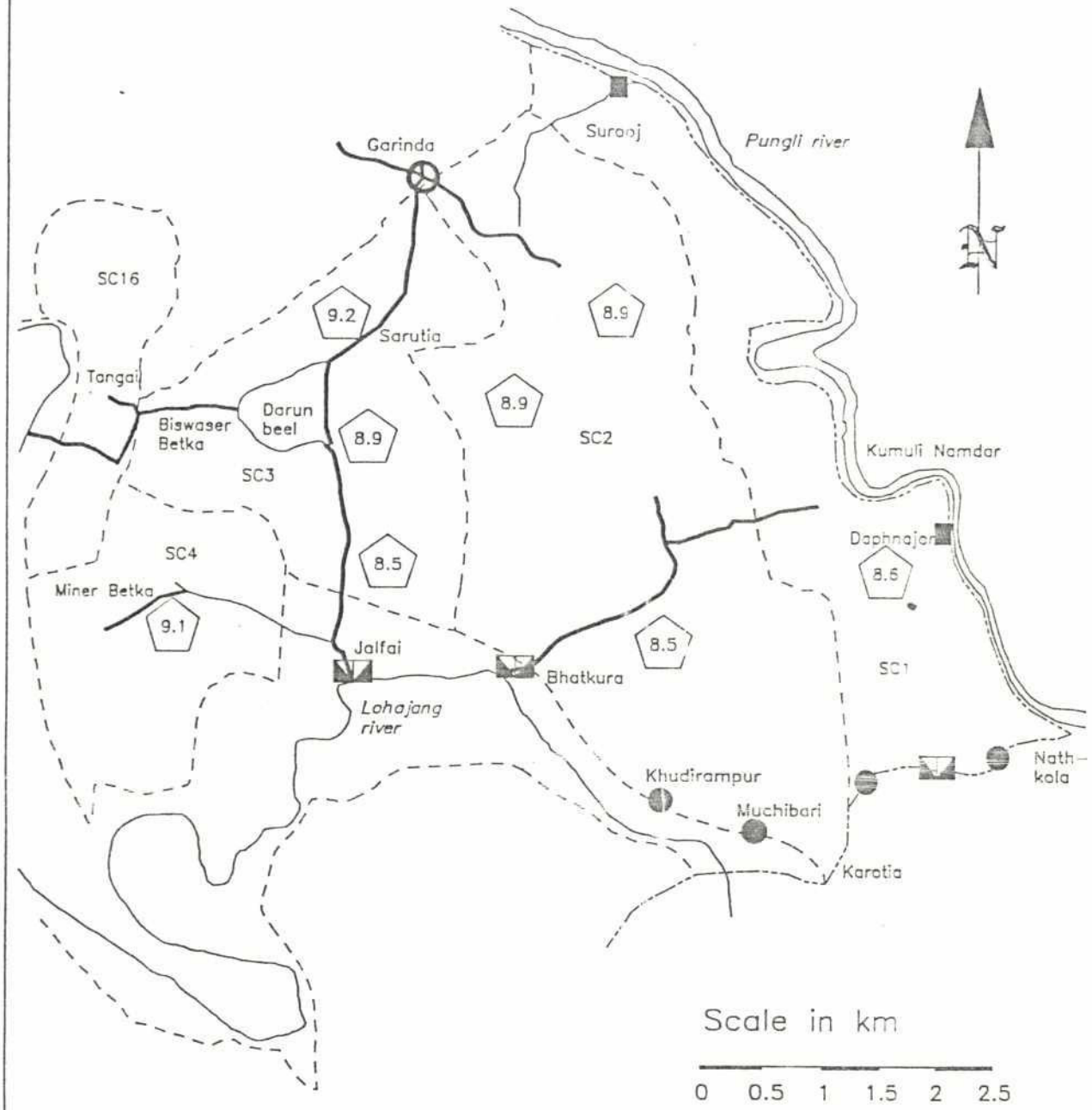
FAP 20

IMPLEMENTATION LAY-OUT SC 5 TO 8 AND E1

Consultant: Euroconsult, Lahmeyer Intl, Bets Ltd, HCL

Drawn by	Checked by:	Figure/Drawing No
Date:	Date:	4.8



LEGEND

- Compartment boundary
- Sub-compartment boundary
- Waterway / (re)-excavation
- Embankment/road
- Main inlet structure
- Medium regulator
- Minor regulator / irrigation inlet
- Controlled drainage outlet
- Weir/outlet
- Bridge
- Beel area & pre-monsoon waterlevel

Note: Source for geo-data: FAP19.

MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION

COMPARTMENTALIZATION PILOT PROJECT
FAP 20

DETAILS SC 1 TO 4

Consultant: Euroconsult, Lahmeyer Intl, Bets Ltd, HCL

Drawn by	Checked by:	Figure/Drawing No
Date:	Date:	4.9

- The *Tangail khal* from the *Lohajang* river to *Biswaser Betka* needs re-excavation. This will be considered under section 4.3.10.

- For proper drainage of the adjacent areas, the *Tangail khal* will be re-excavated from *Biswaser Betka* to *Darun beel* as well as the link channel from *Darun beel* to *Sarutia*; the total length is estimated to be 0.5 km.

- The road system within the sub-compartments 1, 2 and 3 is poorly developped. A total number of 10 bridges is proposed at different locations.

- For proper drainage of sub-compartment 2, two regulators near the *Lohajang* are needed. One will be at *Muchibari khal* near *Karatia* bazar and the other one at the outfall of the *Khudirampur khal*.

- In order to release the drainage congestion in SC 1 it is proposed to excavate the link canal from *Kunuli Namdar* to *Bhatkura khal* via the *Kachna beel* and Birnali chalk. The total length of the channel will be 0.8 km.

- In SC 4, the link channel will be re-excavated connecting low pockets of *Mirrer Betka* with the *Namdar Betka khal*. The total length is 0.4 km

4.3.10 Water management on the Lohajang floodplain

The future situation in the *Lohajang* floodplain will be different from the present situation as:

- The waterlevel in the *Lohajang* will be lowered through the structures at the off-take.

- Natural drainage of these areas may be directed towards the sub-compartments. Drainage may be blocked by the closure of the *Lohajang* embankments.

The lower waterlevel in the *Lohajang* may call for supplemental irrigation which may be provided by low lift pumps. No special measures are required.

The natural drainage pattern has been interrupted at two locations:

- The *Lohajang* floodplain area at *Khanpur* is draining towards sub-compartment 11. A controlled drainage outlet should be constructed.

- The *Lohajang* floodplain area at *Bamail* is draining towards SC8. As indicated in section 4.3.8. it is proposed to reconstruct the embankment of SC8 close to the *Lohajang*.

4.3.11 Water management for Tangail town

Drainage

Excessive rainfall or high water levels in the *Lohajang* river cause flooding of Tangail town once or several times a year. Especially the center of the town is susceptible to flooding.

Occasional flushing of the urban area during the monsoon period is definitely beneficial. Inundation of part of the town does disrupt urban activities and is therefore disadvantageous.

The higher flood level at Tangail town during 1991 was 12.07 m+PWD. This resulted in a flooding of about 0.70 m maximum in the central part of the town. Consequently, flooding of Tangail Town will not occur with a water level in the *Lohajang* below 11.75 m+PWD. This corresponds with a water level of 12.15 m+PDW downstream of the main inlet site.

It can be concluded that flooding of Tangail town can be prevented by operating the main inlet for all flood events with a frequency upto 1:20 years.

Flooding from rainfall may still persist. This is related to the complete blockage of the central drain in Tangail. It is proposed that this drain be excavated to increase the capacity. Most roads have gutters for runoff discharge (See Figure 4.9).

In order to assess the discharge capacity for urban drainage the 2 hr rainfall intensity with a 2 year return period is commonly used. This has been assessed at 37 mm.

Assuming a draining area of 130 ha the discharge is 6.7 m^3/sec. The length of the central drain is 2.6 km. The following dimensions have been calculated:

bed width	:	4.0 m
gradient	:	7 cm/km
design depth	:	2.0 m
side slope	:	1.5 m/m
k.manning	:	50

Flood protection

The peripheral flood protection for the level of compartment will have a safety standard of 1:20 years return period (spilling of emergency spillways on the peripheral embankment). While considering the development of Tangail town, an urban centre within a rural area, it is not proposed to raise the protection standard for the town by an additional ring embankment around Tangail with a lower flood frequency.

Erosion protection

There are about five sites within Tangail town where river erosion takes place. As government buildings are threatened at these sites, protection measures have been proposed and are under design by the BWDB Design Office.

4.3.12 Mitigation measures

Floodplain fisheries

The controlled situation will be negatively affect the floodplain fisheries within the compartment. One of the most important issues to be dealt with in the consultation process, is the provision of mitigation measures. Those who will be disadvantaged should actively be involved in formulation of such measures. Especially the migratory species will be affected by compartmentalization (see Section 6.3).

As the excavation of *beels* is considered only marginally beneficial to floodplain fisheries it is proposed that also specific borrowpit areas be made more suitable for floodplain fisheries. Further study is needed.

Detailed plans will be provided at a later stage. For costing purposes a lumpsum is proposed to cover the cost for enhancing flood plain fisheries.

Navigation

For the peripheral (gated) control structures mooring places and improved road facilities have been provided at specific locations to serve the (mostly modest) navigation.

The navigation within the compartment is mainly limited to small non-motorized country boats. The internal management structures will negatively affect navigation within the sub-compartments. It is proposed that all regulating structures will be provided with a small and simple mooring place on either side of the structure and that the structure will be connected with an earthen road.

A lumpsum will be provided for the additional costs.

Embankment breaches

It is intended that after breaching of an embankment in a sub-comparment, the excess water will be retained in that sub-compartment or a group of sub-compartments until it can be drained out properly.

For this purpose the sill level of all culverts, that are normally providing for overland flow along the compartments must be raised to a level that corresponds with the 1:20 year return period of the adjacent embankment. Dumping of earth is suggested.

Extreme floods

During extreme floods with a probability beyond the design event the overflow spills will start working. This discharge has to be re-distributed over the sub-compartments.

Water flows from one sub-compartment to the next when the waterlevel within the sub-compartment exceeds the 1:20 years floodlevel.

All major road sections have sufficient capacity for drainage to pass this discharge; the road from Santosh to Porabari has 6 culverts; the road from Tangail to *Silimpur* has 4 culverts and the road from Tangail to Garinda Baruria has 6 culverts.

The sill level of these culverts may be raised in order to control the flow between sub-compartments. However, during these extreme flood events the remaining cross-section should be sufficient to permit adequate flow between the sub-compartments.

Additional safety during extreme flood events may be provided by enlarged embankment sections and refuge areas in the flood plains. These elements will be taken up at a later stage.

4.4 Non-structural interventions

4.4.1 People's participation; in FAP 20

To achieve sustainable development through water management the FAP 20 ToR puts much emphasis on people's participation and its institutionalization:

> *"The compartment is basically a management unit in which the involvement of beneficiaries is considered essential for its success"*. [ToR,p.3].
>
> *"The non-structural output which constitute the basic objectives of the Pilot Project will cover the following*:
> .....
> *2. Social Aspects*
> *Policies and Guidelines of involving the scheme beneficiaries and disadvantaged groups in the planning and implementation of physical works and their management ...*
> *4. Institutional Arrangements*
> *Policies and Guidelines for strengthening existing institutions and/or establishing new ones for the management of compartments or sub-compartmental development with the emphasis on local government and beneficiary participation* ... [ToR p. 6, 7].

This emphasis on involving the effected people in all aspects of compartmentalization has been strongly reconfirmed by evaluations of existing FCD/I projects (see particularly FAP 12/13). These have highlighted that success and sustainability require people's participation throughout the project. FAP 20 has therefore designed a comprehensive programme to experiment with involving all concerned in the process of designing and testing compartmentalization.

4.4.2 Needs assessment

As mentioned in the Inception Report (April 1992) people's participation can be anything between genuine grassroots development and the "selling" of a programme (designed by others) to the people concerned. FAP 20 does not follow either of these extreme approaches. Within the limits set by the specific objectives of FAP 20 ("testing the

compartmentalization concept in the field under real operating conditions"), a "bottom-up" approach is emphasized.

The FAP 12/13 and other evaluations have shown that, whether or not the project will be sustainable, depends to a large extent on whether it addresses the needs of the people. To find out the perception of the different interest groups about the existing water management related situation, the problems as they perceive them and their ideas about potential solutions, a Multi-Disciplinary Sub-Compartmental survey has already been carried out in Tangail CPP. This needs assessment survey involved farmers, fishermen, landless, women and urban people. The same survey has been conducted in up- and downstream areas as well as in the adjacent floodplains.

4.4.3 Four options; cross-fertilization of people's and the specialist's views

As proposed in the Inception Report (April), the CPP Team has taken the many detailed and localized suggestions from the needs assessment, and have combined these into an overall and coherent development option. The focus of this option was pre- and post-monsoon drainage through re-excavation of existing channels.

At the same time the different CPP Specialists have given their professional view as to what else could be done to fully develop the potential of the area, and how this can technically be achieved. This has resulted in a number of other possible development scenarios. During May, using the Multi-Criteria analysis as described in the FPCO *"GUIDELINES FOR PROJECT ASSESSMENT"*, the number of possible options was narrowed down to the following four:

Option "A", provided for improved drainage during the pre- and post-monsoon, and improved fish migration through re-excavation of existing khals. In the opinion of the rural population this would give their winter season agriculture more security and would increase agricultural and fisheries production this scenario, through improving the connection of the floodplain to the river, increased the danger of monsoon flooding. Flood protection of specific localities, among them Tangail town, was planned by improving existing embankments.

Option "B" was an expansion of option "A" in that it provides for a number of ungated structures where rivers/*khals* enter the compartment. These structures would "throttle" the inflow of river water and thus compensate for the loss of such throttling effect due to re-excavation of existing *khals*. The danger of additional flooding during the monsoon, caused by re-excavations (Option "A") would thus be reduced to some extent, and conflicting operation of the main structures would be prevented.

Option "C" took flood control one step further by providing gates to the structures of option "B" and a further improvement of the horseshoe embankment. This would allow for more flood control in case of extreme flooding as well as for the possibility of regulating the monsoon flood level. The main additional benefits would be further improved flood control and an increase in the area that can grow HYV T. Aman. Negative impacts would be the need for land acquisition and a reduction in floodplain fisheries and navigation possibilities.

The final option "D" envisaged total flood control by adding to option "C" the closure of the southern boundary by heightening the existing road and placing regulators in the main outlets, particularly the one in the *Lohajang* river.

4.4.4 Proposed consultation process

In the Inception Report it was proposed to take these four options to all concerned in a three-months-long consultation process. The aim of this next step in the process of people's participation was to give all concerned a chance to voice their opinion as to the desirability of each option. This step was considered essential because ultimately the people of the area would have to live with the additional benefits and negative effects that each option brings. Where the majority would draw the line between additional benefits and losses, would only be revealed by such open-ended consultation.

4.4.5 Additional flood protection an option or a precondition?

Just before the consultation was due to start (May 28, 1992) objections were raised by FPCO/POE against this procedure. Options A, B and C were said to be not relevant as they did not provide for the envisaged level of flood protection. Accordingly, the PD requested the FPCO to arrange a high-level meeting to decide on the issue.

On June 29, 1992 a meeting was held at FPCO to discuss this matter. In that meeting the FPCO/POE confirmed the opinion that options without the flood protection provided by gated inlet structures, could not be considered. A decision about a gated outlet in the river *Lohajang* would be left till next year. As far as internal water management is concerned all options were left open.

4.4.6 The abridged consultation process

During July 1992 details of the FPCO/POE decision were worked out in a number of follow-up meetings. This resulted in additional design work and redesigning the consultation process.

The decision to prescribe the peripheral food protection works meant that the consultation process now had to be used to carefully explain the provision of flood protection facilities, in the context of the purpose of the pilot project, to the public whose support and participation would be sought for constructing and maintaining these facilities. The reaction of the public was recorded. As far as internal water management is concerned, the original plan of presenting different options for discussion, could be maintained.

Due to the discussions about flood protection mentioned above and the resulting change in approach, the consultation process was delayed by 6-8 weeks. Both FPCO and the donors expresses the need to maintain the original date for handing in the TANGAIL CPP INTERIM REPORT, October 1. To accomplish this the consultation process was reduced from 3 months to 3 weeks. The northern sub-compartments, both inside and outside the Tangail CPP area, most affected by the flood protection works, were covered. In addition in 3 sub-compartments the consultation regarding the internal water management options were held.

In this way the abridged consultation process took place between mid-August and early September. In total 26 meetings were held with the different interst groups. The results of this process have, as far as the peripheral works are concerned, lead to a heavier emphasis on navigation, still more emphasis on mitigation works in the up-stream area and a provision that people from that area can also qualify for earth and maintenance work. As far as the internal water management is concerned the stage has been set for the process of fine-tuning the interventions foreseen for 1992/93.

4.4.7 Future consultation process

The planning is for the consultation process to continue during the next few months to cover the remaining internal and external sub-compartments. Particular attention will be paid to cover Tangail town, as it requires an approach making more use of the existing representative and municipal bodies.

4.4.8 Landless Contracting Societies

Much earth work is planned for the re-excavation of existing *khals* and for repairing embankments. Of this work 30-50% has been reserved for Landless Contracting Societies. The existing BWDB rules and regulations for such LCSs require a level of administrative involvement that few existing groups of landless have. Therefore FAP 20 will spend help the target group to get organized and registered so that they can in due course make use of this employment opportunity.

This facilitating work will start about 9 months before the actual earth work is to be done, so that the necessary administrative and legal matters can be fulfilled within the time frame provided by the rules and regulations.

4.5 Institutionalisation Programme

4.5.1 General

The main elements in FAP 20's approach on institutional issues are:

(a) creating mechanisms for the direct involvement and representation of the various categories of water users in decisions and actions that affect water management;

(b) creating mechanisms for coordination with and direct involvement of the various government agencies concerned with the use of land and water;

(c) experimentation with institutional arrangements for comprehensive area-based water management at compartmental and sub-compartmental level;

(d) strengthening skills and motivation in relevant government agencies and among users' representatives by way of training and exposure to other initiatives.

For each of these elements FAP 20 has started to investigate the actual situation, discussed possible approaches with concerned parties and designed strategies for field-testing

and elaborating the selected approaches. The Tangail CPP is now ready to take up implementation of the chosen approach and to study operational aspects, effects, impact, costs and replicability. Over the next three years the project will undertake this work and will produce results at four levels:

(1) Actually functioning institutions in charge of water management at users level, sub-compartmental level and compartmental level in Tangail and. These will be involved in design, operation and maintenance of the structural works to be undertaken by FAP-20. It is crucial that progress on the structural aspects of FAP-20 takes place in line with the establishment and functioning of such institutions;

(2) Consolidated data on the performance of such institutions and on other relevant aspects, obtained through regular monitoring and special studies;

(3) Tested procedures, manuals and guidelines for the establishment and running of the various institutions, for inter-departmental coordination, and for organizing the involvement of water users;

(4) Improved skills and knowledge among selected water users, staff of government agencies (in particular BWDB, BRDB, DAE), NGO's and Union Council members. The training activities will cover all major aspects of comprehensive water management and the practical aspects of facilitating people' participation in this regard. Training packages will be developed, tested and applied and consolidated for utilisation beyond this Pilot Project.

In the Tangail area four types of institutions will be developed. The formal names and status of the various institutions still need approval and will be adjusted if required:

(1.a) **Compartmentalization Pilot Project Executive Committee (CPP/EC)**; this is conceived to be a precursor to the eventually envisaged:

(1.b) **Compartment Water Management Board (CWMB);**

(2) **Sub-Compartment Water Committees (SCWC);**

(3) **Water Users Groups (WUG).**

The composition, roles and ways of establishing of these institutions are discussed in detail in Annex 5 ("Institutional aspects") and are summarized below. The phasing of the concerned activities is discussed in chapter 5.

The institutionalization programme 1992-95 will include:

(1) Complete official formalities so that the CPP/EC is constituted and operational by November 1992;

(2) Further development of the concept of the Compartment Water Management Board and, possibly through an intermediate step of a Provisional Board, establishment of this institution;

(2) Organisation of the Water Users Groups simultaneously to the progress of structural works to become functional following the phasing of the Sub-Compartment Water Committees;

(3) Establishment, training and fine-tuning of the Sub-Compartment Water Committees in a phased manner;

(4) Establishment and effectuation of procedures for direct involvement of a number of government departments and local government bodies in Tangail district;

(5) Development and execution of the training and exposure programme for the various committee levels, users groups and government staff;

(6) Production of manuals, operating procedures, tested training packages and guidelines on the respective aspects of institutionalisation;

(7) Design and execution of special studies on:

- Experiences in and formats for people's participation in Bangladesh and outside;
- Institutional arrangements for comprehensive water management in different settings;
- Legal, fiscal and procedural aspects of water management in Bangladesh.

In addition, there will be activities in a number of adjacent Sub-Compartments in and adjacent to the main compartment pilot project area. Arrangements will be made to:
1. determine the undesirable effects of the CPP and
2. to undertake activities to mitigate the effects of CPP by:
   a) creating awareness about the flood amongst people,
   b) improving the existing roads and other structures, and
   c) controlling structures of FAP-20 (say the *Lohajang* Sluice Gate) to minimize the ingress of flood water.

There will also be distinct arrangements for the Tangail Pourashava (Municipal) sub-compartment area, which concern:
   a) flood protection,
   b) flushing,
   c) drainage,
   d) improvement of sanitation,
   e) improvement of the quality of drinking water, and
   f) control of soil erosion caused by the *Lohajang* river.

4.5.2 Compartmentalization Pilot Project Executive Committee and Compartment Water Management Board

As soon as practically possible at the compartment level (i.e. at Tangail), a Compartmentalization Pilot Project Executive Committee (CPP/EC) will be formed, with the following roles:

Role of CPP/EC:

1. To review progress of the Tangail Compartmentalization Pilot Project (CPP).

2. To advise the Project Team on policy matters.
3. To facilitate coordination between CPP and concerned Government agencies (departments and others) and Non-Government Organizations.
4. To review and advise on alternatives developed by CPP.
5. To ensure practical collaboration between and among CPP, the various Government agencies and Non-Government Organizations.
6. To facilitate linkages between CPP, District Coordination Committee (DCC), other concerned committees and Thana's.
7. To solve problems and remove constraints of CPP.
8. To advise and assist in the establishment of sub-compartment water committees (SCWC).
9. To provide guidance to sub-compartment water committees.
10. To assist SCWC to procure inputs.
11. To serve as a forum for training on integrated water management.
12. To assume responsibility in regard to selection and O&M of compartmental structures and sub-compartmental structures affecting more than one sub-compartment
13. To advise and assist in the establishment of the Compartment Water Management Committee.

Composition of the CPP/EC:

The composition of the CPP/EC at its inception will be:

Project Director, FAP-20, Chairman in first phase
Deputy Director, DAE - Member
Deputy Director, BRDB - Member
District Fisheries Officer, DOF - Member
District Livestock Officer, DOL - Member
Executive Engineer, LGED - Member
Executive Engineer, BWDB, Member
Executive Engineer (Irr.) BADC - Member
Executive Engineer, Tangail Pourashava, Member
Secretary Tangail Pourashava - Member
NGO Directors - 2 Members
Thana Nirbahi Officers (Tangail Sadar and *Delduar*) - Members
Thana Agriculture Officers (Tangail Sadar and *Delduar*) - Members
Thana Fishery Officers (Tangail Sadar and *Delduar*) - Members
Thana Livestock Officers (Tangail Sadar and *Delduar*) - Members
Thana Rural Development Officers (Tangail Sadar and *Delduar*) - Members
Thana Engineers, LGED (Tangail Sadar and *Delduar*) - Members
Institutional Specialist, CPP - Member
Executive Engineer, CPP - Member-Secretary

And then, as soon as the respective Sub-Compartment Water Committees are being formed (for timing see above), their Chairmen will become members of the CPP/EC, which eventually add to the CPP/EC:

Chairmen of Sub-Compartment Water Committees: approx. 10 members (number determined by final number of sub-compartments)

Persons representing special interest groups of the CPP area such as industry, environment, fishery etc. and consultants of Project Team of CPP, having continuous 6 months tenure or more, may be coopted as members, when needed.

	CPP Executive Committee later to convert to: Compartment Water Management Board		
Category:	Staff from line departments:	Beneficiaries' representatives:	Others:
Number and nature:	7 from district level 10 from Thana level	approx. 10 chairmen of SCWC's	NGO's :3 Tangail Pourashava: 2 CPP: 3
Comments:	final representation to be reviewed	phased entry as SCWC's are established	optional: special interest groups; CPP eventually phased out.

The composition of the CPP/EC will be reviewed at regular intervals (mid 93 and mid 94) to reflect experiences gained so far. At those occasions chairmanship, secretarial arrangements and other procedural matters will also be reviewed. The CPP/EC can decide to select a smaller

Transition to Compartment Water Management Board

Around the middle of 1994 the CPP/EC should have reached a more stable character, as all Sub-Compartment Water Committees will have been constituted and will be represented. At that time the CPP/EC will convert into the Provisional Tangail Compartmental Water Management Board, to become responsible for Water Management in the Tangail Compartment according to GOB decisions made at that time. This will also be contingent on the outcomes of FAP 26. The (Provisional) Water Management Board will look after all of the functions mentioned under CPP/EC to the extent still needed, but will become the focal point for O&M of all major and medium structures and support to the Sub-Compartment Water Committees. within the compartment. It will remain operative until such time as it is necessary for execution of the project and in due course it will be converted into/merged with Tangail Compartment Water Management Board.

FAP 20 has already initiated official formalities for necessary Government approval for establishment of CPP/EC. Training activities will be prepared that will assist in the orientation and preparation of the members of the CPP/EC. Practical collaboration with other departments, in particular DAE, BRDB, DOF and Local Government in the context of the execution of FAP-20's activities has already started and will be intensified. To facilitate this collaboration the various departments will depute staff and the project will assist by meeting additional costs that are incurred.

4.5.3 Sub-Compartment Water Committees

General

Presently 17 sub-compartments have been demarcated in the CPP Tangail plan area. This number is expected to be reduced to about 10. In each of these sub-compartments, a Sub-Compartment Water Committee will be organized in a phased manner (for phasing see chapter 5). The SCWCs are the key element in FAP-20's approach to decentralized and participatory water management. It is the link between people in the Sub-Compartment, organized in Water Users Groups, and the institutions at Compartmental level, organized in the CPP/EC and eventually the CWMB. It is also a direct link between government departments, interest groups, local government and NGO's.

The sequencing of the establishment of the SCWC's will be the same as for the structural works (see implementation chapter). It is considered crucial that final choices regarding the installation and operation of these works will be made together with the concerned people in each sub-compartment and that procedures for O&M will be developed with and by the SCWC. This implies that the mobilisation and organisation of water users in so-called Water Users Groups will be taken up before the design of structural works is finished and that the SCWC needs to be trained and functioning by the time such structures are ready.

Three organisations will play a central role in the establishment of and support to the SCWC: BRDB and DAE in some locations and a selected NGO in others, will assist through their field staff in the identification and formation of Water Users Groups, identification of leaders of such groups and in the formation and training of the Sub-Compartment Water Committees themselves. This approach will have the advantage of building on existing organisations and, hopefully, leaving stronger organisations behind. It will also circumvent the need for CPP to employ a large number of field workers. The drawback is the need for extensive liaison, for intensive coordination and for budgetary and operational flexibility.

Composition of Sub-Compartment Water Committee

The Sub-Compartment Water Committee (SCWC) brings together representatives of directly concerned water users, field staff of the most relevant departments and local government. At the sub-compartment level DAE has staff designated as Block Supervisors and the BRDB sponsored TCCA has Block Inspectors. These staff, numbering between 2 and 4 per sub-compartment will be official members of SCWC. As BWDB is the lead agency of the project, effort will be made to have also Sectional Officers/Work Assistants as official members. There will be an NGO representative in the SCWC in those sub-compartments where NGO's have a substantial involvement. Local Government will be represented by 3 Ward Members of the concerned Union Parishad.

Finally and most importantly there will be approx. 6 or 7 non-official members from Water User Groups within the Sub-Compartment. Although there will be flexibility in the way Water Users Groups are formed and represented in the SCWC, the general guideline is that (where applicable) three members will represent high land, medium land, and lowland interests, one representative for fishermen, one for landless and one from

women. One urban dweller, where applicable, will also be included. Where the particular physical, geographic or social circumstances within the Sub-Compartment justify this, slight variation will be allowed.

One of the Union Parishad Members or Chairmen will act as the Chairman of the Sub-Compartment Water Committee. If there are more than one UP Chairman in a sub-compartment, they will themselves select the proposed Chairman of SCWC, under guidance of the CPP/EC. In total, the membership will be about 13. The SCWC can be represented diagrammatically as follows:

Sub-Compartment Water Committee		
Users Representatives: from Water Users Groups: 6 or 7	**Government field staff:** 1 DAE, 1 BRDB, 1 BWDB. Plus: **NGO-representative:** 1	**Union Parishad Members:** 3

Role of SCWC:

The roles of the Sub-Compartment Water Committee will be as follows:
A. planning and operation of flood and water control structures;
B. advice and supervision of water management;
C. mobilisation of resources;
D. providing necessary support to beneficiaries mainly through the Water User Groups;
E. representation to other levels.

Each of the above roles is elaborated as follows:

A. planning and operation of flood and water control structures
1. assist in the planning of structures on a participatory basis,
2. operation and maintenance of all structures as laid down in the O&M manual,
3. monitor all Government inputs related to water management,
4. establish structure committees, if required.
5. advise on all government inputs related to water management

B. advice and supervision of water management
1. advise on design and framing of rules of sub-compartment,
2. advise and supervise on water management of sub-compartment,
3. settle conflicting interests.

C. mobilisation of resources
1. negotiate with BWDB, LGED and concerned line departments and other organisations on contributions,
2. mobilize labour input for constructions and excavations,
3. control local funds for minor structures,
4. advice to Union Parishad on water related budget,
5. advice on water management tax, betterment fees etc. to Union/Thana (if introduced),
6. participate in training on water management,

D. providing necessary support to beneficiaries

1. assist in the establishment and functioning of Water Users Groups to the extent required,
2. facilitate training towards WUG members,
3. advise WUG regarding issues at the level of Sub-Compartment and Compartment,
4. facilitating access to field-staff of BWDB, BRDB, LGED and DAE,
5. facilitating material support to WUG's for drainage and flood-control measures undertaken by them.

E. representation to other levels

1. field staff of BRDB and DAE are ex-officio members of the SCWC and will channel information between these Committees, their departments and the Thana level,
2. Union Parishad ward members are members of the SCWC and will maintain the link to the Union Parishad,
3. chairmen of the SCWC is member of the CPP/EC (and eventually the CWMB) and represents the SCWC at that level,
4. WUG's directly represented in SCWCs.

4.5.4 Water User Groups

General

The most crucial level in this project is the level of the beneficiaries. They are the one who will be affected by any water management arrangements and without their involvement and input these arrangements will neither be effective nor valid.

FAP-20 should avoid imposing a rigid approach toward organizing beneficiaries. There are profound differences from one location to the other and people need the have the freedom to group and represent themselves as they see fit. At the same time the CPP needs a regular system for interaction with beneficiaries and for ensuring their central involvement at the level of Sub-Compartments and Compartment.

The way out of this dilemma is to capitalize on the knowledge and contacts present with organisations that have been working at this level for a longer time and, at the same time, to allow for a large degree of flexibility in the first stages of the compartmentalisation process. FAP 20 will work with the field staff of the BRDB, DAE and a selected NGO. Depending on the (locally) specific strengths and interests of these respective organisations they will take up the major role in identifying existing Water Users Groups, establishing new Groups, identifying and training leadership and offering support to the groups. The existing interests and needs of the various categories of farmers (at high, medium and low elevations; with or without irrigation, etc.) fishermen, landless, women, urban dwellers and possibly others will be the starting point for their organisation into Water Users Groups and for their representation in the SCWC. In some cases these interests might largely coincide with geography, in others they might not. In some cases groups might already exist or present groupings can incorporate the water management focus of compartmentalization. In other cases new groups might come into existence around drainage interests or flood control measures initiated or supported by CPP.

In all cases the guiding principle will be actual interests and needs of water users and their willingness to become actively involved. With the noted flexibility in each Sub-Compartment Water User Groups will be identified or formed as FAP 20 proceeds: in three Sub Compartments during he dry season of 92/93; 8 during the first half the next dry season and the remaining ones during the latter half of the 93/94 dry season.

Each group would comprise 50 to 100 households. This puts the theoretical number of W.U.G.'s between 25 and 50 per Sub-Compartment (containing on average approx. 15.000 people or 2500 households). But in reality much lower numbers are expected if real interest in aspects of water management is taken as a criterium. This is another issue that needs fine-tuning through practice.

Role of Water User Groups

With the proviso that Water User Groups will vary and that FAP 20 will avoid imposing obligations or narrow procedures on such groups, the following roles can be distinguished:

1. To organise the affected people/beneficiaries to form WUG.
2. To elect or select representatives for each group.
3. To participate in the training programmes related to water management
4. To organize specific groups of water users around common interests and initiatives, such as:
5. In the case of farmers: to prepare seasonal production and loan plans.
6. To arrange for joint procurement and use of inputs or equipment.
7. To keep continuous watch over minor local structures and conduct preventive maintenance and repairs of such structures.
8. To monitor the performance of larger local structures and report to SCWC, BWDB or LGED as appropriate
9. To operate regulators with only limited local effect
10. To operate regulators with larger than local effect within boundary conditions agreed with SCWC.
11. To provide input in the design of drainage and flood control structures undertaken by the SCWC, BWDB, LGED
12. To assist in the settlement of local disputes around water.
13. To undertake construction works of the project.
14. To provide input in the work of the SCWC through representatives.
15. To prevent wilful damage to structures.
16. To ensure adherence to commonly agreed rules for the use of water and water related structures (e.g. bunds construction)
17. To collect water taxes or fees if and when levied.
18. To assist in the monitoring and evaluation of FAP 20.

4.5.5 Training

This project will design and execute a substantial training programme, aimed at different

target groups and covering different subjects. This programme is tentatively outlined in Annex 7: "Training Programme", and can be summarized as follows:

TRAINING IN CPP-TANGAIL			
Target group	**subjects**	**location**	**comments**
Members CPP/EC	1.Introduction to CPP	Tangail	by CPP-staff and resources people: tailor made
Key members CPP/EC	2.Integrated Planning and Management	Location in Asia	existing course
BWDB XEN/SDE's	3.Planning and management of integrated development	Location in Asia	existing course
Project Director or XEN	4.Project Management	Europe	existing course
Members of SCWC's	5.Introductory course on SCWC	Tangail of location in sub-compartment	contracted to specialised inst.
	6.Special course for chairmen: running of committees	Tangail	CPP plus specialists: tailor-made
District and thana level staff	7.Comprehensive area-based water management	Tangail	tailor made by CPP and specialised training institute
Field staff of BWDB,BRDB, DAE & NGO	8.Comprehensive area-based water management	Tangail or location in sub-compartment	CPP and contracted institute
	9.Introduction and management of CPP	Tangail	CPP
Group Organizers	10.Working with beneficiaries	Tangail	specialized institution; tailor made
	11.Formation and function of W.U.G.	Tangail	CPP & specialised institute; tailor made
Water Users Groups	12.Local water management	sub-compartment	field staff & group organisers; tailor made
	13.Role of W.U.G.	sub-compartment	field staff and group organisers; tailor made

The purpose of the training programme is not merely to enhance skills and knowledge at the various levels and to establish strong institutions, but also to develop and test a training package that can be used at other locations. One of the end results of the project will be sets of training materials which will comprise printed and audio-visual materials. For the development of various courses specialised training institutions will be contracted.

Apart from training at location, Tangail and at specific training institutes in Asia and (in one case) Europe, extensive use will be made of excursions. These will primarily take place within Bangladesh, but an excursion to the Philippines or Indonesia will also be included to show instructive examples of well organized comprehensive water management.

4.6 Monitoring

4.6.1 Hydrological data

The principal elements to be monitored are:

- Groundwater level
- Rainfall
- Evapotranspiration
- River stages by means of gauges program
- Land flooding stages by means of gauges program
- Changes in water demand and supply and possible cause (project, non-project)
- Erosion processes and possible cause/origin
- Sedimentation processes and possible cause
- State of structural works (embankments, structures)

The erosion and sedimentation processes will be assessed by means of levelling of relevant cross-sections of canals and drains in the dry season. It is estimated that one team for one month per year per compartment would be sufficient.

In addition FAP 20 proposes that the mathematical model will be updated each year for possible changes in the set-up. Further details are given in Annex 4.

4.6.2 Environment

The following factors are relevant environmental key indicators. Indicators will be further defined in cooperation with FAP 16.

- Fish catch and fish populations in the *beels*, canals and flooded plains of the compartment
- Water quality (ground and surface water)
- Navigation
- Unused land of agricultural potential (fallow and unused flooded land)

- Fuel use for domestic purposes (changes in kind and quantity)
- Livestock populations
- Soil quality and intensive cultivation (fertility and erosion)
- Pests (insects and rats)
- Water related diseases (malaria, diarrhoeal diseases).

4.6.3 Social and economic

The following socio-economic key indicators have been chosen to be monitored during the project life cycle:

- Distribution of temporary income
- Distribution of structural benefits
- Employment opportunities as expressed in the wage rate
- Cropping pattern changes
- Yields of crops
- Crop damage
- Cropping intensity.

4.6.4 Institutional

Compartmentalization involves conflicts of interest. The institutional arrangements will be designed in such a way as to provide an efficient way of settling these conflicts. The effectiveness of the institutional arrangements will be monitored by checking the following key indicators:

- Functioning of the Compartmental Water Management Board
- Functioning of the Sub-compartmental Water Management Committees
- Conflicts between people living inside and outside the compartment
- Inter sub-compartmental conflicts
- Illegal interventions
- Functioning of Landless Contracting Societies, Earthwork and structure maintenance groups.

4.7 Post-project evaluation

The post-project evaluation will be done by repeating the baseline survey in as much as it is relevant to the then existing situation. The monitoring programme will provide relevant data for a trend analysis while a repeat household survey will provide the more detailed socio-economic and agricultural data.

The household survey will again be done in the project area, the adjacent area and the control area. If the development of the control area does not differ too much from that of

the Tangail CPP area (apart from compartmentalization), then the data thus acquired might give an indication of the impact of compartmentalization.

It must be pointed out however that the factors contributing to income growth and distribution are so many and their interrelationship so complex, that it is unlikely that detailed conclusion can be drawn on the basis of the impact of compartmentalization on households of different occupations and classes.

Relevant GOB department data (DAE, DOF) will also be used in the post project evaluation.

4.8 Special studies

Compartmentalization is a new concept and is therefore likely to produce new questions. The ToR allow for these issues to be looked into in-depth through special studies. These studies will contribute to special reports covering agriculture, fisheries, livestock, markets and communications. The special reports will suggest additional policies and guidelines for the development of these areas under compartmentalization.

Based on the preliminary survey and discussions with other FAP projects, issues have been prioritised for further research. These issues are summed up in the next sections. A number of these studies have been worked out in relevant Annexes while others will be worked out in detail over the next few months.

4.8.1 Agricultural studies

At this stage the following agricultural studies have been planned. Just like the studies mentioned above these too will be worked out in the implementation plan.

Farming systems management

Although a full farming systems research activity falls outside the scope of the project, a good understanding of the farmers way to cope with the risks and benefits of the floods is essential for a better understanding of the bottle necks in their farming system. This applies in particular to flood related problems and to the question how the possibility of better water management might change the farming systems.

Incoordination with the On-farm Research Unit of Bangladesh Agricultural Research Institute (BARI), located in Tangail, a study will be formulated into the way farmers are adapting their farming systems and cropping patters to the existing and improved water management conditions.

Crop demonstration plots

To introduce new varieties and cultural practices adapted to conditions related to new water management situations, it is planned to start crop demonstration plots in farmers fields. This programme should be implemented by the DAE. Limited funds to cover expenses for input supply and crop failure are required to support this programme.

4.8.2 Fisheries

Fisheries is one of the important interests competing with crop production in the compartments. It not only has a national economic value, a means of earning income for the landless, but most importantly it is a major supplier of food (protein). In order to assess the present status of fish production in the proposed sub-compartments - culture as well as capture fishery - and also to maintain and increase the production level of fisheries, special studies are being conducted on the following aspects. These are done in cooperation with FAP 17 and to some extent FAP 16. For more details see Annex 3.

Fish migration and spawning habitats

The fish populations in the rivers are known to depend on the resources of the flooded floodplains for their reproduction. This relationship needs careful investigation to known how and when the movements take place, what the conditions are for spawning and where and when that takes place. Part of this study can be combined with the wetlands study.

Catch assessment survey of beels

To assess the pre-project fisheries production and its vulnerability to project implementation, stock assessment of *beel* fisheries in some selected sub-compartments and one or two *beels* located in the control area will be conducted. This will be done on catch assessment survey basis. The methodologies developed by the Fisheries Resources Survey System of the Department of Fisheries may be followed for the study.

The study will provide a picture of the present status of the fisheries resources on the basis of which cost-benefit assessment and necessary mitigative measures could be developed. The study will also give information on species composition and gears used. Fish disease may be monitored with the same study.

Brood fish sanctuary

To increase fish production in the sub-compartments improved management will be needed. Part of this is the protection of brood fish of particular species such as snakeheads, catfishes, perches, puntis and other small fishes which breed in *beels*. This is expected to supplement natural fish seed production and as a result increase fish production.

Jugini beel in sub-compartment 09 has been selected as sanctuary for breeding fish rearing. The fish breeding there will produce fry, which in the rainy season will spread in the *beels* and paddy fields for feeding. The people in the wider area will be informed about the purpose of the experiment and their cooperation sought so as to prevent fishing in the sanctuary.

Initially a study is required for at least one year to investigate whether that really will increase the fish production.

Borrowpit

There are some borrowpits located in different sub-compartments within CPP area along the road side. Generally the borrowpits are of varying sizes. Some are 50-60 ft long 15-20 ft width and 2-3 ft deep and sometimes some are more than that containing shallow water. These are at present uncared and unproductive whereas these borrowpits have small scale potential from a fisheries point of view. Considering its fisheries importance some or most of such borrowpits may be brought under development after a detailed investigation as to their total area, suitability for culture fishery, influx and outflux of water and ownership. The investigation task is proposed to be executed in the next year.

4.3.3 Socio-economic studies

In compartmentalization knowledge about the socio-economic situation of all affected catagories of people is of importance for planning and evaluation. Aspects as people's participation and mitigation measures for those who are or may become disadvantaged through the present or future water management, require more information than available now. In the study plan the following issues might be included.

Labour market

One of the aims of the CPP is to direct as many structural benefits of compartmentalization as possible to the disadvantaged. To do so the major mechanisms (locality and season related) that together determine the demand and supply of labour must be understood.

The (local) mechanisms behind supply and demand for labour will be studied. This will start with a literature study followed by in-depth interviews. If possible a link will be made to the wage level monitoring so as to correlate and verify the data and information gathered.

People's participation in water management

People's participation is at the centre of the compartmentalization concept. There is however only a limited amount of knowledge on how this can be effectively integrated in a governmental project such as CPP.

A number of innovative experiments have been conducted regarding people's participation in water management projects. As yet the information about these projects, their findings and recommendations is scattered and not easily accessible.

An inventory will be made of the water management projects that have been attempting people's participation. Where possible and relevant field visits will be done and interviews held.

Local water management committees in the CPP areas

The institutionalization of water management, from the local to the national level, is also a task of FAP 26. However, the set-up of the local institutions and the process of decision making can not be separated from the total water management structure. There are existing institutional arrangements at all levels. It is likely that the CPP will advise on setting up new or renewed institutional arrangements, starting at the local level.

The CPP is not the first water management related project in Tangail or Sirajganj. There are sluicegates, irrigation equipment etc. that often have management committees of one kind or another. Before venturing into local institutional arrangements it is necessary to know more about these committees.

A special study will be made about the existing sluice gates and irrigation committees in the Tangail CPP areas. The study will include interviews with those concerned (beneficiaries and those affected negatively) as well in case of at least one sluice gate, field observations.

Institutional study

It is understood, that the project cannot be effective and successful on its own without any integrated judicial support. Before designing an effective judicial framework for the project, a detail inventory of existing rules, regulations and laws is needed. To achieve this, an in depth survey will be conducted.

Following that inventory, a special study will be done to investigate which regulations and laws are needed to support compartmentalization and the related water management. For details see Annex 5.

4.8.4 Environmental studies

As there is such a fundamental lack of basic information concerning the natural environment as a resource base, that only preliminary information can be expected from these surveys. The following items will studied.

Quality of ground and surface water

The expected impact of the project on the water quality, mainly instrumental via changes in agricultural practice, might be considerable. On the base of the results of the FAP 16 Tangail CPP EIA it will be decided which aspects may need further attention through monitoring and further investigation.

Wetlands

The objective of the FAP makes it possible to preserve wetlands, if needed. Their importance for fish fry and small fish is recognized but details are not available. Their role for soil fertility, wild plant and animal life (frogs, migratory birds), disease factors, livestock etc.), water quality, natural gas (methane) production (escaping into the air), groundwater recharge, transportation, etc. are much less understood, especial in their mutual relationships.

Dependent on the outcome of the FAP 16 Tangail CPP EIA a study will be carried out.

Soil erosion/vertiver grass

A study may be made of the soil conditions and erosion of farmlands (fertility and structure) in relation to inundation (silt/sand) and to the use of these farmlands (ploughing, dung and fertilizer use, type of crops). The results of this study may give useful directions for the way the water regime in the compartments must be managed. Special emphasis should be given on the introduction of Vetiver grass and its multi-purpose character.

Energy sources

Rural life depends on locally available energy sources particularly for cooking and processing purposes. Changing cropping patterns may affect the local balance negatively. Mitigating measures might be necessary so as not to deteriorate the position of the poor and particularly of the women.

Information will be collected on the existing situation and expected developments. Based on a review of the existing literature and (NGO) programmes possible mitigation measures will be prepared.

4.8.5 Verification of 1964, 8" to the mile map

The 8" to the Mile map from 1964 covering Tangail compartment has been used extensively by FAP 20 and others. A preliminary comparison of the data from the map and surveyed data along the southern embankment has given considerable differences (see Section 2.2.2.).

As the landscape along an embankment is likely to be disturbed, it is proposed to do a special study to verify the 1964 map by surveying more or less undisturbed land away from existing *khals*, roads or embankments. It is proposed to survey 2 reaches of 5 km each through a relatively high and a relatively low area.

4.8.6 Transport and markets

On the base of the changes resulting from compartmentalization (as well as regional influences such as the Jamuna Bridge) a study of the expected future communication, marketing and transport requirements in the compartment will be done. This will result in a special report on the integration of water management, water transport and road transport, taking into account the social, economic, environmental (pollution) and seasonal aspects of all modes of transport.

5 IMPLEMENTATION SCHEDULE AND COST ESTIMATES

5.1 General

In the ToR the following is stated about the relationship between structural and non-structural interventions:

> *"Detailed design and construction of works will follow ... It will be important to maintain a flexible approach and programme, linked to the non-structural activities"* [ToR, p. 8.9].

The basic assumptions behind making the construction of works dependent on the non-structural activities are:

- fixed structural works, such as re-excavated *khals* and un-gated structures, only yield their expected benefits if the required non-structural pre-conditions (credit, training, seeds supply etc.) are available,
- operable structures, such as gated regulators, will furthermore only yield their optimal and sustainable benefits if operation takes into account all affected interest groups,
- as gated structures are vulnerable to misuse by vested interest groups, the other interest groups must be firmly established before balanced operation can be expected.

For these reasons it is proposed to only make the new structures operable, i.e. fit part or all of the gates, when the committees are in place to operate them.

In this chapter the implementation schedule for the structural interventions is dealt with first. It is followed by an overview of the costing of those interventions. Next the schedule for the non-structural is given, again followed by details on their costing.

5.2 Implementation schedule of structural measures

The implementation of the structural measures as proposed in section 4 will be spread over the 1992-95 project period.

In order to start the actual testing of the compartmentalization concept, a schedule is proposed, based on 6 implementation alternatives (see Figure 5.1 and also section 4.2).

Construction period 1992/1993.

- Peripheral control by strengthening the horse shoe embankment including the erosion protection works.
- Internal control in sub-compartments 9, 10 and 11, including the development of the adjacent *Lohajang* floodplain.
- Construction elements for institutional measures.

- Mitigation measures for floodplain fisheries.

Construction period 1993/1994.

- Completion of sub-compartments 9, 10 and 11.
- Internal control of sub-compartments 1-8, E1 and 15, including the development of the adjacent *Lohajang* floodplain.
- Implementation of mitigation measures.
- Urban development.
- Completion of bankprotection and river training.

Construction period 1994/1995.

- Completion of sub-compartments 1-8, E1 and 15.
- Completion of sub-compartments 12-14.
- Completion of peripheral control at southern embankment (if this will be decided).

This implies that compartmentalisation can be tested in SC9 whether or not the main inlet will be completed in the 1992/1993 construction period. If the main inlet will be completed whithin one year, then the testing can also be done in sub-compartments 10 and 11. However, the decision whether gates will be installed in the main northern inlets, will be taken in a later stage during 1993.

For the 1993/1994 construction period the internal control of the sub-compartments 1 to 8 and 15 is planned because the peripheral control is not sufficient to improve the water management in the sub-compartments 1-4 and 15.

In the last construction period the sub-compartments 12-14 will be taken up together with the southern embankment, if so decided.

The structural elements are enumerated in Tables 3 in Annex 6.1 in which cost estimates and the construction year are shown. These tables form the basis for the proposed (combination of) implementation alternatives as outlined in Figure 5.1 on the next page.

Figure 5.1 Implementation Alternatives Tangail (Timing and Cost)

IA FULL COMPARTMENTALIZATION; ALL PERIPHERAL STRUCTURES GATED WITH THE EXCEPTION OF THE UNGATED OR PARTLY GATED NAVIGABLE INLET STRUCTURES *LOHAJANG* AND *SADULLAPUR*; LIMITED PERIPHERAL ROAD (20 KM); SOUTHERN EMBANKMENT AS FEEDER ROAD WITH BRIDGES/UNGATED STRUCTURES; FLOW REGULATORS BETWEEN *LOHAJANG* AND COMPARTMENT ONLY IN SC'S 9, 10 AND 11				
	92/93	93/94	94/95	Total
Total Cost (Lakh)	803.95	843.96	228.59	1876.50

IB THE SAME AS IA BUT ALSO GATED, UN-NAVIGABLE INLET STRUCTURES *LOHAJANG* AND *Sadullapur*; INCLUDING MOORING FACILITIES (OR LOCK)				
	92/93	93/94	94/95	Total
Total Cost (Lakh)	819.70	853.21	228.59	1901.50

IIA THE SAME AS IA, BUT ALSO INCLUDING FLOW REGULATORS BETWEEN *LOHAJANG* AND REMAINING SUB-COMPARTMENTS				
	92/93	93/94	94/95	Total
Total Cost (Lakh)	819.70	1131.21	378.59	2329.50

IIB THE SAME AS IB, BUT ALSO INCLUDING FLOW REGULATORS BETWEEN *LOHAJANG* AND REMAINING SUB-COMPARTMENTS				
	92/93	93/94	94/95	Total
Total Cost (Lakh)	819.70	1131.21	378.59	2329.50

IIIA THE SAME AS IIB, BUT WITH CLOSED/REGULATED STRUCTURES ALONG SOUTHERN EMBANKMENT, WITH EXCEPTION OF THE OPEN *LOHAJANG* OUTLET				
	92/93	93/94	94/95	Total
Total Cost (Lakh)	819.70	1310.08	431.29	2561.07

IIIB THE SAME AS IIIA, BUT WITH COMPLETE PERIPHERAL ROAD (60 KM)				
	92/93	93/94	94/95	Total
Total Cost (Lakh)	819.70	1664.17	549.32	3033.19

5.3 COSTING OF STRUCTURAL ELEMENTS

The costs of the structural means for compartmentalization are based on the latest BWDB Schedule of Rates from June 1992. Part of the proposed measures are rather detailed while other elements are still on a pre-feasibility study level. The following is assumed:

Earthworks are presented on a m^3 basic. For the major embankments and *khals*, a topographic survey has been done which permitted a rather accurate assessment. For those elements, where no topographic survey has been made up to date, an estimate of the required m3 per m has been presented.

Cost assessment of all structures has been based on preliminary cost estimates for typical structures.

For those elements where no design is available as yet, one of the following procedures has been followed:

- A lumpsum will be assumed (mitigation measures etc.).
- For marginal embankments, a volume of earthwork of 10 m^3 per meter length has been assumed.
- For drains, a volume of earthwork per meter length has been assumed based on expected maximum discharge. For a discharge up to 1 m^3/sec, from 1-2 m^3/sec. and above 2 m3/s the volume of earthwork is 2.5, 5 and 7.5 m^3/m^1 respectively.

The cost estimates for each construction element is given in Table 3 of Annex 6.1.

O&M costs are based on a percentage of the construction cost as indicated in Annex 7 of the Guidelines for Project Assessment. Further analysis of costing is presented in Chapter 8.

5.4 Implementation schedule of non-structural interventions

The main non-structural interventions are;

- establishing the Compartmentalization Pilot Project Executive Committee
- facilitating GOB interdepartmental cooperation
- training programme
- consultation process
- establishing and facilitating Water Users Groups
- establishing and facilitating Landless Contracting societies
- establishing and facilitating Sub-Compartmental Water Committees
- establishing and facilitating Earthwork, Embankment, Channel and Structures Maintenance Groups

The CPPEC is to be established by November 1992. From mid 1993 onwards the CPPEC is to be expanded with representatives from the SCWC. This process will continue until mid 1994. By that time the CPPEC should be transformed into the Tangail Compartment Water Management Board. For more details see Annex 5.

As pointed out in Annex 5, field-level cooperation with the relevant GOB departments requires the necessary incentives and facilities for their staff. From the 1993/94 financial year these are expected to be included in the TAPP. For the 1992/1993 ad-hoc arrangements will be made. For more details see that Annex.

The training programme is to start by November 1992. It will peak during the first year after that and then continue at a lower level for another 2 years. For more details see Annex 7.

The activities related to water management inside the compartment (from the consultation process to establishing Earthwork Maintenance Groups) are phase in such a way that they precede the planned structural interventions (see previous section). The following overall implementation schedule is planned;

- **Oct 1993-May 1993**; Sub-compartments 9, 10 and 11 and adjacent *Lohajang* floodplain
- **Oct 1993-Feb 1994**; Sub-compartments 1 - 8, E1 and 15 and adjacent *Lohajang* floodplain
- **March - May 1994**; Sub-compartments 12, 13 and 14

Within this overall framework the consultation process will be the starting point for the non-structural interventions in the sub-compartments. It will take place during the first 2-3 months of the dry-season and will result in the establishment of WUGs and SCWCs.

Early on in the dry season a start will be made with establishing LCSs while EMG will be formed later on in the season.

Due to their nature the non-structural interventions require a flexible approach to planning and implementation. The experiences gained during implementation in the first dry season will be used to adjust the planning for the remaining seasons.

5.5 Costing of non-structural interventions

Costing of the non-structural interventions has been done on the basis of the information presently at hand. It is quite likely that the details will change after the experience of the first dry season.

	1992/93	1993/94	1994/95	Total lakh Tk
- establishing and facilitating CPPEC	2	3	4	9
- facilitating interdepartmental cooperation	7.5	7.5	5	20
- training programme	30	20	10	60
- consultation process	1.5	2	1.5	15
- establishing and facilitating WUGs	7	10	10	27
- establishing and facilitating LCSs	1	2	2	5
- establishing and facilitating EMGs	1	2	2	5
- special studies	p.m.	p.m.	p.m.	p.m.
Total	50	46.5	34.5	131

5.6 Summary of work planning

The implementation alternatives proposed require 4 decisions to be taken:

- o by mid-1993 : on the choice between installation of all gates, partly of the gates or no installation of gates in the *Lohajang* and *Sadullapur* inlet structures.
- o by mid-1994 : whether or not elsewhere on the *Lohajang* the remaining flow regulator have to be installed. This choice depends on the experience with the regulator in sub-compartments 9, 10 and 11.
- o by mid-1994 : whether or not the southern embankment should be provided with gated outlet structures.
- o by mid-1995 : whether or not, or to what extent, the peripheral road should be constructed.

All four decisions can also be deferred if it can be expected that additional field experience, alternative designs, or availability of information on the implications of the *Bhramaputra* Left Embankment and/or the *Dhaleswari* Mitigation Plan would increase the justification of the respective choices.

The schedules of structural activities, non-structural measures and on studies and reporting are summarized in Figures 5.2, 5.3 and 5.4 respectively.

Figure 5.2: Schedule of Activities for Tangail Compartment Sept. 1992 – Dec 1995: Consultation and Construction

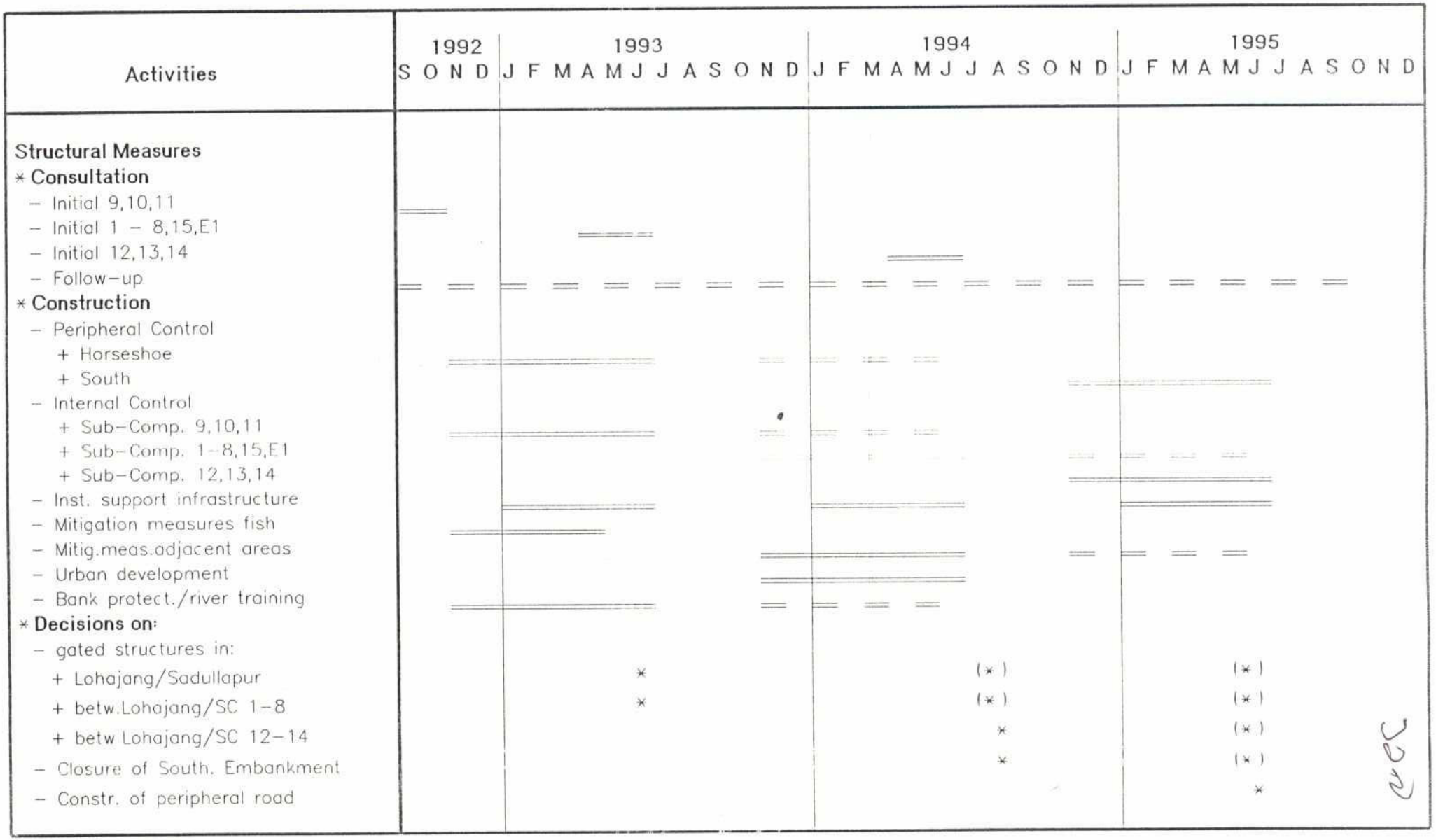


Figure 5.3: Schedule of Activities for Tangail Compartment Sept. 1992 – Dec 1995: institutionalization and Training Programme

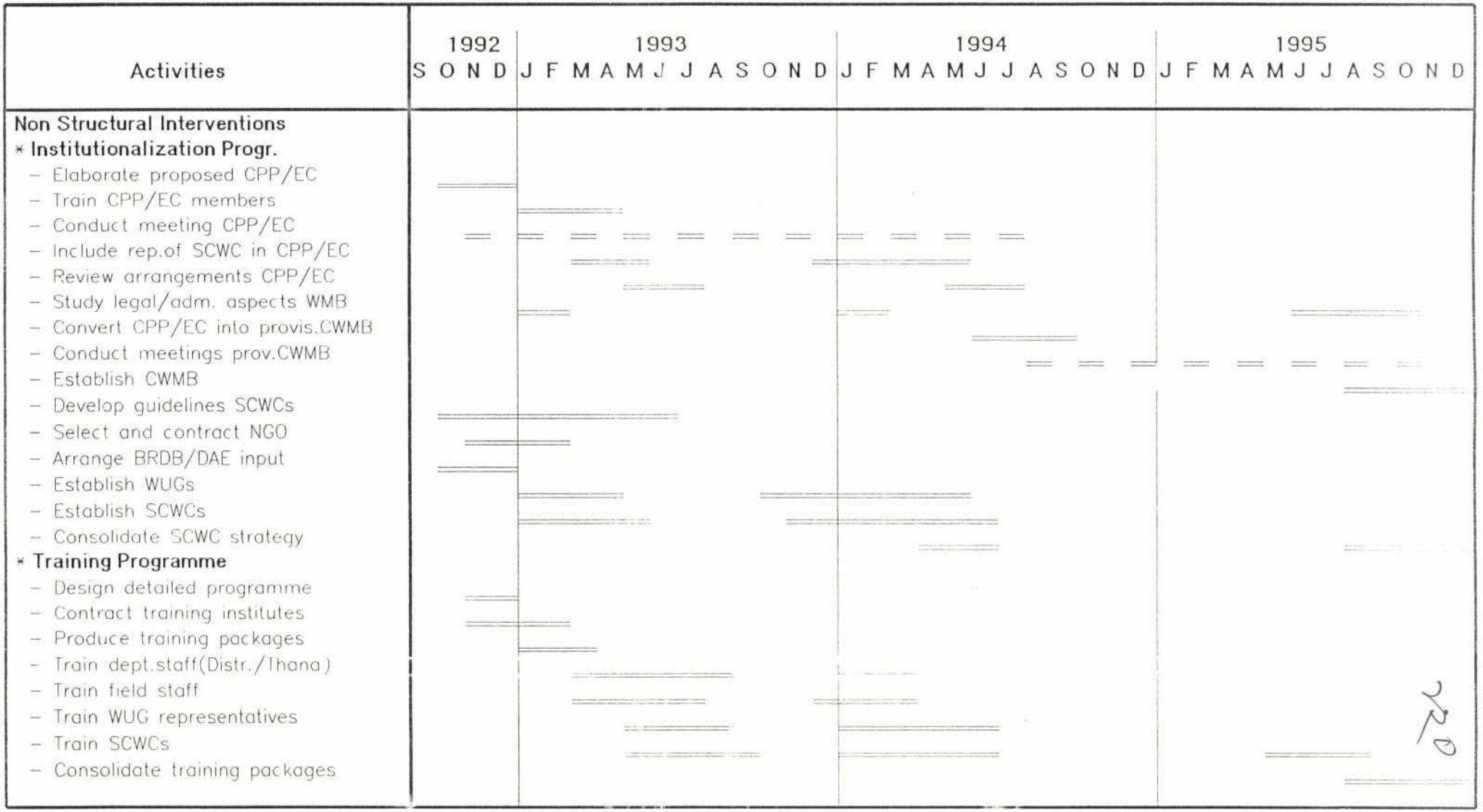
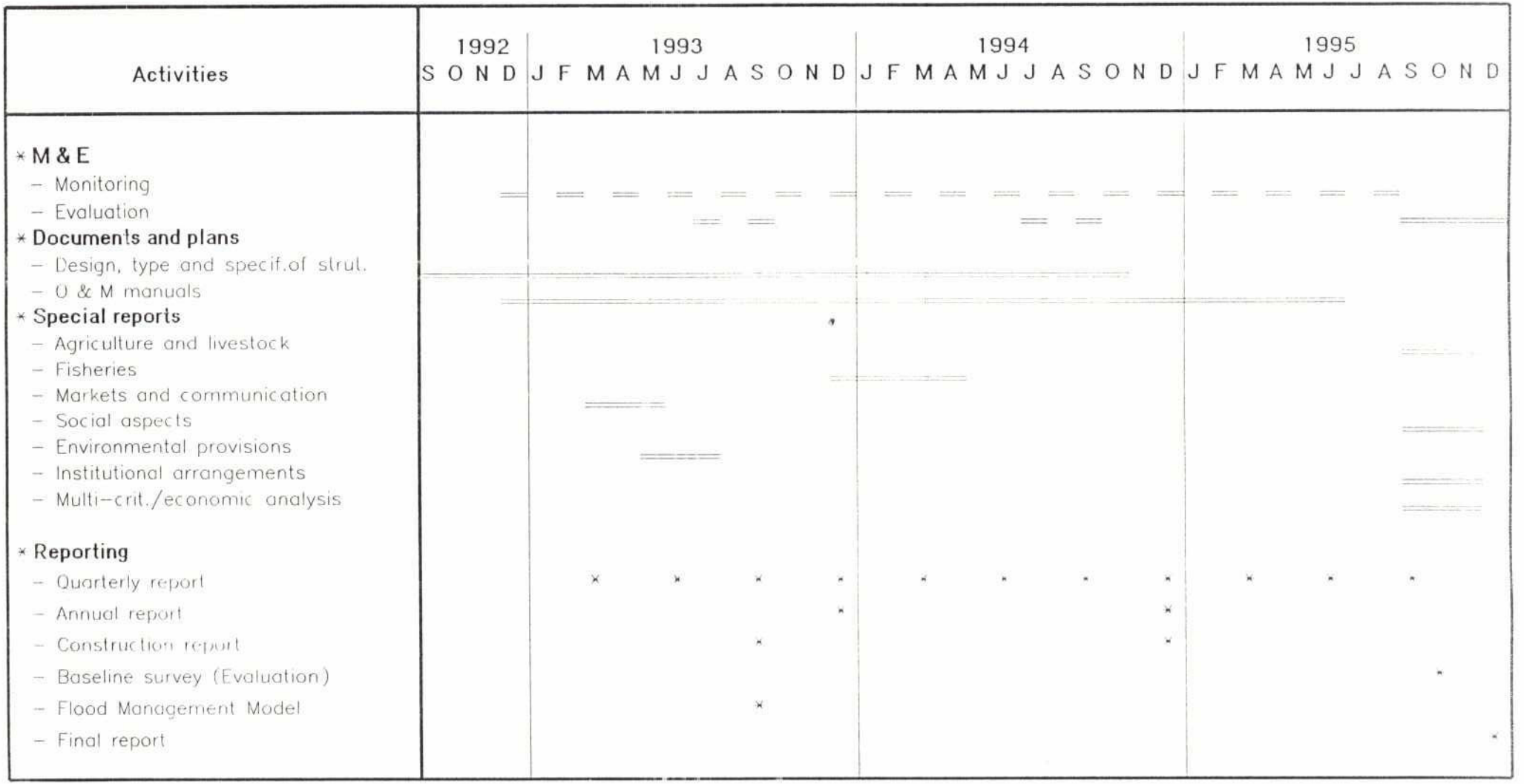


Figure 5.4: Schedule of Activities for Tangail Compartment Sept. 1992 - Dec 1995: Studies and Reporting



6 ASSESSMENT OF IMPACTS

6.1 General

The ToR have the following to say about the overall objective of compartmentalization:

> *"The overall objective is to provide, through water management, a more secure environment for intensive agriculture, fisheries and integrated rural/urban development, and thereby improve the economic security and quality of life of the floodplain population."* [ToR, p. 3].

In general we can distinguish the following hierarchy of project activities; first order **inputs** second order; **outputs**, third order; **effects,** fourth order; **impacts**. The relationship between these different project objectives is a sequence of cause-effect.

The first order objectives are those inputs which the project plans to provide. They are more or less completely within the influence of the project. The second order objectives require the response of others, outside the project, to materialize. The third order objectives are the benefits and disadvantages due to the water management provided by compartmentalization. The fourth order of objectives is that of impacts on the water management, on the institutional framework and the households in the affected area. These kinds of impact are part of long-term trends on which the project interventions only have a diffused effect. Furthermore such impacts are extremely difficult to measure.

As mentioned, compartmentalization aims to "improve the economic security and quality of life of the floodplain population". This is obviously a fourth order objective, linked to project interventions through a long chain of causes and effects. For that reason it is impossible to quantify such impacts with any degree of certainty. In this chapter we will therefore put major emphasis on a qualitative assessment of likely impacts.

6.2 Agricultural development potentials

6.2.1 Land capability potential

The soils in the area are very fertile and used intensively. F0 and F1 land has the highest agricultural potential and can produce 2 transplanted rice crops each year on impermeable soils. F0 and F1 land with permeable soils are suitable for a wide range of dry land cash crops, especially with irrigation. F2 and F3 lands have a lower potential than F0 and F1 lands. Development opportunities are restricted by flood water levels in the monsoon season and by risks of flood damage by untimely or high floods.

6.2.2 Assumptions in agricultural development

Since the cropping intensities in the project area are high, it is assumed that future improvements in agricultural production will result from a number of factors including moderate increase in cropping intensity, higher production levels, better farming methods, higher resource investment in inputs and the use of improved varieties.

6.2.3 Impacts of controlled flooding and improved drainage

If protection against flooding is provided and drainage impediments can be eliminated a further increase of production can be attained. With higher crop security farmers are inclined to shift from local varieties to high yielding ones with higher inputs like, seeds, fertilizers and agro-chemicals (Table 6.1). This shift is only possible because of the shift in landtypes from the present situation to the "with project" situation as illustrated below.

	F0 (0-30)	F1 (30-90)	F2 (90-180)	F3 (180-300) cm
Present (%)	10%	36%	45%	9%
Future (%)	28%	37%	35%	0%

TABLE:6.1 FUTURE CROPPING PATTERNS

	F0:0-30cm	F1:30-90cm	F2:90-180cm	F3:180-300cm
Single Cropped	**Rainfed:** T.Aman (HYV) Aus (Local) Sugarcane Vegetables *Rabi* Crops	**Rainfed:** T.Aman (Local) Aus (Local) Sugarcane Jute Vegetables	**Rainfed:** D.W.Aman (TR) Jute Aus (Local) Sugarcane	**Rainfed:** D.W.Aman (TR+B) Aus (Local) Jute
	Irrigated: Boro(HYV)	**Irrigated:** Boro(HYV)	**Irrigated:** Boro (HYV)	**Irrigated:** Boro (HYV)
Double Cropped	**Rainfed:** T.Aman (HYV)-*Rabi*/Potato Aus (Local)-T.Aman (HYV)	**Rainfed:** Jute/Aus(Local)-T.Aman(Local) T.Aman(Local)-*Rabi* Crops	**Rainfed:** D.W.Aman(TR)-*Rabi* Crops Aus/Jute-*Rabi* Crops	**Rainfed:** Aus(Local)-*Rabi* Crops D.W.Aman(TR+B)-*Rabi* Crops
	Irrigated: Boro(HYV)-T.Aman(HYV)	**Irrigated:** Boro(HYV)-T.Aman(Local)	**Irrigated:** Boro(HYV)-D.W.Aman(TR)	**Irrigated:** DW Aman(B)-Boro(Local) Boro(HYV)-*Rabi* Crops
Triple Cropped	**Rainfed:** T.Aman(HYV)-*Rabi* Crops-Summer Vegetables	**Rainfed:** Aus(Local)-T.Aman(Local)-*Rabi* Crops T.Aman(Local)-*Rabi* Crops-Vegetables	**Rainfed:** Aus-DW Aman(TR)-*Rabi* Crops Aus+B.Aman-*Rabi* Crops	**Rainfed:** D.W Aman-Mustard-Vegetables
	Irrigated: Boro(HYV)-T.Aman(HYV)-*Rabi* Crops/Veg./Spices	**Irrigated:** Boro(HYV)-T.Aman(Local)-*Rabi* Crops	**Irrigated:** Boro(HYV)-D.W Aman(TR)-*Rabi* Crops	**Irrigated:**

Improved water management has, besides a shift from local to high yielding varieties, other impacts as well like:

- A shift from deep water aman to local aman.
- Some direct seeded deep water aman will become transplanted DW Aman.
- Jute and sugarcane areas will be reduced.
- Potential for mustard in the northern sub-compartment will increase.
- Increase of irrigated area planted to Boro will decrease the Aus area.

6.2.4 Projected area, yields and production

In Table 6.2 the areas, yields and production of major crops are shown in the present situation (1991-92) and the projected ones 'With' and 'Without' project situations. Yield projections are based on the yield development in the last 10 years on average.

Table 6.2 Area, Yield and Production of major crops in the CPP Tangail area in present (P), without (WO) and with (W) project situations

Crops	Present (P)			Without Project (WO)			With Project (W)		
	Area (ha)	Yield (t/ha)	Production(t)	Area (ha)	Yield (t/ha)	Production(t)	Area (ha)	Yield (t/ha)	Production(t)
Rice									
Aus Direct Seed (Local)	1864	1.45	2704	1801	1.47	2656	1801	1.47	2656
Aus Transplanted (HYV)	356	2.75	978	356	2.68	955	356	2.72	967
Aman Transplanted(Local)	848	2.16	1835	831	2.19	1823	1272	2.19	2790
Aman Transplanted(HYV)	222	3.24	720	234	3.25	761	710	3.25	2307
DW Aman Direct seeded(Local)	1464	1.52	2229	1415	1.53	2158	1317	1.52	2008
DW Aman Transplanted (Local)	2254	1.81	4085	2346	1.84	4312	2028	1.84	3728
Boro (Local)	167	2.92	488	159	2.91	463	159	2.91	463
Boro (HYV)	3390	4.47	15142	3549	4.48	15886	3634	4.48	16265
Total	**10565**		**28181**	**10691**		**29014**	**11277**		**31184**
Jute	1514	1.73	2615	1456	1.74	2538	1287	1.74	2242
Wheat	1963	2.26	4442	1996	2.29	4577	2036	2.24	4769
Oilseeds(Mustard)	1267	0.86	1088	1275	0.87	1105	1394	0.87	1208
Potato	495	9.84	4870	499	9.43	4704	509	9.46	4816
Pulses	733	1.06	779	742	1.06	789	754	1.06	803
Vegetables+Spices	939	7.97	7484	939	8.07	7574	939	8.07	7574
Sugarcane	691	30.77	21262	694	30.75	21332	553	30.79	17021
Others	512			459			984		
Total	18678			18751		42649	19733		38493
Cropping Intensity	203			204			215		

6.3 Fisheries development potential

The establishment of new or "appropriate" water management systems always affects the fish population and consequently the fisheries output. From a fisheries point of view, it can be stated that the major part of the water management systems established until now in Bangladesh, serve to increase outputs from agriculture and to provide flood protection. Two major factors negatively affect the natural fish stocks:

Drainage of rainwater congestion around the *beels* in the pre-monsoon in order to secure the crops of the low land farmers hamper the reproduction and nursing of *"Beel-fish"*.

Reduction of the inundated floodplain area by drainage in the monsoon and post-monsoon and sub-compartment water management systems reduce the total available nursing and grow-out area for both "River" and *"Beel-fish"*.

In order to assess the impact on fisheries of the different water management systems, to be studied by the FAP 20 team, a three step analysis was developed. The hydrographs from the CPP-mathematical model were linked with a fisheries production model and calibrated with the fisheries and hydrological data of 1991. The predicted total fish production under each scenario was subsequently subdivided species-wise in order to create a differentiation in fish prices.

All 12 scenario's (see Annex 3) have a negative impact on the fisheries production of the CPP area. The minimum loss will be 47 t/year or US$ 63.000/year (scenario 9, peripheral control with "fish friendly" structures) and the maximum loss, 138 t/year or US$ 176.000/year, will be created by the introduction of scenario 4, small gated inlets. In general it is concluded that the highest losses are found in the more sophisticated water management schemes.

Complete peripheral control and complete peripheral control combined with sub-compartment water management can be implemented by taking into consideration the technical aspects of water management only or by also taking into consideration both water transport and fish migration. The difference in effect between implementation with or without "fish friendly" structures is limited, due to the fact that the structures only are facilitating the migration of the major carps hatchlings. The scenario's are compared with the existing situation of 1991, which consists of a declined carp production due to factors beyond the influence of the CPP. Evaluating "fish friendly" or "standard" regulators on the bases of economic parameters only would not be useful, particularly as most of the floodplain fish are caught and consumed by landless households (see below).

Mitigation measures,such as the integrated farming of rice/fish and culture based fisheries are studied by many as a potentially beneficial measure. However, even if the integrated farming of rice/fish is profitable, it will be hampered by the fact that this culture pattern is traditionally unknown with the farmers and that at present the use of HYV is the nucleus of rice farming in Bangladesh.

From a technical point of view, culture based fisheries is a tool to restore some of the lost natural carp production. A preliminary technical and financial analysis of this mitigation

measure indicated that as a prerequisite each fishermen should have access to 4 ha of water. Moreover, low priced small fry or fingerlings should be readily available.

Fisheries projects in Bangladesh are up to now mainly focusing on the high valued carp species. The growth of aquaculture within the last decade was possible because carps are "high" valued, making it economically feasible to culture them, and losses were more or less compensated. However, the major part of the rural population depends on the natural resources for its daily animal protein intake, which consists of "miscellaneous" or "small" fish, and can be caught freely, because the rural population traditionally has a free access to the waters. Therefore, when water management systems and fisheries are evaluated, factors other then economic or production figures on a kilogramme bases must also be taken into consideration. Even an at first sight less harmful option of "drainage only", affects directly the production of this free accessible source of protein. Mitigation measures should also be evaluated within this setting. The introduction of culture based fisheries can compensate some of the fisheries losses, but at the same time it will worsen the situation of the rural poor, because a shift from "free access" to "limited access" will take place.

The restoration of carp fisheries is beyond the limits of the CPP, but limitation of the losses of *beel*-fish due to the introduction of water management systems can be influenced. A *Beel* concept is proposed, in which the low land farmers are not recuperating all the potential available agriculture land, thus keeping partially intact the environmental conditions, needed for reproduction and nursing of the *"beel"* fish

The evaluation of FCD/I projects in Bangladesh on fisheries is hampered by the fact that most often no base-line information of the pre-project situation is available. Therefore, a Special Fisheries Study started in May 1992 under FAP 20, in cooperation with FAP 17 and FAP 16 (for the details of the proposal see Annex.3). This study covers the following aspect of fisheries:

Frame Survey
Catch assessment
Hatchling migration of major carps
Adult fish migration
Reproductive behaviour of *beel*-fish

An analysis of preliminary results of hatchling migration measured in the *Lohajang* river in 1992, indicates that time-span of migration can shift over the years and that they arrive in peaks. This mechanism implicates that secure water management regulation will be difficult to apply. The programme is carried out as planned and first results would be forthcoming by the middle of 1992, but at present it is realised that the final results will be much affected by the absence of floods during 1992. Until mid-September 1992 almost no flooding occurred within the CPP area and the floodplain is still dry and consequently the fishing activities are at dry season level. The representative value of the results will be limited in the case that now flooding occurs within this monsoon period and it is recommended to extend the special fisheries study over a full monsoon period during 1993 if this is the case.

The urbanisation level of the CPP-area, due to Tangail Town, is effecting the overall picture of fish production and fish consumption. Until now this subject is not covered,

but its importance justifies a special study, covering transport, marketing and consumption of fish.

Profound knowledge of fisheries science and its application in the development of fisheries management schemes is lacking in Bangladesh. Therefore it is proposed to train one or two fisheries biologists abroad. The 6 week training course on fisheries management, organised by the International Agriculture Centre, Wageningen, the Netherlands or the fisheries training course of ICLARM in the Philippines are recommended.

The introduction and investigation of new water management will be a continuous process and changes in the fisheries sector will take place gradually. Therefore, it is recommended to monitor fisheries on a permanent and regular base by one of the trained biologists during the planning, implementation and operational phase of the project.

6.4 Internal socio-economic impact

6.4.1 General

The main effects from compartmentalization with as yet ungated inlet structures would be:
- better drainage of low lying areas during the pre- and post monsoon,
- a reduction of flood plain fisheries due to a reduction of the time that the floodplain is flooded,
- no negative impact on navigation and on replenishing of soil fertility.

The main effects from the compartmentalization with gated structures are;
- flood protection, particularly for *Tangail* town,
- stable flood level and duration during the monsoon,
- a further reduction in capture fisheries and to some extent navigation.

All these effects will be more pronounced in the northern sub-compartments because they are affected by the inlet structures in the North more than the southern sub-compartments.

6.4.2 Farmers

Farm households (here defined as those households that operated 0.5 decimals or more) make up slightly less than 30% of rural households and 36% of the rural population. Of all farm households 4.5% are pure share-croppers, 23.5% are marginal farmers, 51.5% are small farmers, 15.2% medium farmers and 5.3% large farmers. Pure share-croppers own 0.6% of cultivated land, marginal farmers 12.0%, small farmers 40.8%, medium farmers 25.6% and large farm households 21.0%.

These figures indicate how skewed landownership is. Of the farm households the pure-share-croppers, about 5% of the farm households, own 0.6% of the land while the large farmers, also 5%, own 21% of the cultivated land.

All farm households operating F1 and F2 land (i.e., all but a few households) would, in the non gated situation, benefit from improved pre- and post monsoon drainage. This will allow an additional Rabi crop and/or timely sowing of Boro.

All farm households would benefit from reduced flood damage in the case that the inlet structures are gated. This is particularly relevant for small and marginal farm households which are often forced to make distress sales following sever flooding.

The main structural benefit from compartmentalization will be improved productivity of land. Large farm households operate a relatively large proportion of the available land. Through their access to (institutional) credit they will be able make the necessary investments. By share-cropping out part of the land they own, they will be able to get additional returns without investment in either capital or labour. Finally as through compartmentalization the need for credit increases large farmers might gain additional profit through lending money (at times re-lending institutional credit) to other farmers. On all these accounts the large farm households are likely to reap more than their proportionate share of the benefits from compartmentalization.

Medium and small farm households, which make up 66.7% of the farm households, and who operate about 70% of the land, are likely to benefit from compartmentalization to the extent that they have access to the necessary credit. If institutional credit were available in time and at the going rate then these categories of farm households would benefit from compartmentalization. To the extent that they have to rely on informal credit at high rates of interest, part of the benefits will be diverted to the money lenders. By improving overall productivity households that do have access to institutional credit might be able to delay they process of marginalization for the time being.

Marginal farmers and pure share-croppers are the least likely to benefit from compartmentalization. They normally have least access to the credit that is necessary to make use of the potential improved production made possible through compartmentalization. Furthermore the existing tenure arrangements divert up to half of the additional benefit to the landowner. Given the prevailing patron-client relationships it is quite likely that marginal and small farmers will be unable to stay in business. The likely increase in the value of land will be an additional factor in pushing them into the ranks of the landless.

6.4.3 Landless

Landless households will benefit from flood protection of their homesteads and whatever cultivated land they still own, in case of gated structures.

Landless might benefit indirectly through additional employment in the agricultural sector. Given the high percentage of non-farm households (over 70%) and the small percentage of medium and large farm households, it is unlikely that sufficient employment opportunities will be generated outside those households to increase the labour opportunities for landless.

To the extent that landless are involved in either navigation (not too much) or subsistence fisheries (very much) they are likely to be affected negatively (see below). The

improvement of the road system through compartmentalization is likely to mitigate these negative impact to a limited extent.

6.4.4 Fishermen

There are about 325 professional fishermen households who live in the Tangail CPP area. According to the household survey data they catch about a quarter of their yearly catch outside the project area. This quarter is unlikely to be affected by the project.

According to the Household survey about three-quarters of their yearly catch comes from within the project area. With compartmentalization this volume is likely to be reduced by 13-21% resulting in a reduction of income of about 20%.

There are about 930 part time or occasional fishermen families in the Tangail CPP area. As they only catch within the project area their total catch is likely to go down by 13-21%. In monetary terms this is about 20% of their income from fisheries.

According to national statistics about 65% of rural households are involved in subsistence fishery. In Tangail CPP this would represent more than 17.000 families, many at the lower end of the social strata. The reduction of 13-21% of catch to them is almost certainly a similar loss of protein intake for which there is no easy replacement. An increase in animal protein through poultry raising might to some extent mitigate this negative impact of compartmentalization.

As these different types of fishermen see their catches decline they may well be compelled to catch whatever fish remains. This would further reduce the fish stock in the area resulting in a continual decline of fisheries resources. Stocking of water bodies by the DOF might mitigate this situation.

6.4.5 Women

Women are likely to benefit from additional flood protection as they and their children are most vulnerable during floods.

The change in cropping pattern, away from sugarcane and DW Aman to HYV T.Aman and from jute to HYV Aus is likely to further aggravate the existing shortage of cooking fuel. The increase in rice production will raise the demand for female post-harvesting labour. This demand is likely to be met mainly from within the farm households as most of them are marginal/small, having excess labour.

The further reduction in livestock due to the reduction of fodder and grazing area will reduce the amount of manure available for drying and use as cooking fuel. All of these trends together will increase the burden of women who will have to spend more time and effort collecting fuel.

6.4.6 Urban population

The population of the towns constitute about 45% of the population of the compartment, and this percentage is still rising and likely to continue to raise in the future. In case of

gated structures the urban dwellers, and the industrial units and service sector, which are likely to be the main beneficiaries from the flood protection provided by the CPP.

Those in the town now depending on cheap navigation for transport of goods and people might gradually have to shift to more expensive road transport.

The environmental condition in the town is likely to improve by the proposed re-excavation of existing channels. However, to substantially improve the environmental situation the municipality will have to implement an integrated water supply, drainage, sewerage, solid waste disposal programme.

6.5 External socio-economic impact

6.5.1 General

The area adjacent to the Tangail CPP area has been divided into four impact zones. The area immediately North of the project, between the river *Dhaleswari* and the river *Pungli* is likely to be affected most directly. This area has a total population of about 38.000. Reduced inflow into the compartment might result in a rise of the water level in this area between 0 and 45 cm (1.5 foot). The highest level would be reached during an extreme flood, immediately upstream of the *Lohajang* intake.

The area West of the project, between the embankment and the river *Dhaleswari* might be slightly affected. This impact zone has a population of 2.500. Here the main impact will be phycological, except in the very North where the *Lohajang* takes of from the *Dhaleswari*. The project is unlikely to cause higher water levels in the river. The area on the West bank of the *Dhaleswari*, with a population of about 50.000 is not expected to be affected at all.

Down stream of the project the impact will vary between slightly less water (during the monsoon) and slightly more during the pre- and post-monsoon. The population in this area is estimated at 42.000.

Finally the northern part of the area East of the project, between the embankment and the river *Pungli*, could face a slightly higher water level during the monsoon. As the area is much smaller than along the *Dhaleswari* embankment, and as there are very few settlements in this area, the impact is likely to be very small.

On the basis of the above mentioned overall impact, the different socio-economic groups are likely to be affected as follows.

6.5.2 Farmers

Farmers in the adjacent areas may face slightly higher levels of water during the monsoon. This will limit their monsoon crop options to jute and DW Aman.

Overall the impact on agricultural production is likely to be minimal.

6.5.3 Landless

The landless in the adjacent areas might benefit from improved navigation possibilities as well as from improved road communication (mitigation measures).

Apart from this the impact on landless is likely to be minimal.

6.5.4 Fishermen

Fishermen of all types (professional, occasional and subsistence) living in the area upstream or adjacent to Tangail CPP are likely to be unaffected or even slightly benefitted by compartmentalization. Availability of fish fry that would otherwise enter the compartment as well as slightly higher water levels could possibly cause this affect.

Fishermen living downstream of the CPP area, along the floodplain of the *Lohajang* might experience a production in their fish catch due to reduced fishery migration.

6.5.5 Women

Women in the up-stream external area are likely to be negatively affected through higher water levels during the peak of the monsoon. Better water transport through re-excavation of the *Gala khal* and mitigation measures such as improved (higher) roads would partly compensate this negative impact. Maintenance work on the embankment would provide a long term benefit to a number of women-headed families.

Women along the *Dhaleswari* river, outside the embankment, could face slightly higher water levels during peaks in the monsoon. Places of refuge included in the embankment would provide a safe heaven during extreme floods. Maintenance work might provide some long term benefit.

The inclusion of representatives from the up-steam area (including women) in the committees once the inlet regulators become gated and thus can be operated, is expected to provide an institutional mechanism to keep the negative impact within tolerable limits.

6.5.6 Urban population

The only urban settlement in the adjacent area is *Delduar* town. Given the existing poor drainage situation of the town post-monsoon water drained out of the compartment might slightly prolong the drainage problem faced by the people of *Delduar*.

6.6 Environmental impact assessment

FAP 20 and FAP 16, the Environmental Assessment Study, have cooperated closely regarding the EIA for the Tangail CPP. As per the working agreement, FAP 20 has shared its baseline and other data with FAP 16. Where necessary FAP 16 has done its own additional data collection.

At the time of preparing this report the FAP 16 Tangail CPP EIA report is nearing completion.

7 OPERATION AND MAINTENANCE

7.1 General

In the ToR a compartment is described as a "management unit". Of such a compartment it is said that "... the involvement of the beneficiaries is considered essential for its success." [ToR, p.3]. In the long term this means that all concerned must be involved in operation. To provide the necessary sustainability their involvement in maintenance is also essential.

In this chapter the technical side of operating the different types of structures is dealt with first. Next the institutional side of operation is looked at and in the final section maintenance.

7.2 Operation of the structures

The structures as presented in Chapter 4, should permit a flexible water management of the compartment. It should be such that different requirements can be met.

This may go from the simulation of the existing situation where only during high flood the peripheral control structures will be closed (when it is decided to install gates in the northern inlets). It may also go up to a fully controlled situation where, depending on the hydrological conditions, only limited amounts of water will be allowed to enter the compartment and excess rainwater will be drained whenever possible.

As the operation procedures for the first situation are rather simple, all gates are open until an extreme flood event occurs whereupon all peripheral gates will be closed, this will not be dealt with here. However, it should be understood that a strong institutional set-up is a pre-requisite for such gated structures.

The operation procedures for the second situation more complex and are fully dependant on the prevailing hydrological conditions. In the following sections the structures will be grouped as follows:

- Peripheral control structures with regional requirements. This is the main inlet structure at the entrance of the *Lohajang*

- Peripheral control structures without regional requirements. This implies the medium inlet structures at *Rassulpur, Sadullapur, Jugini* and *Baruha* as well as the Kumuli inlet for SC15.

- Compartmental outlet structures. This implies the structures at District *khal*, Jalphai and *Bathkura* for the eastern halve of the compartment and the structures at *Dithpur, Kagmari, Baratia, Deojan* and *Birkushia.*

- Sub-compartmental regulating structures. This implies the structures at *Salina, Inayetpur* and *Gharinda* for the eastern halve of the compartment at *Singarkona* and

Santosh for the western halve of the compartment and at *Pashim Pauli* (SC 1), *Pathrail* and *Chala Atia* in the southern embankment.

- Minor drainage outlets to the *Lohajang*, to major drains and to the southern adjacent area.

- Irrigation inlets along the adjacent rivers including the existing structures along the *Dhaleswari* and *Elanjani* and the inlets at *Pathrail* and *Fusuki*(SC15).

- Irrigation passes along the adjacent rivers for dry season and wet season supplemental irrigation.

7.3 Technical guidelines

The following indication for the operation of the structures will be based on a typical year that starts with a dry compartment and low rivers; with abundant rainfall during the pre-monsoon; rising water levels in the rivers and the compartment during the monsoon and declining rainfall and river levels during the post-monsoon.

Peripheral control structure with regional requirements (main inlet)

At the start of the monsoon season the gates of the main inlet will be fully open. Flooding from the river is highly unlikely before mid June so that there will be no harm to the *Boro* crop.

Up to mid-July there is no requirement for flow-regulation for agricultural purposes. During this first period fish migration should be facilitated as much as possible.

From mid-July onwards there is a need for reduced water levels within the compartment for the planting of HYV Aman. A down-stream water level of 11.0 m+PWD corresponds with a flooded area within the compartment of about 50 %. It is suggested that this down-stream water level be maintained as closely as possible after mid July.

The proposed lay-out of 8 vents with two 2 blade vents at the outer sides of the structure will be operated as follows:

- When the down-stream water level rises above 11 m+PWD, the central vents will be closed first; the two side vents will remain fully open.

- When this does not provide sufficient control, the lower blade of the side vents will be closed as well. The overspill flow will facilitate fish-migration as far as possible.

- Only during exceptional flood events will the top blades of the side vents be lowered in order to close the structure completely. This may be expected once in several years.

- Incase alternative IA will be chosen, the operation rule will be adapted.

As indicated in section 4.1. it is envisaged that the main gate will be opened when the water level in the river reaches a 1:20 years high (13.15 m+PWD at *Ramdepur)* and the emergency spillways start to function.

Peripheral control structures without regional requirements

These structures will also remain open till mid-July in a typical year. There after it is possible to regulate the flow, depending on the needs of the beneficiaries flow will be regulated. It is proposed that for these structures again 2 blade vents will be used. This will imply that a first stage of regulation will be done by lowering the first blade, still permitting overspill flow, which is considered less harmful to fish migration.

In order to obtain sufficient control over the water levels within the compartment, these gates shall be completely closed for several days during several flood/rainfall events during the monsoon season. Depending on the downstream water level condition these structures may be fully open again during low flood periods in the monsoon.

At the end of the monsoon these structures are to be fully opened again as they will provide some drainage of a limited command area. These gates should also be opened when the emergency spillways start functioning (expected with the 1:20 years flood).

Compartmental outlet structures

These structures may serve both as inlet and outlet structures depending on the compartment/river water level.

Before mid-July they shall be open. They may serve as an outlet for the compartment during high local rainfall or as in inlet, permitting fish migration, during an early flood situation.

After mid-July the emphasis of these structures shall be on drainage promoted by the head difference over the main inlet. At a river stage higher than the compartment level they shall be closed and be opened again when the situation reverses.

At the end of the monsoon these structures shall be opened completely. The gates may also be opened when the emergency spillways start functioning (expected with the 1:20 years flood).

Sub-compartmental regulating structures

These structures do consist of two parts; a low section with a regulator based on the pre-monsoon discharge requirement and a weir section where the fixed weir level is based on the required water level in the upstream part during the monsoon.

The regulator part will be open during pre-and post-monsoon periods and closed from mid July onwards.

During an extreme flood when the emergency spill sections are functioning, the weir section will permit a full discharge.

Minor drainage outlets

The operation procedures for these structures may be similar to the compartmental outlet structures. Since the operation procedures for the compartmental outlet structures are quite complicated it is suggested that the minor drainage outlets be open during pre and post monsoon and be closed continuously from mid July onwards. Their capacity is limited and it may be expected that the necessary discharge during the monsoon passes via overland flow to the compartmental outlet structures.

Irrigation inlets

The irrigation inlets will normally be closed. Only during dry spells in the monsoon period they may be opened for flooding of the compartment.

Irrigation passes

Irrigation passes mainly serve a purpose during the dry season to permit flow from low-lift pumps through the embankment. They are normally closed during the wet season except for supplemental irrigation during dry spells with low water levels in the adjacent rivers.

When the river flooding is late start of the regulation should be at a later date to permit sufficient migration of fish. When river flooding starts exceptionally early it may be suggested to invoke peripheral control in May/June in order to prevent damage for the Boro harvest.

It may be suggested furthermore that different parts of the compartment will be exposed to different levels of control thus favouring fisheries or another group of beneficiaries, instead of agriculture.

7.4 Institutional guidelines

The complexity of the structure and the scope of its impact will determine which institutional arrangements for its operation are desirable. The actual competence of a particular institution will determine whether responsibilities for operation will indeed be delegated to that institution, possibly after training and with provisions for technical advice.

In practical terms this means that operation of structures that affect areas larger than the compartment will, for the time being, be done by the BWDB. Lacking any representative institutions beyond the compartmental level and taking into account the sophistication of operation requirement, the BWDB provides the only practical option.

Going below this level the envisaged Compartment Water Management Board can, when built up to a sufficient degree of capability and representation, be charged with decisions regarding operation that affect the compartment as a whole. FAP 20 intends to install the Provisional Compartment Water Management Board after mid 1994, when all sub-compartments will be established physically and institutionally, and when relevant training is expected to be completed. The precursor to this provisional Board is the CPP/Executive

Committee which might gradually become involved in advice and guidance regarding operation of main structures. Whatever the precise arrangements will be, three conditions will need to be met in the case of compartmental institutions assuming some degree of responsibility for operation:

- the establishment of operational guidelines by CPP and BWDB
- the establishment of consultative arrangements with Sub Compartment Water Committees.
- effective understanding with other relevant agencies, such as LGED, Union Councils.

For structures that substantially affect more than one sub-compartments either the concerned SCWC will establish a mechanism for joint operation, or the CWMB will assume responsibility for these structures. The latter will be the case if the number of involved sub-compartments and/or the competence or compatibility of the concerned sub-compartments do not allow the decentralization of these decisions and their monitoring.

For structures that essentially affect only a particular sub-compartment, the SCWC will be in charge. In a number of cases the "boundary conditions" for the operation of such structures will be determined by the CWMB. This will be determined on a case by case basis, depending on technical criteria. The SCWC will oversee operation, consulting with CWMB and BWDB on the one hand and with Water Users Groups on the other.

Structures that affect only an area within a sub-compartment will be the responsibility of a Water Users Group, provided such a group exists and reflects a balanced representation of the various socio-economic categories of those concerned. In many cases this will be obvious, e.g. an irrigation inlet supplying an identifiable group of farmers. In other cases the situation could be more complicated, as down-stream or upstream interest groups (fishermen!) can be affected. In such situations the SCWC will either set boundary conditions for the Water Users Group operating the structure, or will establish a mechanism for the various affected groups to work out common solutions or, in case all else fails, will assume operational responsibility for the structure.

Summarizing the rule will be that the responsibility for operation of structures will be put at the lowest possible level (which will normally be the level exclusively affected by the structure) with consultation towards the next lower level and supervision by the next higher level. In the following diagram these various aspects are displayed.

structure type	deciding agency	consulta-tion	operat. criteria	execut-ing agency	con-troling
peripheral control with regional req.	BWDB	MIW-DFC	regional WL	BWDB operator	MIW-DFC
peripheral control w/out reg, req.	CWMB	SCWC	US/DS WL	CWMB operator	BWDB
compartment outlet structure	CWMB	SCWC	US/DS WL	CWMB operator	BWDB
sub-compartmental regulator	SCWC	WUG	US/DS WL	SCWC operator	CWMB
minor drainage outlet	SCWC	WUG	US/DS WL	SCWC operator	CWMB
irrigation inlet	SCWC	WUG	rain/ flood	SCWC operator	CWMB
irrigation pass	WUG	farmers	rain/ flood	WUG operator	SCWC

Following abreviations have been used:
- MIWDFC: Ministry of Irrigation Water Development and Flood Control.
- BWDB: Bangladesh Water Development Board.
- CWMB: Compartmental Water Development Board.
- SCWC: Sub-Compartmental Water Committee.
- WUG: Water User's Group.
- US/DS WL: Upstream and Downstream water level.

7.5 Maintenance

7.5.1 General

Maintenance in the compartment is required for structures, embankments and channels.

In line with the procedures elaborated by SRP maintenance can be divided in:

- preventive maintenance
- periodic maintenance
- emergency maintenance and
- rehabilitation.

Preventive maintenance entails replacement of minor spare-parts, greasing, painting, filling of earthwork patches, turfing etc. at fixed time intervals.

Periodic maintenance is the verification of the structural works on their functioning and general performance, repairing elements as required.

Emergency maintenance is required when the proper functioning of the structure can not be guaranteed any more because of the degradation or mal-functioning of some parts of the structure.

Rehabilitation is done when the design standard is not met after emergency maintenance or when the design standard need be adjusted.

7.5.2 Responsibilities

Maintenance of structures has traditionally been done by the BWDB and, for minor structures, by the Local Government Engineering Department (LGED). Under compartmentalisation other participants will also be involved in maintenance, to the degree such participants are organized in a structured and accountable institution:

- CWMB (Compartmental Water Management Board), with the CPP/EC as its predecessor.
- SCWC (Sub-Compartmental Water Committee),
- WUG (Water Users Groups)

It needs to be worked out to what extent local contributions will be sought through these various institutions. The long-term objective is that the maintenance costs of sub-compartmental specific structures will become the responsibility of the SCWC, with subsidy from the GOB (via BWDB). Subsidy arrangements will need to be elaborated. Local contributions can be collected via levies and labour input collected at the sub-compartmental level.

For more sophisticated structures at the sub-compartmental level, that require more specialized maintenance the BWDB and LGED will be the executive agency. However the SCWC will be responsible. Subsidy arrangement will have to be established, whereby labour will be an accepted form of local contribution.

For structures at the compartmental level the BWDB will do maintenance, unless other arrangements are made, while responsibility will eventually be with the CWMB, which will in due course supersede CPP/EC. No local contribution is envisaged for O&M at this level.

7.5.3 Execution

For the actual realization of maintenance three types of maintenance groups may be involved:

- SMG: Structures Maintenance Group.
- EMG: Embankment Maintenance Group.
- CMG: Channel Maintenance Group.

The distribution of roles for these groups or agencies for specific tasks is proposed as follows:

For **structures** different aspects are important for the implementation mode of maintenance:

- a controlled or semi-controlled structure.
- the size and impact of the structure.

This will determine the degree of specialisation of the work. Most tasks will be so much specialised that the BWDB has to be involved, while in a number of situations LGED will do the work (e.g. culverts, bridges). Only for related earthwork of controlled and semi-controlled, medium and main structures may other agencies or groups be involved. Provided that they receive a proper training, preventive maintenance may be done by a SMG.

Only the very minor structures (e.g. irrigation passes) may possibly be fully maintained by a SMG or even a WUG under responsibility of a SCWC.

Maintenance of **embankments** requires a considerable amount of non specialised work for filling of erosion trenches and replanting of the turf layer. This may be done by EMG's and eventually WUG's.In case of an embankment failure, overtopping during a high flood or up-grading of the design standard, emergency maintenance and rehabilitation will be required. In order to maintain the design standard, specialised supervision is required (BWDB).

For the maintenance of **channels** a distinction can be made between local channels for the drainage of a *beel* area and (sub)-compartmental channels for the drainage of a larger area. The former can be excavated by a group of interested users. The (sub-) compartmental channel will not be excavated in this way because it has more regional implications. Payment for the work by CMG's is required.

The principal maintenance activity is excavation of earthwork. Channels that are completely silted up may be rehabilitated under supervision of the CWMB or the LGED.

The following table summarizes maintenance tasks and the institutions involved. The most appropriate institution for maintenance monitoring has also been indicated:

Distribution of responsibilities for Maintenance:

Maintenance for:	Maintenance	Rehabilita-tion	Monitoring
Major structures	SMG/BWDB	BWDB	BWDB/CWMB
Medium structures	SMG/BWDB/LGED	BWDB/LGED	BWDB/LGED/CWMB
Roads	DRHW	DRHW	DRHW/CWMB
Minor structures	SMG/LGED	LGED/BWDB	SCWC/BWDB
Embankments	EMG	BWDB/CWMB	BWDB/CWMB/SCWC
Earthwork major/ medium structures	SMG	SMG/BWDB	BWDB/CWMB/SCWC
(Sub-)compartment channel	CMG	SCWC/LGED/ CWMB	SCWC/CWMB
Beel channel	WUG	SCWC/LGED/ WUG	SCWC
Retention bunds	WUG/farmer	WUG/SCWC	SCWC/DAE

The following abbreviations have been used:

BWDB: Bangladesh Water Development Board
CWMB: Compartment Water Management Board
SCWC: Sub-Compartment Water Committee
LGED: Local Government Engineering Department
DRHW: Department of Roads and Highways
WUG : Water Users Group
EMG : Embankment Maintenance Group
CMG : Channel Maintenance Group
SMG : Structures Maintenance Group
DAE : Department of Agricultural Extension

8 MULTI-CRITERIA ANALYSIS

8.1 General

The primary objective of this chapter is to analyze and present the overall impact of FAP 20 with emphasis, however, on economic criteria in the light of national aspects. This is justified as flood protection and improved water management, both main objectives of CPP, cannot be independently provided to selected individuals. However, this is not a feasibility or pre-feasibilty study as such and should not be read like that. Such a study is not foreseen in the ToR and should have asked for different approaches and staffing.

The approach followed is that of a Multi Criteria Analysis of which the core consists of a Cost/Benefit analysis. These are supplemented with some comments on the private sector. The data applied and the information used in forming the conclusions presented in this report originate in most cases from the inputs of all other disciplines as presented in previous chapters of the present report. If other sources have been used they will be cited accordingly. All prices used in forthcoming calculations are those proposed in the *GUIDELINES FOR PROJECT ASSESSMENT* (FPCO, May'92). Financial costs are corrected with conversion factors provided by the same source in order to reflect the economic opportunity costs of resources and commodities. The cost of capital is fixed at 12 %.

The data used and all conclusions forwarded hereafter is therefore based on the latest available information with bearing on the project region. This, however, does not exclude a continued verification of all vital data as the project advances.

The approach used here to document the findings is based firstly on the general examination of all relevant costs, followed by the description of the benefits attributable to the project. Multi-criteria-assessment elements have been used to evaluate both costs and benefits which are not quantifiable in monetary terms.

8.2 Costs of the Tangail CPP

8.2.1 Direct costs

Direct costs in the context of CPP will be divided into:

- investment costs, and
- recurrent costs.

Investment costs will be determined by the flood control and water management structural measures required to achieve the given objectives. Structural requirements and designs have been explained in detail in Sections 4.2 and 4.3 . The implementation schedule and cost estimates are presented in Chapter 5. They are not recapitulated in this chapter. It is, however, worth mentioning that those structures may be classified according to their main objectives into measures designed for peripheral control and for internal control, whereby peripheral control is again subdivided into external peripheral control and peripheral control south.

This classification in three parts has not only been decided on in view to streamline implementation schedules more conveniently, but should also be understood as an attempt to optimise investment costs without neglecting conditions influencing fixed compartmentalization criteria. Parts of them or even complete entities may be excluded or included in the computations in view to costing considerations, as preliminary figures already in the early planning stage revealed the heavy burden of investment costs on the project. For this reason, alternative construction options have been elaborated. They differ mainly in the number of regulators and the volume of mitigation measures envisaged, like the number of mooring facilities for instance and the length of roads to be realised. Those alternatives and the reasoning for varying combinations will not be repeated here. Their overall financial costs per alternative as well as the breakdown into their main components are summarized below as follows (in million Taka):

Alternative	Peripheral control South	Peripheral control	Internal control	Total
I A	119.63	3.70	64.32	187.65
I B	122.13	3.70	64.32	190.15
II A	123.63	3.70	103.11	230.45
II B	126.13	3.70	103.11	232.95
III A	126.13	26.96	103.11	256.11
III B	173.34	26.96	103.11	303.32

A more detailed break down of above costs has been provided in Table 3 (Alternative IA, IIA and IIIB) in Annex 6.2, giving additional information on the timing of investments and the part to be paid in foreign exchange. The percentage in foreign exchange has been estimated based on the experience of the consultants in similar assignments but most of all on rates identified by FAP 3 (Preliminary Supporting Report VII, Engineering, July 1992). It is believed that the overall rate of foreign exchange in all alternatives will be about 40 % of total investment costs.

In the computations, neither replacement costs nor salvage values have been considered for the proposed structures, as all components are believed to last at least the economic life span of the project, assumed to be 30 years. Directly related to the construction are engineering fees, which, in compliance with the Guidelines for Project Assessment, have been fixed at 15 %. Other investment costs, like buildings, vehicles or equipment have not been determined so far. Due also to like of suffiently detailed information on construction materials and their origin, the following factors have been applied to convert financial into economic prices:

- all labour intensive work (embankment, erosion control, drainage) = Standard Conversion Factor for unskilled labour, equal to 0.65, and

- all others = SCF Engineering and Administration: 0.87

Recurrent costs

Again, because of the non-availabilty of yet exact information on specified operation and maintenance costs (O&M), those have been determined by means of percentage rates of the corresponding investment. The rates applied originate from the Guidelines and are quoted as follows:

- Erosion control	10 %
- Embankment, drainage, mitigation measures	6 %
- Roads	5 %
- Vehicles, equipment [1)]	4 %
- Regulators, culverts	3 %
- Buildings, bridges	2 %

1) not considering direct operational expenses

Note: no SCF is stated, as O&M costs will be changed automatically to economic costs when those are applied to the investment costs.

Other recurrent costs are expenses for technical staff, required to supervise and partly to operate the system. The number of staff required, their designation and corresponding wage rates as proposed by the Project Team are shown hereafter:

Technical Staff Requirements

Designation	Number of staff per alternative			Wage rate Tk/m
	IA	IIA	IIIA	
Sluice Khalashi	10	22	26	2.000
Assistant	3	7	9	3.000
Emb. Khalashi	24	32	40	2.000
Assistant	3	3	4	3.000
Section. Officer	2	2	2	5.000
Surveyor	2	2	2	3.000
Other	2	2	2	2.000
Subdiv. Officer	1	1	1	7.000
Office Assist.	2	2	2	3.000
Other	4	4	4	2.000

Note: Sluice Khalashis will only be engaged for five months per year during the monsoon period. The functions of embankment Khalashis will be taken over partly or totally by Earthwork Maintenance Groups.

The conversion factor applied to convert costs of technical staff into economic costs is the SCF for skilled personnel, equal to 0.87.

The costs for Technical staff may have been overestimated, as part of their costs is considered to be included in the percentage provisions for corresponding investments. On the other hand the application of the SCF for unskilled labour in calculating economic

investment costs for embankments, erosion control and drainage may lead to an underestimation of the respective costs as well.

Additional recurrent costs are to be considered for administrative overheads, estimated to be 10 % of the costs for Technical staff.

All recurrent costs identified to be of importance are summarized as follows:

Recurrent costs per Alternative (mill Tk.)

Alternative	O&M Staff	Technical Overhead	Adminis.	Total
I A	8.6	0.8	0.1	9.5
I B	8.7	0.8	0.1	9.6
II A	8.9	1.1	0.1	10.1
II B	9.0	1.1	0.1	10.2
III A	9.9	1.2	0.1	11.3
III B	12.3	1.6	0.2	14.1

It should be noted that the recurrent costs cited above represent the maximum costs as from project year three onwards, as the construction will be completed by then. The development of recurrent costs is demonstrated in Table 2 in Annex 6, referring to the alternative concerned.

8.2.2 Indirect Costs

Indirect costs attributable to FAP 20 which may be determined and quantified in monetary terms are costs for:

- Land acquisition,
- Production foregone.
- Non structural measures.

Most of the land to be acquired will be of the F0 category which, according to the Household Survey, fetched a price in 1991 of Tk 75,000 acre or Tk 182,500 ha. Multiplied with the corresponding area, estimated to be about 210 ha, this amounts to Tk 38.9 million for land acquisition in the first year of implementation. Those costs do not include any provisions for administrative costs surely involved in the identification of the persons entitled and the disbursement of the compensatory payments. It is normal practice to value land acquisition costs equally in financial and economic terms as this distinction is met in the evaluation of the agricultural production foregone.

Production foregone has, of course, to be orientated on those lands permanently lost for agricultural production. This is the same in area and quality with the land to be aquired for construction purposes. Its evaluation in monetary terms is based on the equivalent of the production foregone, expressed in Taka per ha Value Added. As this land belongs to the category F0 land, with an overall cropping intensity of 145 %, a correction factor of

0.71 has been introduced to allow its comparison with the Value added calculated on the average cropping intensity of 203 % in the project region. In computing the final value of the production forgone the area to be taken into consideration will be 168 ha as only 80 % of the corresponding area is presently cultivated. Giving a Value added of presently Tk 20,502 ha (Tk 17,722 ha in economic terms) the production foregone amounts to Tk 2.47 million per year (Tk 2.11 million in economic terms).

Non-structural measures are believed to be vital for the success of the project, including training for both, participants in project activities on beneficiary level and various personnel on staff level. Information on type of non-structural measures and corresponding costs have been forwarded in Section 5.4. Here only the total costs of Tk 13.1 million, to be disbursed over the first three years, have been retained.

Further indirect costs are to be considered, for instance to mitigate some of the losses in fish production expected to be caused by the additionally introduced regulators into the region, even though they will be constructed as fish-friendly as possible. Those measures could consist in the provision of fingerlings to aditionally "stock" the floodplain during the flood period. As those fingerlings will consist mainly of minor or major carps (see Section 6.3 for more details), the losses in production may partly be replaced, but not the huge amount of small fish on which especially the poorest strata of the population depend for the provision of vital protein in their daily diet. This part of the population will also have no access to the additionally provided fry as it will surely be controlled by the more influential people in the region.

8.3 Benefits of the Tangail CPP

8.3.1 Direct benefits

While at least the most important part of the direct costs may be computed fairly accurately, benefits will - prior to the implementation of the programme - all have to be estimated based on the assumptions on which the project objectives have been formulated.

The following major fields for potential direct benefits will be dealt with in detail:

* Crop Agriculture and livestock
* Fisheries
* Damage prevention

8.3.1.1 Agriculture and livestock

Crop production

The most important positive effects expected by improved water-management will result in more favourable conditions for agricultural production by delaying early floods in the Kharif I season and by lowering of waterlevels in Kharif II season combined with faster drainage of water of late floods in the beginning of the *Rabi* season. This will, of course, not increase the cultivable area. It will, however, allow a further intensification of agricultural production by permitting a switch from broadcast aman to transplanted aman.

This may be accompanied by a more intensified use of the *Mug* season (possibly one additional crop of mustard) due to more effective drainage. As virtually all other important crops like wheat, oilseeds, pulses, potato and most vegetables are winter (*Rabi*) crops, this will leave large options for crop diversification, especially as these crops will compete with Boro-rice for the limited amount of suitable land for irrigation. Sufficiency levels in staple food (cereals) at farm level already at present, crop diversification at the expense of rice may become a viable option for many farmers (for further reference see Section 6.2).

Expected agricultural benefits have been estimated and evaluated by means of a model. The model informs on relevant impact in consecutive steps. Forthcoming information has been compiled in tables as explained below. (All tables may be consulted under corresponding numbers in Appendix E, Annex 2).

Table 1: Gives an overview of the general situation of agricultural production in the project area in terms of gross area, cultivable area and cropped area based on the 16 sub-compartments. In addition to percentages of land in view to multiple cropping, it also shows the overall cropping intensity in the project region,

Table 2: Shows details as to the composition of rice crops in the project area and the respective hectareage per type and sub-compartment,

Table 3: Informs on the total rice production broken down into quantities as per type grown and their respective yields per unit.

Table 4: Divided into sub-tables 4.1 and 4.2, repeats the information given in Tables 2 and 3, now referring, however, to other major crops grown in the area under review,

Table 5: Calculates the variations of important economic criteria like gross margins and value added. These variables are essential for comparison of possible developments in the "With-out" project and the "With" project situation. (They include prices and conversion factors applied, in financial and economic terms).

Table 6: Summarizes the impact of programmed development in terms of changes in absolute and relative terms as to cropped area, total production and yields per crop grown. It further specifies two important variables.
a) the ratio: local varieties to HYV in rice, and
b) the ratio: rice crops to non-rice crops (diversification).
This table contains most of the decisive information on the impact of the proposed interventions they will have on agricultural development and, consequently on the expected benefits.

Table 7: Translates the information shown in the table above to monetary values related to additional production and informs on changes as to agricultural employment and draught power, due to project impact.

Prior to the presentation of the potential impact of the project on agricultural development the underlying assumptions are summarized in Table 8.1 below.

Table 8.1: Growth rates in future development (in %)

Crop	future situation with project yield	future situation project area	future without yield	future situation project area
Potato	0.0	2.9	-0.3	0.8
Wheat	0.0	3.7	-6.1	1.7
Sugarcane	1.0	-20.0	-1.1	0.4
Jute	0.9	-15.0	0.9	-3.8
Mustard	0.9	10.0	0.9	0.6
Vegetables	1.2	0.0	1.2	0.0
Pulses	0.1	2.9	0.1	1.2
Boro, HYV	0.2	7.2	0.2	4.7
Boro, local	-0.5	-4.7	-0.5	-4.7
Aman, HYV	0.1	220.0	0.1	5.6
Aman, local	1.4	50.0	1.4	-2.0
DW Aman, broadc.	0.1	-10.0	0.1	-3.3
DW Aman, transpl.	1.4	-10.0	1.4	4.1
Aus, HYV	-1.2	0.0	-2.4	0.0
Aus, local	1.7	-3.4	1.7	-3.4

Growth rates shown in the above table have been computed by means of a trend analysis on both, crops cultivated in the area and on yields. Both have been based on periods between fourteen (all rice crops) and seven years (wheat), according to the data available from the existing sources. Figures have been corrected by mutual agreement of team-members to take into account very recent developments, additional information originating from the Household Baseline survey and special conditions (areas) in the project region as made available by the GIS atlas (FAP 19). Growth rates, however, for all Aman-rice as well as for sugarcane and jute referring to the future situation "with project" have been calculated by the Agronomists to account for additional opportunities which will be created through controlled water management, especially during the Kharif II season.

The outcome of the project in comparison with assumed developments in the "with-out" situation is shown in Table 8.2.

Table 8.2: Summary of Impact on Agricultural Development

Criteria	Present situation			Future situation					
				with project			without project		
	Area ha	Product. tons	Yield kg/ha	Area ha	Product. tons	kg/ha	ha	tons	kg ha
Rice area									
- total	10,564	28,181	2,668	11,278	31,184	2,765	10692	29013	2,714
- Boro	3,557	15,630	4,394	3,793	16,727	4,410	3708	16348	4,409
* HYV	3,390	15,142	4,467	3,634	16,265	4,476	3549	15886	4,476
* local	167	488	2,921	159	463	2,906	159	463	2,912
- T.Aman	1,070	2,555	2,388	1,982	5,097	2,571	1065	2584	2,426
* HYV	222	720	3,244	710	2,307	3,247	234	761	3,252
* local	848	1,835	2,163	1,272	2,790	2,194	831	1823	2,194
- DW.Aman	3,717	6,314	1,699	3,346	5,736	1,715	3761	6470	1,720
* broadcasted	1,464	2,229	1,523	1,317	2,008	1,524	1415	2158	1,525
* transplanted	2,254	4,085	1,813	2,028	3,728	1,838	2346	4312	1,838
- Aus	2,220	3,682	1,659	2,157	3,623	1,680	2157	3611	1,674
* HYV	356	978	2,748	356	967	2,715	356	955	2,683
* local	1,864	2,704	1,450	1,801	2,656	1,475	1801	2656	1,475
- Jute	1,514	2,615	1,727	1,287	2,242	1,743	1456	2538	1,743
- Potato	495	4,680	9,455	509	4,816	9,455	499	4704	9,427
- Sugarcane	691	21,262	30,770	553	17,021	30,790	694	21332	30,738
- Wheat	1,963	4,442	2,263	2,036	4,769	2,343	1996	4577	2,293
- Mustard	1,267	1,088	859	1,394	1,208	867	1275	1105	867
- Pulses	733	779	1,063	754	803	1,064	742	789	1,063
- Vegetables	939	7,484	7,970	939	7,574	8,066	939	7574	8,066
- Other crops	513	2,543	4,962	984	4,900	4,980	459	2281	4,969
Ratio:									
Local/HYV (rice)	1 :	0.60		1 :	0.71		1 :	0.63	
Other crops/rice	1 :	1.30		1 :	1.33		1 :	1.33	

Source: Project computations

Above figures are produced by the model based on the underlying assumptions described earlier in this chapter. They may be interpreted as follows:

The future situation with project compares favourably with present situation in terms of overall cropped area, which rises from 18,679 ha to 19,733 ha, adding 981 ha to the totally cropped area. This figure has already been corrected by the expected development in the "with-out project" scenario. Rice crops take the major share with 586 ha (59.7 %) leaving 395 ha for non-rice crops. The most outstanding feature is the switch from D.W. Aman to T. Aman and the additional increase in the HYV Aman area. The development in non-rice crop is characterized by losses of cropped area of jute and sugarcane and substantial gains for mustard and "other" crops. ("Other" crops function as a buffer in the model.)

The cropping intensity will move from 203 % at present, to 215 % in the future. This development is estimated to be achieved in year seven of the project or, more precisely, five years after the implementation of the major components.

The ratio of local varieties to HYV in rice will improve from presently 1 : 0.60 to 1 : 0.71 during this period, while the ratio of non-rice crops to rice-crops will remain more or less stable - 1 : 1.30 at present compared to 1 : 1.33 in the future.

The impact on production shows a plus of about 2,200 tons in rice (corrected by "with-out project" figures) while the overall production of non-rice crops will decrease by about 1,550 tons, mostly non-staple crops, like sugarcane and jute.

The average value added of all crops slightly improves in the "with" project situation, due to an improvement in yields (local to HYV) and a switch from less to more profitable crops (deep water aman to transplanted aman). Rates are shown below:

Value Added

Agricultural Production	Financial value,Tk/ha	Economic value,Tk/ha	% Increase
Present situation	20,502	17,722	3.1%
With-out project	20,558	17,777	
With project	20,610	17,832	6.2%

The value added, defined as the final produce less the value of material inputs (raw material, intermediate materials and utilities like irrigation water and electricity), is the value that has been added by the labour and capital employed by the producer. It is used to quantify the agricultural benefit in monetary terms. The computation of the value added (and gross margins) for all individual crops included in the evaluation, are shown in Tables 5 (in financial and economic terms), Annex 6, informing on the parameters applied.

The value added determined for the "with project" situation multiplied by the additional area cropped gives the annual agricultural benefit and amounts in this case to Tk 20.22 mln. in financial and to Tk 17.49 mln. in economic terms.

Livestock production

Apart from some small dairy farms and beginning poultry activities, organised and commercial livestock production in the project region is almost non-existent.

The present population of livestock in the project area as to number, species and their regional distribution are of minor importance here and may be taken from the Household Baseline Survey. The following figures only refer to total numbers of respective species to allow a first orientation.

In the project area there is a total number of 38,000 cattle, some 68 waterbuffaloes, 7,860 sheep, 25,000 goats and almost 104,000 poultry and 15,000 ducks.

Non-grazing dairy activities in the project area seem to be concentrated in the Union of Danya where two dairy cooperatives are active, with 288 milch cows in one and 338 in the other. Average performance per cow was about 345 ltr/year with a peak season between January and June.

The most important use of waterbuffaloes and oxen is as draught animals. Their efficiency, however is reduced by sub-optimal feeding, both in quality and quantity, most of all in the dry season.

The situation described, as well as the scarcity of reliable data in combination with the little quantifiable impact on future livestock activities by the project has led to the decision not to attempt monetary evaluation at present. Increased efforts to improve the data base on livestock activities in years to come may allow the quantification in monetary terms at a later stage.

Intangible benefits or disbenefits will, however, be discussed in Section 8.4.

8.3.1.2 Fisheries

The impact of especially the structural measures of flood protection and improved water management as proposed by the CPP, has been described in detail in Section 6.3 and Annex 3. It has been concluded that the overall impact will be negative, resulting in an annual loss in production of almost 50 tons of fish, valued at Tk 2.12 mln. Further details may be derived from Table 8.3 below.

Table 8.3: Fish Production as affected by CPP

Species	Present situation			Future situation			Impact
	Rivers Beels To/yr	Flood plain To/yr	Rivers Beels To/yr	Flood plain To/yr	Prod. To/yr	Market price Tk/kg	Value Tk mln
Major carp	10.7	4.0	7.7	3.8	-3.2	80	-0.26
Minor carp	10.9	0.0	7.9	0.0	-3.0	70	-0.21
Catfish	15.9	17.6	11.5	16.4	-5.6	45	-0.25
Live fish	7.0	5.3	5.8	5.0	-2.4	45	-0.11
Sm. Shrimp	4.8	0.0	3.5	0.0	-1.3	30	-0.04
Miscellaneous	76.8	156.1	55.6	145.9	-31.4	40	-1.26
Total	127.0	183.0	92.0	171.1	-46.9	45	-2.12

Above data refer to financial prices and have been taken from the sources cited above. It has already been mentioned that the production foregone consists to the overwhelming majority of small and miscellaneous fish. Those fish constitute the main source of protein for the poorest part of the population, otherwise deprived of other means to compensate for the deterioration in their nutrition.

Taking this into account and giving the fact that the Guidelines apparently do not specify a conversion factor for fish, the economic value in the present evaluation has been calculated by a SCF of 1.2. The corresponding value would amount to Tk 2.54 mln. per year. This seems to be justified in view of mitigation measures required to restore the nutritional value for the population most seriously affected. The factor proposed, is based exclusively on estimates of the economist and may even be on the low side. Agreement on FPCO level on justified approaches to compute a respective factor would be appreciated.

Even though the impact on fisheries is negative, thus representing costs and not benefits, they are for methodological reasons (fisheries need not be per se negative) classified as benefits - in the present case unfortunately as disbenefits.

8.3.1.3 Damage prevention

Floods in the context of compartmentalization will be understood as either the single or 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.

Assessment of damages from both external and internal floods still seems to be controversial in two aspects. Firstly as to the sources of figures about flood damages and secondly, in view to the extent of damages prevented through compartmentalization.

As to the first topic, official information collected in August 1991 from the Thana office of the Ministry of Relief and Rehabilitation, see Table 1 in Annex 6.2, differ substantially from those provided by the Livestock Department and Department of Agricultural Extension, both also at Thana level. Differences in some categories, especially as far as livestock is concerned, are as high as 500 %.

The reason for retaining such figures may be understood as an attempt to provide information on the high side of damages. This may not be justified given following arguments:

Damage of floods on physical infrastructure (embankments, roads, buildings etc.) are most likely overestimated by far because of:

- mismanagement by autocrities of those in charge of maintenance of these assets and lack of funds,
- constant misuse of existing roads by overloaded trucks and busses going at high speeds,
- poor construction of buildings and roads,
- overestimation of agricultural production in terms of yield and most likely area.

In reality, exceptional floods uncover to a large extent man-made deficiencies. Real damages attributable to floods are much less severe. Floods seem at present to be used to some extent to hide human shortcomings in national resources management.

The second aspect, the capability of compartments as such to reduce damages, is of course of equal importance. Controversial points may not be the methodological approach, but rather the source of the data and the calculation of the figures themselves.

The approach finally adopted to assess damages should be studied at Flood Action Plan level, to make assessments transparent and comparable when used in different FAP projects.

Table 2 and Graph 1 in Annex 6.2 inform on data and methodology used to estimate values for flood damages prevented. It is based on both official data, converted to the project region and figures already subtracted from the HH-survey. All of them are still believed to be highly overestimated and are thus questionable. The total sum amounts to Tk 6.4 mln. Taka per year in financial terms and Tk 5.57 mln. in economic terms (SCF = 0.87).

8.3.1.4 Recapitulation

In recapitulating all direct benefits the figures shown below refer to the estimates described above.

Summary of direct benefits in Tk mln. per year

Component	financial	economic
Plant production	20.22	17.49
Live stock	n.a.	n.a.
Fishery	- 2.12	- 2.54
Damage prevented	6.41	5.57
Total	24.51	20.52

It should be noted that above figures refer to full development, which will be reached five years after the completion of major structural measures. The development of annual benefits are presented in Table 7, Annex 6.2.

8.3.2 Indirect benefits

Indirect benefits may accrue in form of farmers contribution in money or kind to pay, at least part of the O & M costs. Without yet precise information on the determination of those contributions, they have been assumed to be 5 % of recurrent costs, equal to about Tk 0.5 mln. per year (about Tk 25 ha/year or Tk 10 acre/year). As they must be regarded as transfer payments, they will not be considered in the economic evaluation (national approach).

Additional indirect benefits have been included to opt for any benefits not or not yet quantifiable in monetary terms. A rate of 5 % of compounded benefits (about Tk 1.0 mln Taka per year) is regarded as justifiable for this purpose.

Detailed information as to absolute figures of the total amount of indirect benefits per year, amounting to about Tk 1.5 mln. per year, may also be taken from Table 7, Annex 6.2.

8.3.3 Summary of benefits

First conclusions may now be drawn as that part of the analysis which concentrates on the evaluation of all factors which may be quantified in monetary terms, is complete. All parameters believed to be vital for judgement as to the viability of the project have been compiled in the following table.

Table 8/ Summary of Economic Criteria

Criteria	Unit	Alternative											
		I A		I B		II A		II B		III A		III B	
		econ.	finan.	econ.	finan.	econ.	finan.	econ.	finan.	econ.	finan.	econ.	finan.
Investment cost	Tk mln.	147.9	187.7	150.1	190.2	185.1	230.5	187.3	233.0	205.7	256.1	236.4	303.3
* Foreign Exch.	%	41.0	41.0	41.3	41.3	45.2	45.2	45.4	45.4	45.6	45.6	40.9	40.9
Engineering cost	Tk mln.	19.3	28.1	19.6	28.5	24.2	34.6	24.4	34.9	26.8	38.4	30.9	45.5
Total investment	Tk mln.	167.2	215.8	169.7	218.7	209.3	265.0	211.7	267.9	232.6	294.5	267.3	348.8
Recurrent cost	Tk mln.a	7.3	9.5	7.4	9.6	7.8	10.1	7.9	10.2	8.7	11.3	10.7	14.1
Total Benefit	Tk mln.a	21.6	26.2	21.6	26.2	21.6	26.3	21.6	26.3	21.6	26.3	21.6	26.5
Max. posit. CF	Tk mln.a	11.0	12.8	10.9	12.7	10.4	12.1	10.3	12.1	9.4	10.9	7.2	7.8
I R R	%	2.1	1.6	2.0	1.5	0.4	0.0	0.3	-0.1	-0.9	-1.2	-3.2	-4.0
NPV	Tk mln.	-125.3	-160.1	-128.3	-163.5	-166.5	-208.0	-169.5	-211.4	-194.2	-242.6	-239.3	-310.6

The analysis of the above presented results clearly indicates that none of the proposed alternatives of the compartementalization programme is viable by normal standards, neither in financial nor economic terms. More detailed information on the behaviour of individual components has been compiled in the corresponding tables which may be consulted in Annex 6.2.

A sensitivity analysis adhering to common methodological standards will not permit a judgement differing substantially from the one provided above. Variations of prices, areas 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.

One more point is of interest. The mathematical model used to simulate external flooding patterns and their hydrological consequences for the compartment is not suffiently refined to allow precise enough simulations of internal water conditions. The additional influence of structures designed for internal control can thus not be accurately determined at present. The benefits identified in the present exercise will thus equally apply to all alternatives.

To show the order of magnitude of necessary changes only to obtain break-even conditions (FIRR = 12 %, NPV = 0), the prevention of flood damages, the only variable which "allows" respective ranges of variation, must obtain annual values of about Tk 30 mln., 4.5 times as high as the presently estimated rates. Considering the comments on damage prevention in Section 8.3.1.3, this option must be classified as unlikely.

It is, however, common understanding that any such programme on national level can not be judged by economic criteria alone. Other factors, possibly producing desireable impacts in fields not to be quantified by monetary standards, have to be identified, analyzed and included in the final judgement. This seems to be so much more true for the compartmentalization concept, as it is a pilot project, yet to be tested under "live" conditions. Impact outside the compartment in adjacent areas needs to be considered as well.

8.4 Qualitative impacts

Where possible, objectively verifiable indicators will be applied to underline our findings on non-quantifiable impacts on fields vital for further economic development of the area.

8.4.1 Primary sector

Soil fertility

An partial indicator towards changing soil fertility conditions may be the ratio of non-rice crops to rice. Information in Table 6, Appendix E, Annex 2 reveals a ratio of 1 : 1.30 (or 8,115 ha non-rice crops to 10,564 ha rice) referring to the situation at present compared to an attended ratio of 1 : 1.33 in the future situation "with" project and almost the same result in the "without" project situation.

This is no substantial improvement, but it will help to stop decreasing soil fertility caused by the present over-dependance on rice-based cropping patterns, which already now demands increasing fertilizer rates only to maintain the present yield levels.

An other indicator of soil fertility is the use of northern inputs. If a more secure environment is felt by the farmers due to reduced flood hazards, natural risk aversion especially of marginal farmers may be reduced in favour of better use of modern inputs. This will also contribute to reduce soil depletion.

Dependency on agricultural services

Dependency on agricultual services may be evaluated - especially in economies where agricultural production is based predominantely 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 present ratio is given with 1 : 0.6 local varieties compared to HYV. The future ratio is expected to narrow to 1 : 0.71. This will certainly increase the dependancy on supporting services which will best be illustrated as follows:

As to the availabilty of HYV seeds, they are still mainly supplied by the BADC and a few private seed dealers, especially in regard to HYV rice. For oilseeds, pulses, wheat, potatoes and vegetable less comfortable supply could be identified. When such crops are grown, seeds come more often from farmers' own resources and from neigbours than from any other source (including to some extent rice seeds). This holds true especially for marginal farmers, mostly because of lack of nearby distribution centers. It may, however, be expected to be the case more often because of a mere lack of funds of marginal and small farmers.

Chemical plant protection is still of minor importance. Pesticides and fungicides may, however, have to be used more frequently in coming years as the expected intensification will include increasingly HYV.

Basically, the required fertilizers are available throughout the project area, sometimes on a credit voucher system, giving part of the crop loan in kind (fertilizer). It can be maintained that the system is functional, it is, however, far from being optimal. The use of fertilizer itself seems also not to be very efficient. The over-emphasis on urea neglects the fact that types and doses of fertilizer have to match the specific properties of different soils as well as the specific demand of crops. Research has proven that substantial improvements in yields are possible only by respecting the balanced needs of specific crops on specific soils, without raising the rate applied at all. The advantage of the low price per Kg pure nutrient in locally preferred fertilizer (Urea, TSP, MP) will definitely be wasted if unbalanced fertilizer doses are applied.

Transport accessibility to local markets is not always easy, as some may only be reached at times by traditional means like oxen carts and rikshah, due to poorly maintained rural roads. The majority of these roads consist actually of regional embankments. Most of those markets may therefore not be served by average sized trucks. The project will most likely alleviate some of the transport difficulties as mitigation measures in that respect are foreseen. Water transport is obviously very important in the region. To which extent, however, this will be influenced by the project remains to be investigated in much more detail, including possible interference with project activities.

The majority of farmers in the project area will by no means be able to cope with these challenges on their own, development will have to be 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.

The first step in progress is, to repeat a cliché, education, including professional training, which may turn even the landless and rural poor into self-reliant individuals. In Tangail Thana, the rate of illiteracy of the rural population is given with 84 % (all ages, 1991, Population census, B.B.S.). This has, however, to be kept in mind when participation of the population is asked for not only in activities directly related to project activities (user groups), but in view to further agricultural development. About two third of the rural population will have extreme difficulties in understanding improved cultivation practices necessary to make use of improved conditions in the Kharif season because of insufficient education.

Livestock

It is assumed that because of intensified land use systems, the number of cattle will continue to decrease, which may largely be explained with growing competition for agricultural land between crop and livestock production. May be because of profitability criteria, cattle will suffer from this competition most, inspite of the active support to dairy activities through Tangail based Milk Vita, an autonomous cooperative. Shortage of feed is the major constraint for further dairy development. All concentrate cattle (and poultry) feed comes from Dhaka. Obviously, the local feed production and processing potential is not used to its optimum.

Poultry activities, including ducks, on the contrary, may expand, mostly because of their suitabilty for production systems adaptable to small and even marginal farmers. This development will further be stimulated by increasing availability of crop residues especially fit as feed for poultry, through growing rice production, partly due to improved water management.

As to the future development of sheep and goats, present trends point towards increasing populations, influenced by apparently lower risks involved for losses during abnormal floods. This, however, is independent of improved water management.

One remarkable fact in connection with draught animals may be of interest. It has been observed that no reduction in cropped area took place, not even after disastrous floods. This may most likely be explained by reduced application frequencies of land preparation activities. The same trend seems to develop in the region due to a general low supply of draught power in addition to an increased use of cows, in spite of disastrous effects on milk production and fertility. The additional demand for draught power because of a growing rice area (estimated to be about 45,400 pair-days/year) in the future situation "with project", will aggravate the situation. Thus, the question of additional systems of farm mechanisation may become more urgent.

Nutritional impact

An overproportional expansion of rice crops under the pressure of growing demand for food (rice) because of population growth will most likely anyway take place in the region, even without the project. This reduces the options for crop diversification which would otherwise improve nutritional standards for the population (in addition to increased availability of feed for livestock and the conservation of soil fertility). Apparently, there will be no compensation for losses in the provision of protein of animal origin (fish production) by a diversified supply of proteins of vegetative origin.

Cooperatives

Acting as link between the public and the private sector, cooperatives were originally conceived to become the pivot of economic development on equity. Their success in Bangladesh, however, is far behind of what has been hoped for.

As for the future, some of the existing structures may be useful to supplement the required institutional support of project activities. They could also constitute means of

communication between all participants in the project on regional level. Participation in project activities of all groups of the rural population concerned could eventually be strengthened through them.

This, however, will not be an easy task, as none of the farmers interviewed earlier were very enthusiastic about their possible involvement in yet another "co-operative" activity. Initiative for active participation will almost for sure not be initiated among their own ranks, from where it would be mostly needed. Understandably, they hope most to gain additional employment opportunities (i.e. maintenance of embankments) during off-seasons, as they only find paid employment during about eight months of a year.

Income distribution

Small holder farming systems are generally accepted as the most adequate form to promote the primary sector where agriculture is based predominantely on subsistence criteria. There must, however, be a clear distinction between small and marginal farmers. Marginal farmers will certainly not be able to contribute favourably to economic growth.

- Available evidence shows that the average farm size in Bangladesh has decreased from about 1.5 ha in 1977 to about 0.8 ha at present, with a growing proportion of marginal and landless 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. It must, however, be taken into account when benefits attributable to the project will have to be assessed.

In the project region the avarege farm size has been identified to be 0.78 ha. The break-down into different farm sizes per farming group is given as follows:

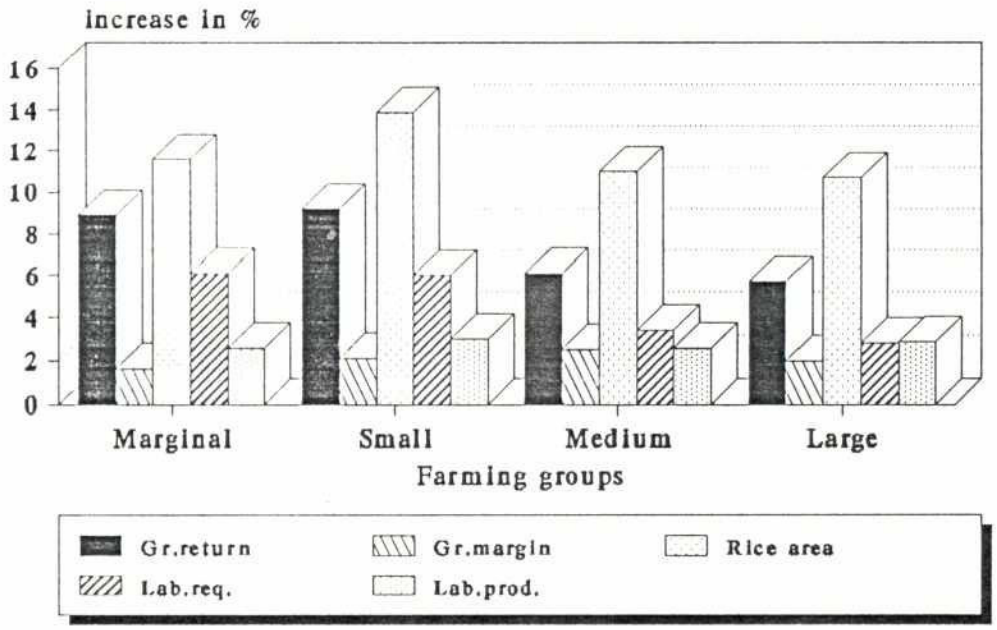
Farming group	Area (ha)	Per cent of total
Marginal	0.34	23
Small	0.70	52
Medium	1.36	15
Large	2.63	5
Share-croppers	-	5

An attempt has been undertaken to analyze the impact the project may have on private farming activities. The criteria used and resulting information is shown in detail in Table 8 in Annex 6.2 and summarized in Table 8.5 hereafter.

Table 8.5: Impact on Farming Activities

Criteria	Margin	Small	Medium	Large
Gross return	108.9	109.2	106.1	105.7
Gross margin	101.6	102.1	102.5	102.0
Cropping itensity	107.1	107.0	103.4	103.7
Rice area	111.6	113.9	111.0	110.7
Labour requirem.	106.1	106.0	103.4	102.8
Labour productivity	102.6	103.0	102.6	102.9

Graph : Income Distribution Criteria
present vs future situation with project



It should be understood that the corresponding results may not yet be regarded as conclusive as too little is known at present on the exact family composition per group, their specific social or economic parameters (cultivation practices, nutritional requirements for the family, literacy rates, repayment capacities, degree of mechanization, marketing rates for their produce, personal preferences). Based on the available information it may be concluded, see the table above, that the project will benefit most of all small farmers, followed by marginal, medium and large farmers respectively.

This conclusion has been reached by attaching high priority rates to desirable developments (gross return, gross margin and labour productivity) and less to rice area,

cropping intensty and labour requirements in that order. They are best illustrated in graphical form as shown on the previous page.

8.4.2 Secondary sector

The greater region of which the project area only forms one, even though considerable part, may be favoured in terms of natural conditions (climate, soils, water...) and may therefore be especially favourable for agricultural production. It offers, however, no outstanding features in favour 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 and soap production, or may be understood as what is best described with the term of "cottage industry". The latter comprises handicrafts related to pottery, bamboo, artificial jewleries and weaving. These activities, will not be touched by the project in its present context, nor will they, with the exception maybe of weaving, affect improved water management (see further down in this chapter).

In between this two extremes is the wide range of activities of the informal sector, guaranteeing functional processes of daily life. In this categorie, all services are included 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 continously formed by autonomous processes which will not ready be influenced by improved water management through compartmentalization. It should, however, be investigated to which extent, on the other hand, improved water management may have to take into account possible future developments in this sector (environment...).

In the following a short overview will be given of some relevant enterprises in the project area, emphasising aspects wich may be important in connection with developments related to improved water management.

The largest agro-industrial entity operating in the project area is the (wheat) flour mill on the outskirts of Tangail. This completely private mill has been started in 1981 by means of favourable credit conditions within a programme to promote industrial development in the area. It has a milling capacity of about 1200 t/month by employing 50 worker on a permanent base. On average 480 to 500 tons are processed per month. Most of the wheat processed originates from outside the project area, up to 40 % even stemming from imports (supplied to the mill mainly through the Food Department). The majority of the finished produce (about 60 %) serves to supply Tangail town itself. The remaining quantities go either to Dhaka or Mymensingh. Wheat bran, a valuable by-product for use as animal feed, is said to be sold (about 4 Tk/Kg) also to Dhaka for further processing to higher concentrated cattle feed. There is one more, though much smaller, flour mill operating in Tangail municipality.

It seems that most of the locally grown wheat is consumed and consequently milled locally by the many village milling units, operating either on diesel engins or on electricity and processing both paddy and wheat. By-products are carried away by clients

to be used as feed for their own livestock. Those mills are more or less efficiently serviced by their operators. As wheat production is believed to remain more or less stable, changes influenced by compartmentalization are thus not to be expected.

In addition to those village mills, 35 to 40 semi-industrial rice mills operate in the project area, about 25 % of them concentrated in Tangail town. Their installed milling capacity is about 400 to 500 tons per month with a labour force between 30 and 40 workers, up to 50 % of them women. The installed milling capacity may almost never be reached as sun-drying (of the parboiled paddy) may not allow more than 50 to 70 % efficiency.

Produce derived from rice are fine rice (69.6 %, with a calculated price of 11.3 Tk/Kg), fine husk (19.0 %, 1.1 Tk/Kg) and coarse husk (11.4 %, 0.8 Tk/Kg). The latter is mostly used to heat the boiler to produce steam used to parboil the paddy.

At first sight it may be of a surprise to learn that none of these mills try to diversify into production of animal feed, based on available by-products with complementary ingredients either supplied from the local market (pulses, oilseeds) or from Dhaka. This would really not demand much additional investment (mainly mixing equipment). However, even though feed is a major constraint for further livestock (mainly cattle, including draught animals) development in the project area, the present demand is apparently not yet justifying such a service.

Next to milling, semi-industrial soap production seems to rank second in offering employment for labour. The total labour force involved is believed to be between 80 and 120, divided between 8 to 10 soap factories operating in the area. With the exception of one local NGO, all are owned privately. They are orientated on laundry soap only, for which all ingredients have to be bought outside the project area. Most of the required raw materials are imported (palm oil, coconut oil, caustic soda). Average capacity per factory has been estimated to be two tons per month. At present, none of the existing units use this capacity to the full.

One small textile mill (20 to 25 employees) is said to be operational in *Karatia*, using local raw material. Finally, some minor bread factories deserve being mentioned.

It may be safe to maintain that agriculture will not be able to absorb the growing supply of manual labour. On the other hand, it is highly unlikely that the little (semi-) industrial activities in the project area, even in combination with the informal sector, will bring the solution to this problem in the future.

Industrial development is determined by factors beyond the influence of improved water management by compartmentalization on a restricted area. Determining factors are, only to name the most popular, the availability of natural ressources (raw materials), comparative advantage in geographical location (i.e. flood-safe conditions...) and physical infrastructure (railway, road net-work, harbour...) to other regions, human ressources (special skills or abilities) and political decisions. None of the above criteria is in particular favour of the project area.

As to the rice mills it may be argued that the increased output of rice (or cereals) due to improved water-management may boost the local agro-industies (rice milling). A closer look into this reveals the following. Based on the estimates outlined further up the

increased output in the project area may be in the range of 3,000 tons of cereals per year. Given the installed milling capacity of the 35 to 40 semi-industrial rice (and wheat) mills in the project area (in addition to the many small rice mills without drying facilities in the villages) of around 500 tons per month each, this would mean about six additional milling month per year or about 0.2 additional milling month (about 5 days) per mill per year (assuming that all additional output would be marketed and processed only by the semi-industrial mills, which is highly questionable). As cited above, the limiting factor for all mills at present is the drying capacity (sun drying on concrete floors), reducing the installed milling capacity by about 30 to 50 % (as discussed with one mill manager). Increased capacity use may therefore be easily obtained by the expansion of the drying capacity, for obvious reasons (limited area) by introducing assumingly new technologies, most likely at the expense of manual labour. The expected positive impact of the project through increased output may thus be reduced by decreasing employment opportunities on the other side.

With respect to the cottage weaving industry, it may not at all be daring to maintain that the handlooms in the form they are used in the region at present will vanish within a decade or so. This will mainly be due to the fact that they seem to be no longer competitive to improved industrial mass-production systems as the ones which have apparently been introduced in India recently. Local handlooms lack most of all sufficient ability to adapt to modern designs and involve comparatively high costs of production.

According to verbal information from tradesmen in the region, respective produce from India already appears on the markets in Bangladesh at a much lower price, compared to the domestic fabriques, seemingly matching much more in modern designs and quality of colours the prevailing local demand. Consequently, the weaving industry in the region will most likely undergo dramatic changes in the years to come, which will, by no means, be influenced by improved water management through compartmentalization. It may, much to the contrary, be relevant to investigate, if necessary changes in production techniques and volumes of production - if the weaving industry (which may then no longer be "cottage") is to remain in the project region - will effect the water management through pollution of irrigation- and drinking water as well as fish production areas.

8.5 Conclusion

Based on the analysis of primarily the direct impacts which may be quantified in monetary terms, the project will hardly be justified, in spite of some tangible benefits especially in favour of the part of the population most urgently in need of support.

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 more marginal in regions, which already own a relatively high degree of economic development, as is the case in the Tangail CPP area. Tentative calculations have shown that the same project, implemented in a region starting at a cropping intensity of, say 180 %, will attain break-even conditions in economic terms at a cropping intensity of about 210 %.

If a more secure environment is felt by the farmers due to reduced flood hazards and improved water management, natural risk aversion, especially of marginal and small farmers, may be reduced in favour of increased and more efficient cultivation practices.

All these elements may result in an intensified agricultural production and additional employment opportunities. These have been identified to be 133,700 man days per year. Outside agricultural activities, new jobs will also be created in connection with operation and maintenance requirements of the water management system.

It should, however, be kept in mind that in general there are good reasons for a region to be economically less developed compared to others. In Bangladesh, this is not only due to the lack of flood protection and effective water management but also to other well known distortions from which agricultural development is suffering, of which sub-optimal land-use systems and insufficient institutional support are only the most outstanding.

Providing flood protection and improved watermanagement by compartmentalization is considered a precondition for the elimination of most of the other distortions. It would thus induce agricultural development, in particular during the monsoon season.

Dry season tubewell irrigation

During the dry season, extensive irrigation of Boro takes place. Tubewells are installed all over the compartment area (both high and lowland). About 40-50% of the Tangail area is cultivated with irrigated Boro crop.

The water requirement of the Boro crop is in the order of 1000-1400 mm. An effective porosity of about 10 % with a maximum drop of the ground water table of 6 m gives a water availability of 600 mm.

Assuming that recharge of the shallow ground water layer from adjacent areas be minimal, it can be concluded that the maximum possible area is irrigated by means of STW's (50 % of the compartment). That nearly the maximum possible area is irrigated is confirmed by the MDSC report. Recent (1991 census) figures mention for Tangail 40%.

Dry season irrigation inlets

During the dry season the standing water in the Pungli river is used for surface irrigation at several locations. The water is lifted by low lift pumps and runs through the embankment which is cut for this purpose. As repair will be below standard mostly, it is proposed to provide for irrigation pipes.

A simple 0.30 m diameter Reinforced Cement Concrete or AC pipe with a box at the in- and outlet will be sufficient for a discharge up to 60 l/s. The pipe inlet will be gated with a sliding gate made of steel with a provision against steeling. The outline design drawing is given in Figure 11 of Annex 6.1. Two sites have been identified at Passbetor in SC5.

These structures may also be used during the wet season for supplemental irrigation. For costing purposes a series of inlets has been planned at regular intervals along the adjacent rivers including the *Gala khal*.

Wet season irrigation inlets

The requirement for supplemental irrigation from 1986 to 1991 has been verified on the basis of rainfall figures for Tangail (see Table 1., Annex 1.2). Supplemental irrigation is considered necessary when rainfall is less than 40 mm/8 days for 2 or more weeks with no major rainfall (more than 80 mm/8 days) shortly before this period.

The periods and the related 3 day maximum waterlevel at *Jugini* was (see Table 2.1, Annex 1.2):

Period	WL at *Jugini* m+PWD
4th week August 85	11.64
2nd week August 89	11.13
3rd week August 89	10.68
4th week August 89	11.12
2nd week September 90	10.88

proposed to split up the model into two sub-models to deal with the eastern and western part of the *Lohajang* separately. The details of the work programme are given in Annex 4.

Proposed follow-up activities can be summarized as follows:

* splitting the model into sub-models for the detailed water management study in the sub-compartments;
* include possible northern *Dhaleswari* closure to evaluate its effect;
* include construction of the *Brahmaputra* Left Bank Embankment (BLE) with a possible rise of 1 m. in the *Dhaleswari* river.
* include combined effect of the construction of the BLE and the *Dhaleswari* northern intake closure.
* refining the models by real time monitoring.

2.5 Flood management model

In addition to the mathematical model based on the Mike11 software, it is envisaged to develop a flood management model for the Tangail area. In contrast with the mathematical model, the flood management model should be more "users friendly" with more emphasis on graphic presentation.

The aim of the flood management model is to provide information for decision making and operational aspects of watermanagement in a compartment.

The Mike11 mathematical model has been developed as a sub-regional model (from the northern *Dhaleswari* intake down to the confluence of the *Pungli* and *Dhaleswari* rivers). In order to obtain the required degree of detail to simulate actual controlled flooding and drainage within the compartment, it is proposed that the flood management model will take up more details in smaller areas.

FAP 20 will develop the Compartmental Flood Management Model in close cooperation with FAP 25. This will be carried out in the framework of the task of FAP 25 to develop Flood Management Models on a national, regional and compartmental level.

The inception period for the Flood Management Model (FMM) is scheduled for the months of October and November 1992. During that period it will be decided whether part of the proposed follow-up activities in Section 2.4 can be included in the FMM study.

2.6 Agriculture

2.6.1 Land resources and agro-climate

Land resources

The Tangail Pilot Project area is located in 2 floodplains, the High Jamuna Floodplain (AEZ 8c) in the western part of the area with relative shallow soils over stratified alluvium, covering 54% of the project area and the Low Jamuna Floodplain (AEZ 8d) in