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

COMPARTMENTALIZATION PILOT PROJECT TANGAIL
GEOGRAPHIC INFORMATION SYSTEM

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

under assignment to
DIRECTORAAT GENERAAL INTERNATIONALE SAMENWERKING
Government of the Netherlands

and
KREDITANSTALT FUR WIEDERAUFBAU
Federal Republic of Germany

Government of the People's Republic of Bangladesh

Ministry of Water Resources

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COMPARTMENTALIZATION PILOT PROJECT, TANGAIL

GIS ATLAS
CPP TANGAIL

TN96/15

September 1996

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Preface

This Geographic Information Systems Atlas is a collection of maps and statistics of the Tangail area in the Compartmentalization Pilot Project. This atlas is compiled using the GIS facilities in the CPP.

The thematic maps and statistics contained in this Atlas have been produced as a guide to the information held within the CPP GIS, and to illustrate the analyses performed.

A preliminary version of this atlas was prepared by the FAP-19 (GIS component) in November 1992.

Pc ARC/INFO GIS software was used in the preparation of the maps in this atlas.

The production of the GIS atlas was considered an appropriate instrument for the completion of the GIS development in phase I of CPP.

The atlas is intended for both the outsider interested in CPP, and in particular the use of GIS in water management projects, and for the professional working in the CPP.

We would welcome any suggestions and recommendations for further enhancement and improvement of this tool with special regard to the CPP.

Abbreviations

AEZ - Agro-Ecological Zone

BBS - Bangladesh Bureau of Statistics

BWDB - Bangladesh Water Development Board

CPP - Compartmentalization Pilot Project

CWMC - Compartment Water Management Committee

DAE - Department of Agricultural Extension

DEM - Digital Elevation Model

DPHE - Department of Public Health Engineering

DW Aman - Deep Water Aman

ESRI - Environmental System Research Institute

FAP - Flood Action Plan

FINNMAP - Finnish Mapping Project

FMM - Flood Management Model

GIS - Geographic Information System

GPS - Global Positioning System

GoB - Government of Bangladesh

ha - Hectares

HYV - High Yielding Variety

ISPAN - Irrigation Support Project for Asia and the Near East

MPO - Master Plan Organization

MWR - Ministry of Water Resources

NGO - Non-Government Organization

PAP - Project Affected People

pcARC/INFO- Personal computer based geographic information system, developed by ESRI

SC - Sub-compartment

SCWMC - Sub-compartment Water Management Committee

SPARRSO - Space Research And Remote Sensing Organization

SWMC - Surface Water Modeling Centre

TC-FMM - Tangail Compartment Flood Management Model

WARPO - Water Resources Planning Organisation

Table of contents

List of maps

List of tables

List of annexes

Introduction

This GIS Atlas is a collection of maps and statistics for the Compartmentalization Pilot Project (CPP) Tangail area, compiled using GIS facilities in Compartmentalization Pilot Project Tangail.

Previously a draft GIS Atlas for Tangail area study was published by ISPAN (FAP19) in November 1992. The series of thematic maps and corresponding tabular statistics contained in that atlas had been produced as a guide to the information held within the Tangail CPP GIS and to illustrate the analyses performed. That atlas serves several purposes; it:

- presents information available to the users, specifically the FAP 16 EIA team and FAP 20, as of November 1992;
- serves as an index to spatial data within the GIS;
- assists in planning GIS analyses;
- provides a format for producing GIS atlases for other projects;
- assists in disseminating results.

This latest version of the GIS Atlas is more authentic and the latest survey data have been used. A number of new maps have been included in this atlas, others have been dropped. The maps in this atlas were produced using pcARC/INFO GIS software and its supporting software ArcView. The area of roads and similar features has not been considered in any analysis because these features cannot accurately be mapped at the 1:20,000 base scale used. Thus, the figures for cultivable land, settlement area etc. within the compartment include a proportion of land that is actually covered by roads, embankments, khals etc.

The GIS Atlas is organized such that each map is on a separate page and the facing page contains the corresponding activities and statistics for the map.

Source of Data, Processing and Quality of Information

All spatial data for this atlas was digitized in AutoCad12 and then converted to pcARC/INFO coverage through Drawing Exchange Files. Digitizing was accurate to approximately 30-100 meters for most coverages. Atlas users should consider this precision when interpreting the maps and statistics. It should be noted that maps used in creating this atlas are from a variety of sources and are therefore of varying quality and accuracy.

Mapping of agricultural landuse within the CPP was undertaken by the field agriculturist of CPP. The survey included the collection of detailed information on acreage of cropped lands, crop types, and fallow lands.

A number of coverages have been collected from Environment and Geographic Information System (EGIS, formerly ISPAN) e.g., the settlement, river network. However, these coverages have been updated in CPP Tangail later on. Land elevation coverage has been collected from Surface Water Modeling Centre (SWMC), which also was updated. A number of coverages have been digitized from 1 : 200,000 Tangail Map and 1 : 20,000 FINNMAP map. There were large 'blank areas' in these maps where roads and khals were not visible under tree cover in the settlements. These gaps were filled using maps made during field checks, and elements like bridges and other structures were added. A number of other coverages such as-spill channels, locations of structures etc., were prepared using information from a Global Positioning System (GPS). Other coverages, e.g. irrigation facilities, pond locations etc., were made by field survey. Statistics about Bangladesh were collected from the 'Statistical Pocket Book' of Bangladesh Bureau of Statistics (BBS). Population data of CPP area were collected from the Thana and District offices.

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Compartmentalization

Objectives

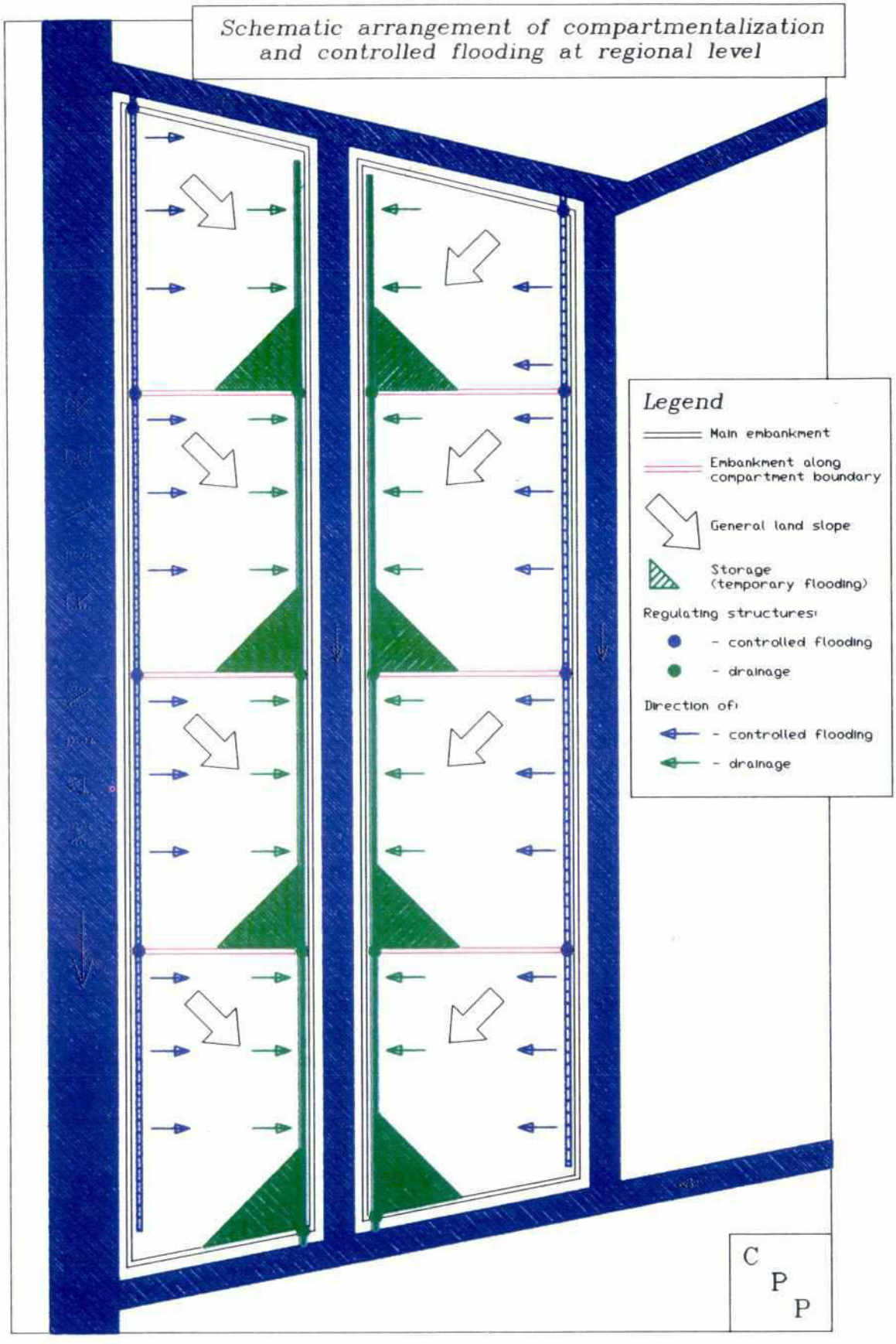
The project has as main objective the development of a new approach to water management, and in particular flood management, for productive activities in flood plains in Bangladesh. Both, new technical methods and institutional procedures, with full participation of the people and in full consideration of environmental aspects, need to be developed and tested on its replicability. The ultimate goal is the uplift of the economic situation of Bangladesh in general, and in the pilot area in Tangail in particular, with a special emphasis on the poor.

Compartmentalization

On a regional scale, compartmentalization entails the construction of compartmental embankments in a (large part of a) flood plain, dividing the area in separate compartments. These embankments facilitate independent water management in each compartment. This large conglomerate of compartments would be surrounded by main embankments that would provide a high degree of protection; see Map 0. Floods with a return period in the order of 20 to 50 years will be controlled by such embankments. The main embankment would allow flood water from the main rivers into the compartmentalized area through gated or un-gated inlets. Entire rivers and spill channels can be allowed into a compartment, depending on the level of water management to be achieved in the compartments and the size and function of the river or spill channel. Between compartments lower compartmental embankments are constructed to allow independent water management inside the compartments, and to limit damage in case of breaching of the main embankment (confinement). Although compartmentalization in its strictest sense could provide 'full' flood protection in the compartment, already from its inception *controlled flooding* (and *controlled drainage*) were at the heart of this approach. 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. It would provide the area with the necessary level of flood protection to allow agricultural and other rural productive activities. Industrial or urban development would not be sufficiently protected, unless they are situated on sufficiently high land. The *siltation* on the fields as well as *fish production* are to be affected as little as possible while environmental issues should also be taken into account. If successful, the entire flood plain on the Jamuna right and left banks could be converted into a set of compartments.

Compartmentalization Pilot Project, the Tangail Compartment

The Tangail Compartment is at present surrounded by embankments that can withstand a flood with a return period of 12 years. The Lohajang river is allowed into the project through a gated regulator at the northern side, not for the supply of water but for drainage, although the river also has a flushing function for the drains of Tangail Town. By lowering the water level of the Lohajang the river will act as a drain for the numerous outlets that discharge into it. In the peripheral embankment on the northern, western and eastern sides of the project area, gated inlets are built to allow water into the compartment. The southern 'embankment' is not an embankment: the road embankment is open (culverts and bridges rather than gated structures) and the Lohajang river and a number of other khals exit the Tangail Compartment without any control. In case of long lasting high floods, flood water will enter the project from the southern side as back flow. Water control structures control water levels between sub-compartments and systems.


Schematic arrangement of compartmentalization and controlled flooding at regional level
Legend
Main embankment
Embankment along compartment boundary
General land slope
Storage (temporary flooding)
Regulating structures:
- controlled flooding
- drainage
Direction of:
- controlled flooding
- drainage
C
P
P

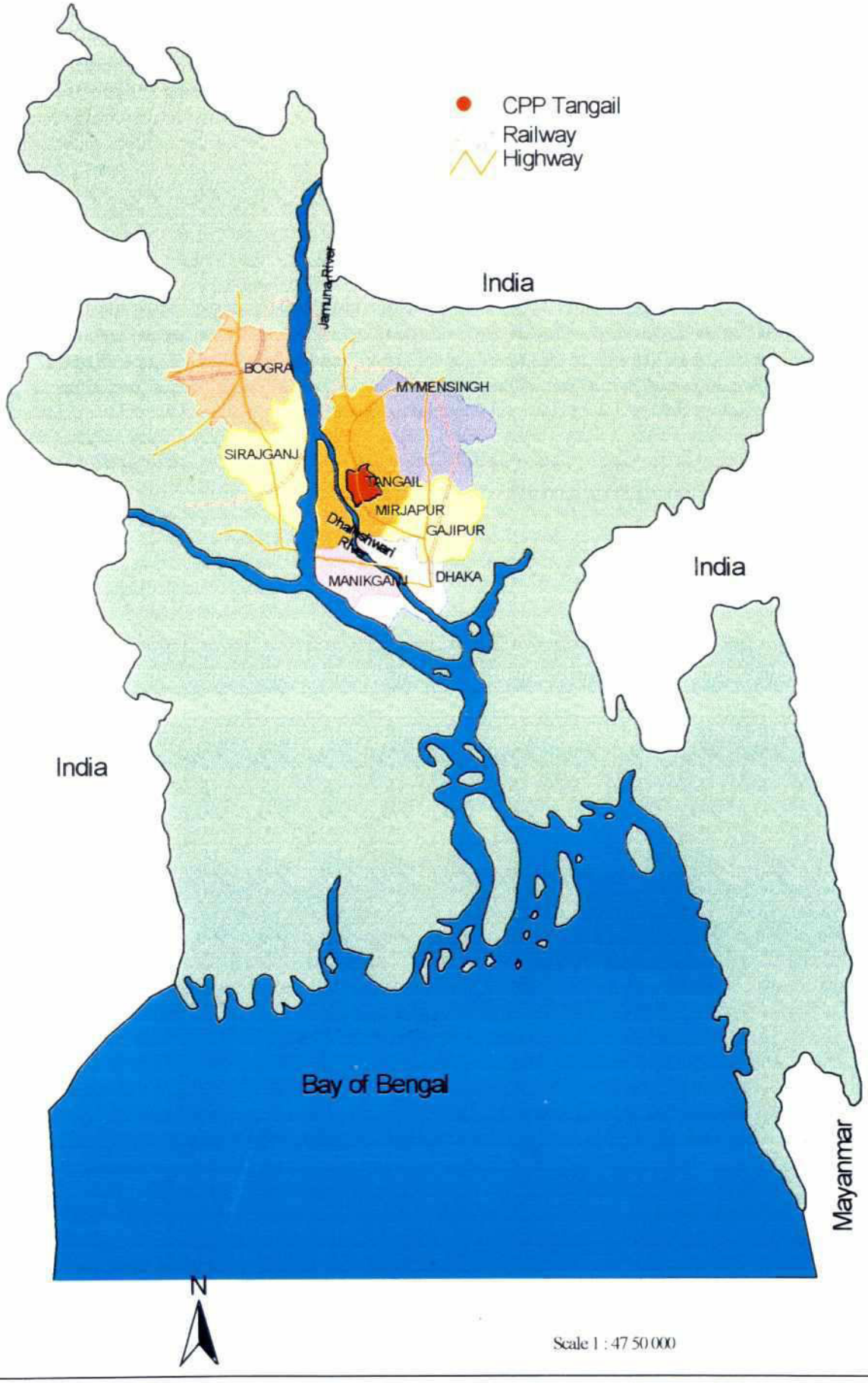
Project's activities

The integrated approach of the project reflects itself in the multi-disciplinary make up of the team and the many different activities that are undertaken by the team. The engineering section is involved in planning and construction of the compartment, but is also involved in the water management preparation of the project, and supports the flood management modelling, that itself supports the planning and the water management activities of the engineering group. The bio-resources group is involved in preparing cropping patterns for the new water management situation, integrated with other aspects of agriculture, monitoring agricultural development, training and running demonstration plots. A large array of activities in the field of fisheries has been conducted, including the development of a model for fish production in compartments, monitoring fisheries development, and developing an aqua culture training programme. On the environmental side the development of an Environmental Impact Plan, and the monitoring of environmental variables in the compartment have been the central activities. The most intangible part, the effective people's participation, is the responsibility of the socioeconomic group. Participation of all the stake holders and the PAP, in all stages of the project, from design to operation, and with special emphasis on the poor and women, has entailed a large input on data collection, monitoring, organising people and training people. This culminated in the establishment of a framework in which all parties, including governmental agencies and NGOs, could communicate and cooperate.

These activities relied heavily on large amounts of data and maps and GIS was a much used tool that proved to be invaluable in linking large amounts of data to maps.

Tangail Compartment in Bangladesh and Regional Setting

Map 1

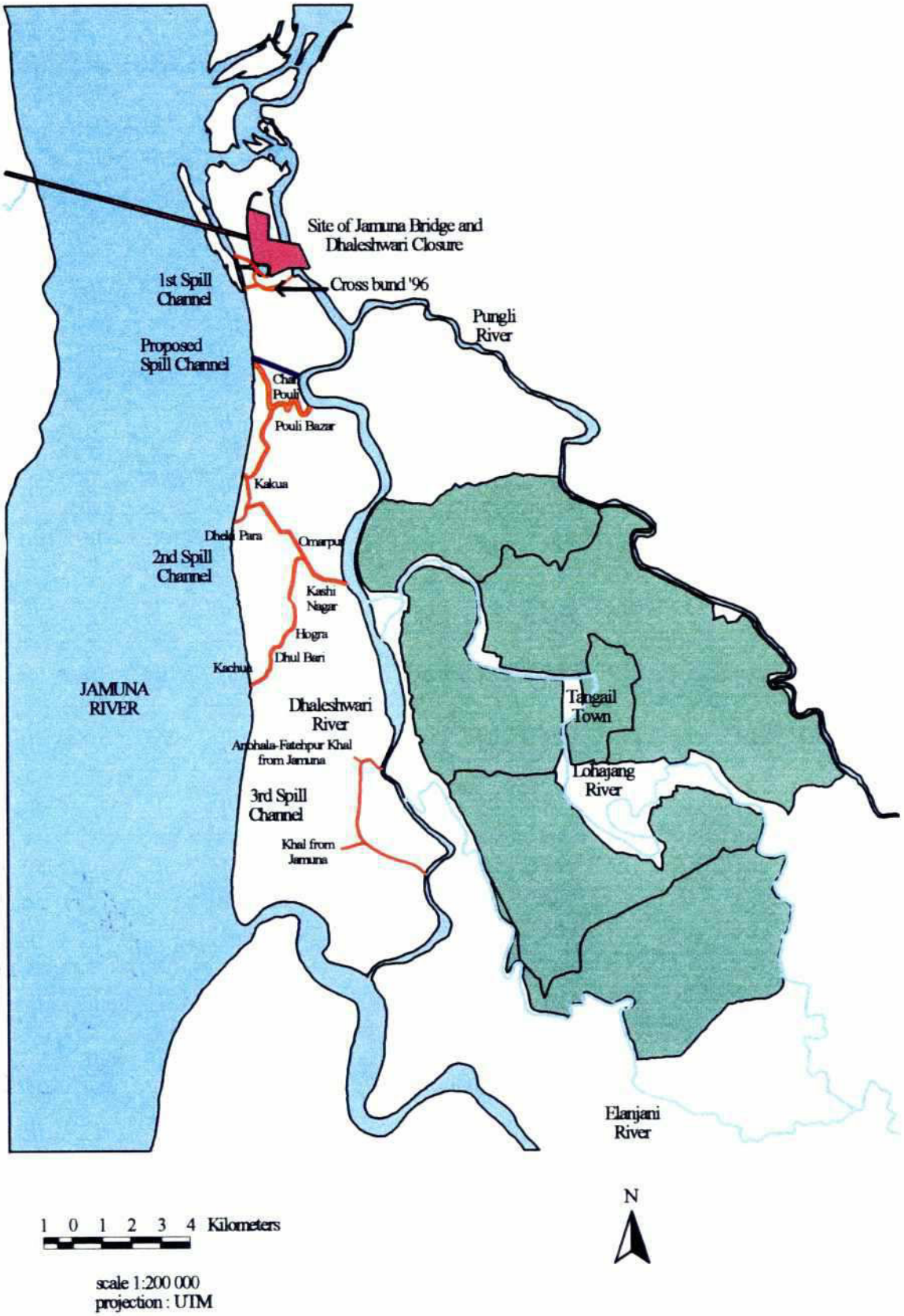


Scale 1 : 47 50 000

Compartmentalization Pilot Project Tangail

TABLE 1.1: BASIC STATISTICS ABOUT BANGLADESH

1. Geographical Location:		Between $20^0 34'$ and $26^0 38'$ north latitude and between $88^0 01'$ and $92^0 41'$ east longitude.
2. Boundary	:	North : India West : India South : Bay of Bengal East : India and Burma
3. Area	:	56977 sq. miles or 147570 sq. km. Territorial water : 12 nautical miles.
4. Population	:	111.4 million on 11 March, 1991 (population census; adjusted) 57.3 million male 54.1 million female Annual growth rate (1981 - 1991) : 2.17 % Density : 755 per sq. km. as on March 1991 (census)
5. Capital city	:	Dhaka
6. Divisional cities	:	Dhaka, Chittagong, Khulna, Rajshahi, Barishal, Sylhet.
7. Main seasons	:	Winter (November- February) Summer (March- June) Monsoon (July- October)
8. Climatic variations	:	Winter temperature average maximum 29^0C Winter temperature average minimum 11^0C Summer temperature average maximum 34^0C Summer temperature average minimum 21^0C Monsoon, average rainfall 1194 mm to 3454 mm.
9. Major rivers	:	Padma, Meghna, Jamuna, Brahmaputra, Teesta, Surma and Karnafulli. Total 230 rivers including tributaries.
10. Standard time	:	GMT + 6 hours.



c:\win32app\cppdata\Location.apr

CPP and the Dhaleswari closure

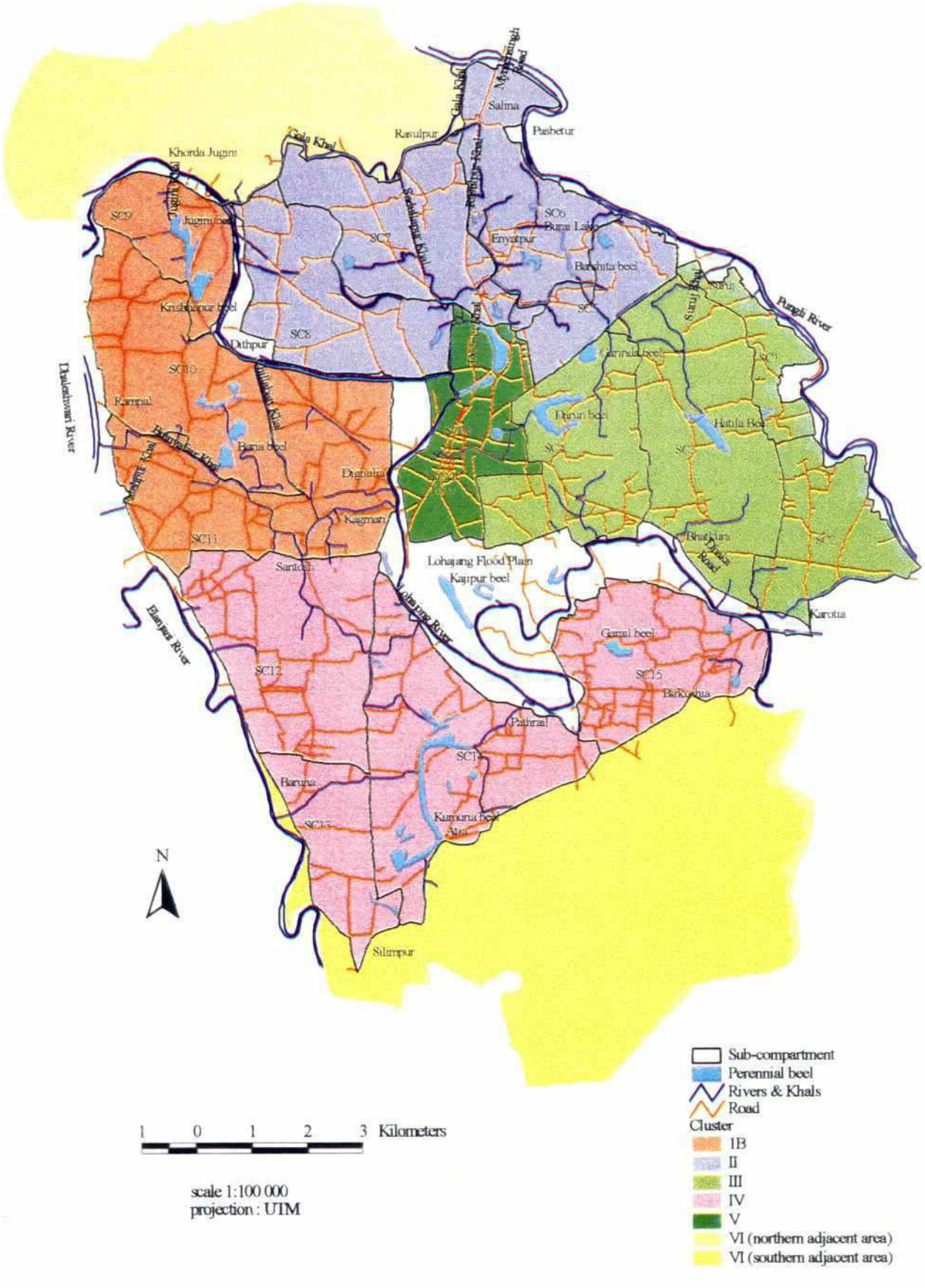
The Dhaleswari river is the main source of water for a large area, approximately 65,000 ha, including the project, on the left bank of the Jamuna river. After the closure of Dhaleswari in December 1994, for the construction of the Jamuna bridge, the supply of water to the Dhaleswari and Pungli rivers became uncertain, and the required water levels for controlled flooding would certainly not be reached. A link canal, at the cost of Tk. 200 million, was proposed as an alternative.

However, in the monsoon of 1995 'normal' conditions in the rivers around Tangail Compartment were restored. During the second flood on the 9th of July, which was very high, spill channel 1 started to flow from the Jamuna river, which was in spate, to the Dhaleswari river, virtually dry. Through tremendous scouring, as a result of the high head difference, a large channel developed, as well as a new river mouth. The maximum discharge in 1995 was found to be 310 cumec, compared to a pre-closure situation of about 500 cumec. A number of surveys were carried out in 1995 in spill channel 1 by JMBA, FAP-24 and CPP, which show that spill 1 was still in the developing stage and should be monitored for at least another two years.

At the beginning of 1996 the JMBA carried out some dredging work in spill channel 1 to bring the bed level to 9.00 m.+PWD. However, in May 1996, as the project was preparing for operating and testing the water management system, the supply of water from the Dhaleswari was again threatened; people living near the spill channel made an earthen cross bund across the channel (Map 2). This bund was about 20 metres wide, stretched up to both banks and was as high as the river bank level. The matter was communicated to the MWR, WARPO, BWDB and Local district administration and in the month of June 1996, after an initiative of the DC Tangail, a small opening was made across the cross bund of about 1.3 meter wide. With the rising water levels in the river Jamuna the cross bund washed away entirely. Discharge measurements in spill channel 1 showed that the channel has restored the discharge in the river Dhaleswari to approximately the pre-closure situation. The maximum discharge found this year is 485 cumec. Water levels in the rivers and khals in and around Tangail compartment have been restored fully. Even so the newly formed channel has to be further monitored and stabilized to prevent siltation and/or runaway river bank erosion in the future, but for the moment the CPP is saved.

Clusters & Sub-compartments

Map 3



Compartmentalization Pilot Project Tangail

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Clusters and sub-compartments

Clusters

The Tangail compartment is, for construction purposes, divided into seven clusters. Four of these are clearly identifiable as agricultural areas with a changed system of water management, Clusters 1[a], 2, 3 and 4. These clusters have an area of approximately 2,500 ha gross cultivable area each. Clusters have no formal, water management related administrative function, but there are institutions inside them to deal with water management: the sub-compartment water management commitees. The other three clusters are cluster 1[a], the peripheral (main system) infrastructure and some mitigation measures; cluster 5, drainage improvement works in Tangail town; cluster 6, mitigation measures in the Northern Adjacent Areas. All reports, data and maps are at present organised around the 4 'agricultural' clusters.

Sub-compartments

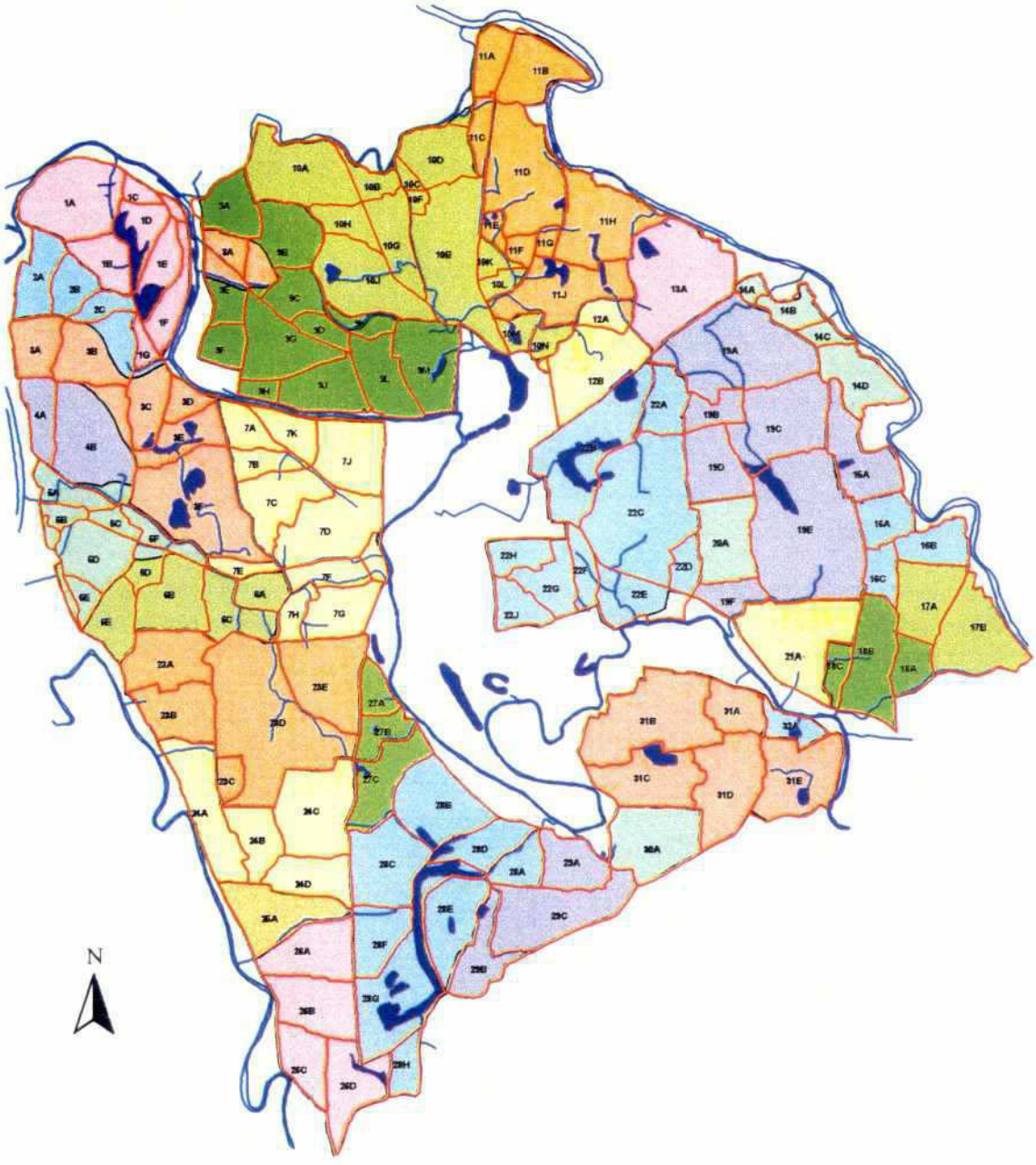
Within a compartment (in the case of Tangail compartment about 13,000 ha large) there are many different watersheds, which necessitate the division of the compartment in sub-compartments. Sub-compartments are in principal hydrological units. However often a compromise has to be struck between administrative and physical conditions, and hydrological significance. The boundaries have been chosen with two objectives in mind: the area should not be too big, since it is also the basis (second level) for the institutional set-up; and the boundaries should be clearly marked watershed boundaries, or it should be relatively easy to make them into watershed boundaries by closing culverts and bridges and providing regulators. The major roads were the natural choices. Even so the size varies to a large extent: 1250 ha gross to 250 ha gross.

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

TABLE 3.1: LANDUSE IN SUB-COMPARTMENTS

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

NOTE: **river area** is the area of Lohajang river only; **beel area** stands for perennial beels.



Compartmentalization Pilot Project Tangail

Systems and chawks

Systems

A system can be defined as the area whose drainage is controlled by one regulator. Systems do not have an administrative function, and are solely used for water management planning, i.e. design and development of water management rules. The size is completely determined by the hydrological conditions of the area, which means in this case the location of the structure, and the size varies more than at sub-compartment level: 30 ha gross to 750 ha gross.

Chawks

The smallest, and actual hydrological unit is the chawk. The chawk is almost entirely constituted around clear infrastructure elements such as roads, embankment, with some regard to administrative boundaries. As in the systems, the area of a chawk varies greatly: from 15 ha gross to 310 ha gross. At this level the chawk committee is organised in which representatives of the farmers are elected. However, in case small chawks lie together, chawk committees are merged to make the institutional setting, more effective.

A list of systems and chawks with land use types is included in the Annex A.

Compartmentalization Pilot Project Tangail

Settlements

TABLE 6.1: STATISTICS FOR TOTAL PROJECT AREA

CPP area (ha)	13200					
Number of Subcompartments	16	Excluding the Lohajang Floodplain				
Number of Thanas	4	Tangail Sadar 82.5%; Delduar 14%; Basail 3%, Kalihati 0.5%				
Number of Unions	12	Paurashava, Gharinda, Karatia, Gala, Danya, Baghil, Porabari, Silimpur (of Tangail Sadar Thana); Pathrail and Atia (of Delduar Thana); Kashil (of Basail Thana); and Elenga (of Kalihati Thana).				
Number of Mouzas	196					
Number of Villages	218					
Number of Households	48,111	Urban:	19,201		28,910	
Population	263,268	Urban:	104,056	Rural:	159,212	
		Male:	135,825	Female:	127,443	

SC	Villages*			Households			Population			Population		Ratio
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Male	Female	M/F
1	5	-	5	941	-	941	6060	-	6060	3080	2980	103%
2	9	-	9	2988	-	2988	16867	-	16867	8873	7994	111%
3	11	-	11	2269	-	2269	14316	-	14136	7223	6913	104%
4	15	4	19	1668	1697	3365	8364	8967	17331	9075	8256	110%
5	10	2	12	1069	1159	2228	5855	6868	12723	6723	6000	112%
6	16	1	17	2002	332	2334	10934	1987	12921	6752	6169	109%
7	14	2	16	1606	246	1852	8740	1408	10148	5170	4978	104%
8	9	4	13	930	1159	2089	4971	6538	11509	5881	5628	104%
9	10	-	10	1002	-	1002	5440	-	5440	2789	2651	105%
10	24	-	24	2306	-	2306	12146	-	12146	6160	5986	103%
11	17	9	26	2492	1968	4460	13140	11361	24501	12526	11975	105%
12	9	3	12	2095	651	2746	11354	3471	14825	7452	7373	101%
13	7	-	7	989	-	989	6031	-	6031	3079	2952	104%
14	16	6	22	2491	1518	4009	13208	7727	20935	10724	10211	105%
15	17	-	17	2920	-	2920	15570	-	15570	8053	7517	107%
16	-	23	23	-	8105	8105	-	42744	42744	22309	20435	109%
LFP	12	13	25	1142	2366	3508	6396	12985	19381	9964	9417	106%
Total	201	67	268	28910	19201	48111	159212	104056	263268	135833	127435	107%

Source: Sociology Section of CPP, Tangail.

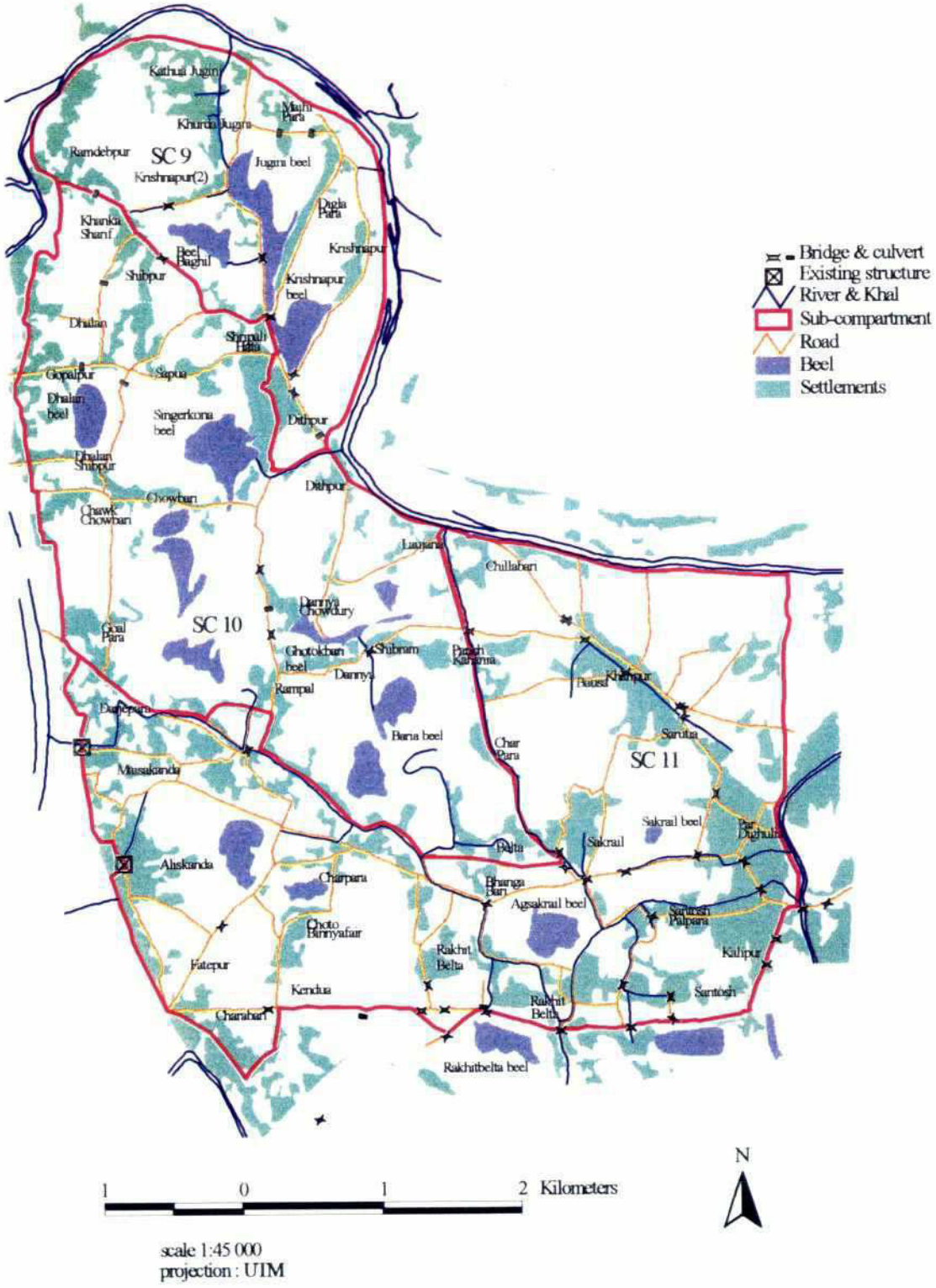
* The total number of villages in the compartment is 218. The total in the table above is higher because villages may be partly in different subcompartments. In such cases the actual percentage within the subcompartment is used in calculating the statistics and the village is mentioned in both subcompartments. The number of villages also includes Mouzas and Mohallas.

Meteorological data

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
rainfall (m	3	23	45	110	263	314	407	212	353	224	43	17
T° max	25	28	32	34	32	31	31	31	31	31	29	26
T° min	12	14	18	22	24	25	26	26	25	24	18	14

Cluster IB : Topographical Features

Map 6



Compartmentalization Pilot Project Tangail

September, 96 c:\win32app\cppdata\cluster1.apr

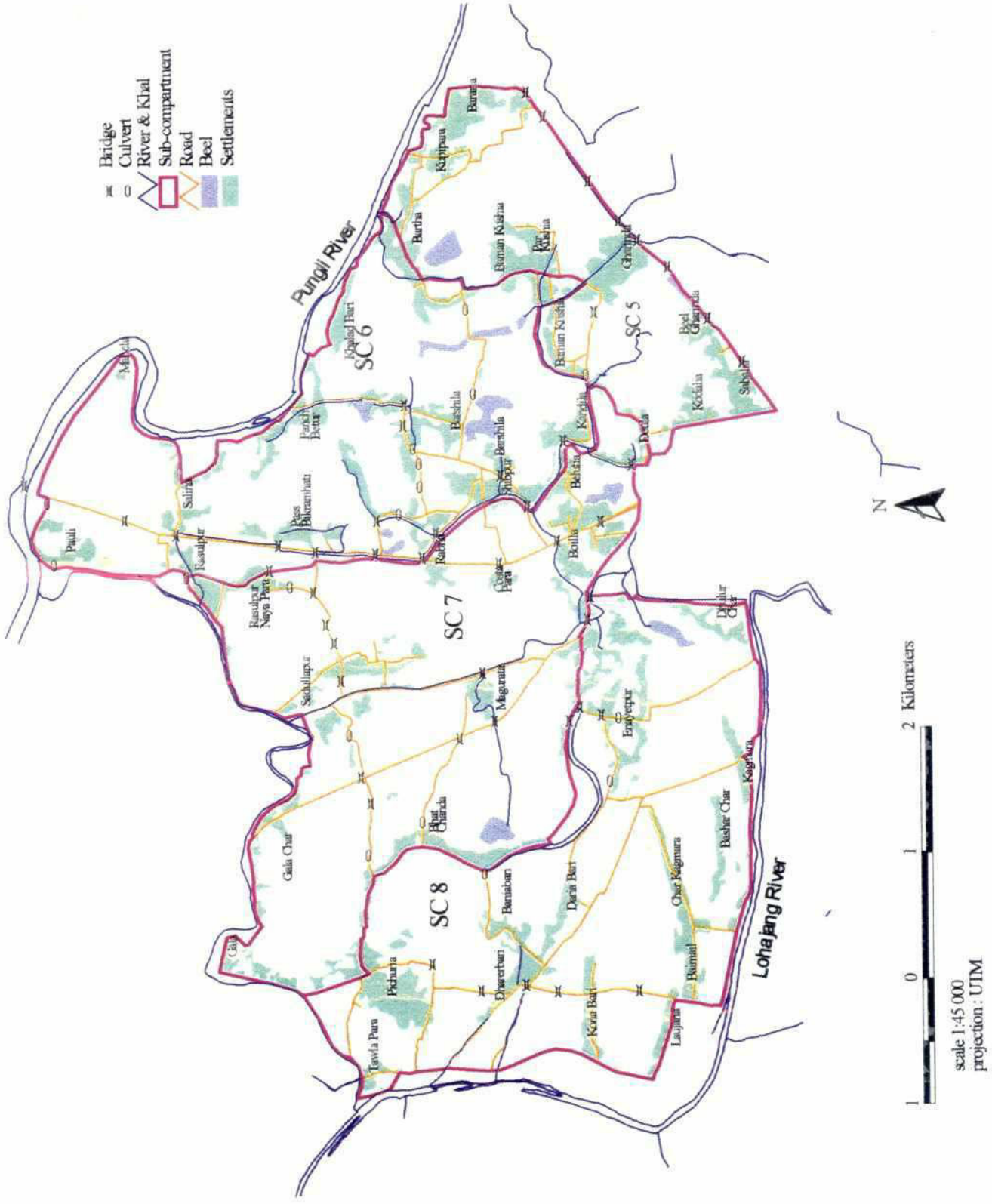
Topographical maps

The topographical maps represent the pre-project situation. The maps are based on the 1 : 200,000 Tangail Map and 1 : 20,000 FINNMAP maps. A Global Positioning System (GPS) and field survey data were used for locating a number of infrastructure elements that could not be immediately located on the original maps.

The post project situation, with improved water management infrastructure, is represented in maps 19 to 22.

Cluster II : Topographical Features

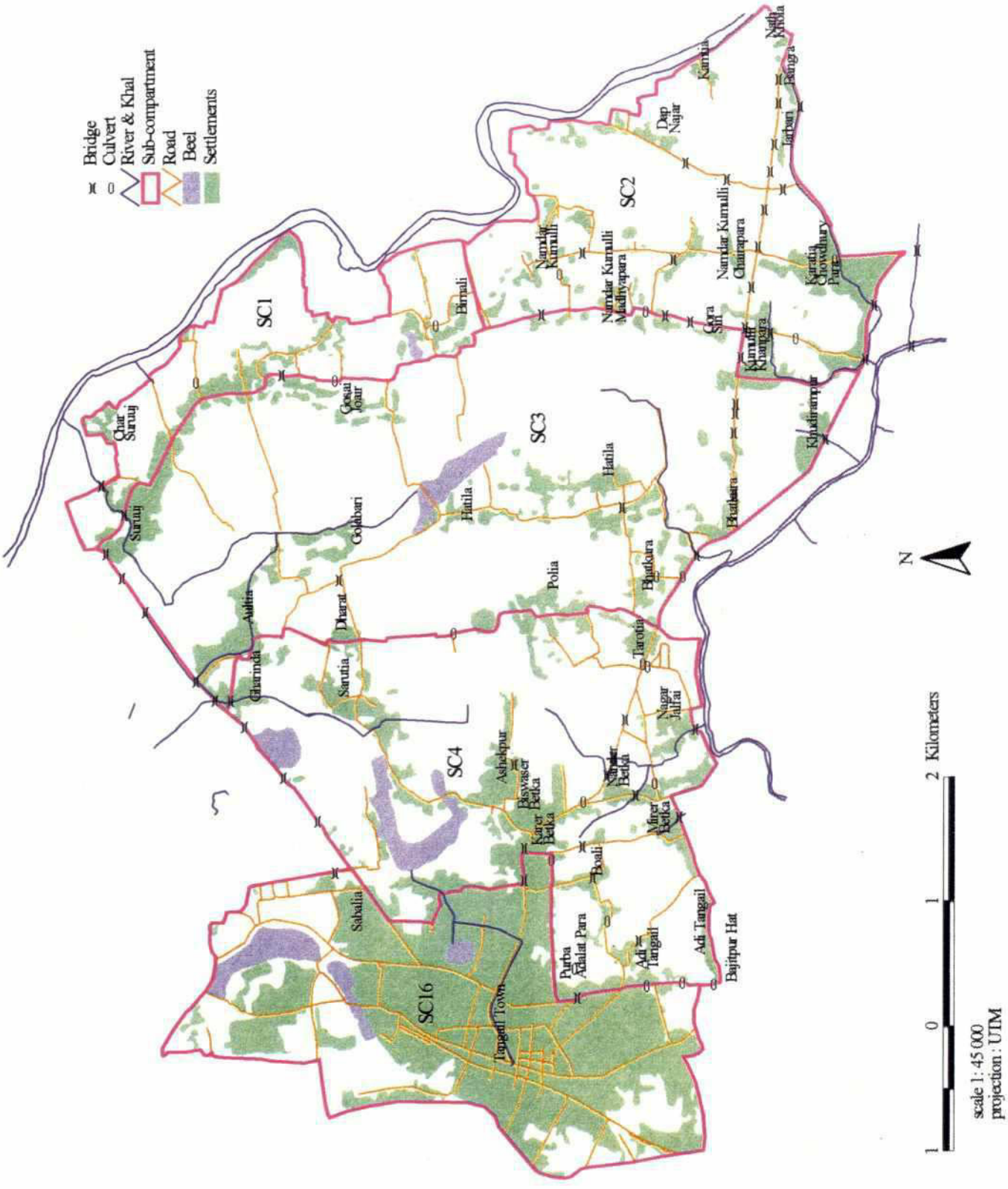
Map 7



Compartmentalization Pilot Project Tangail

Cluster III & V : Topographical Features

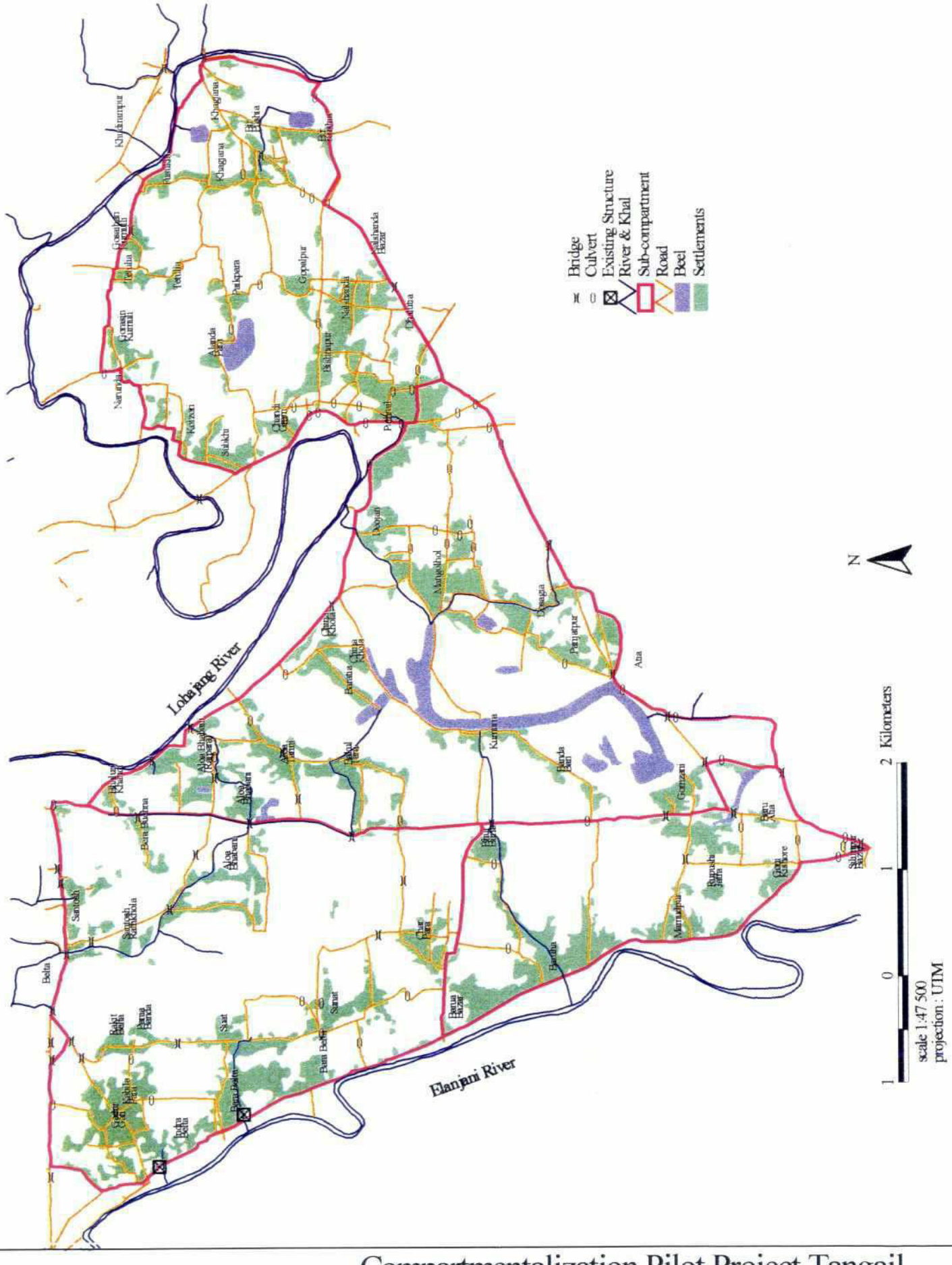
Map 8



Compartmentalization Pilot Project Tangail

Cluster IV : Topographical Features

Map 9

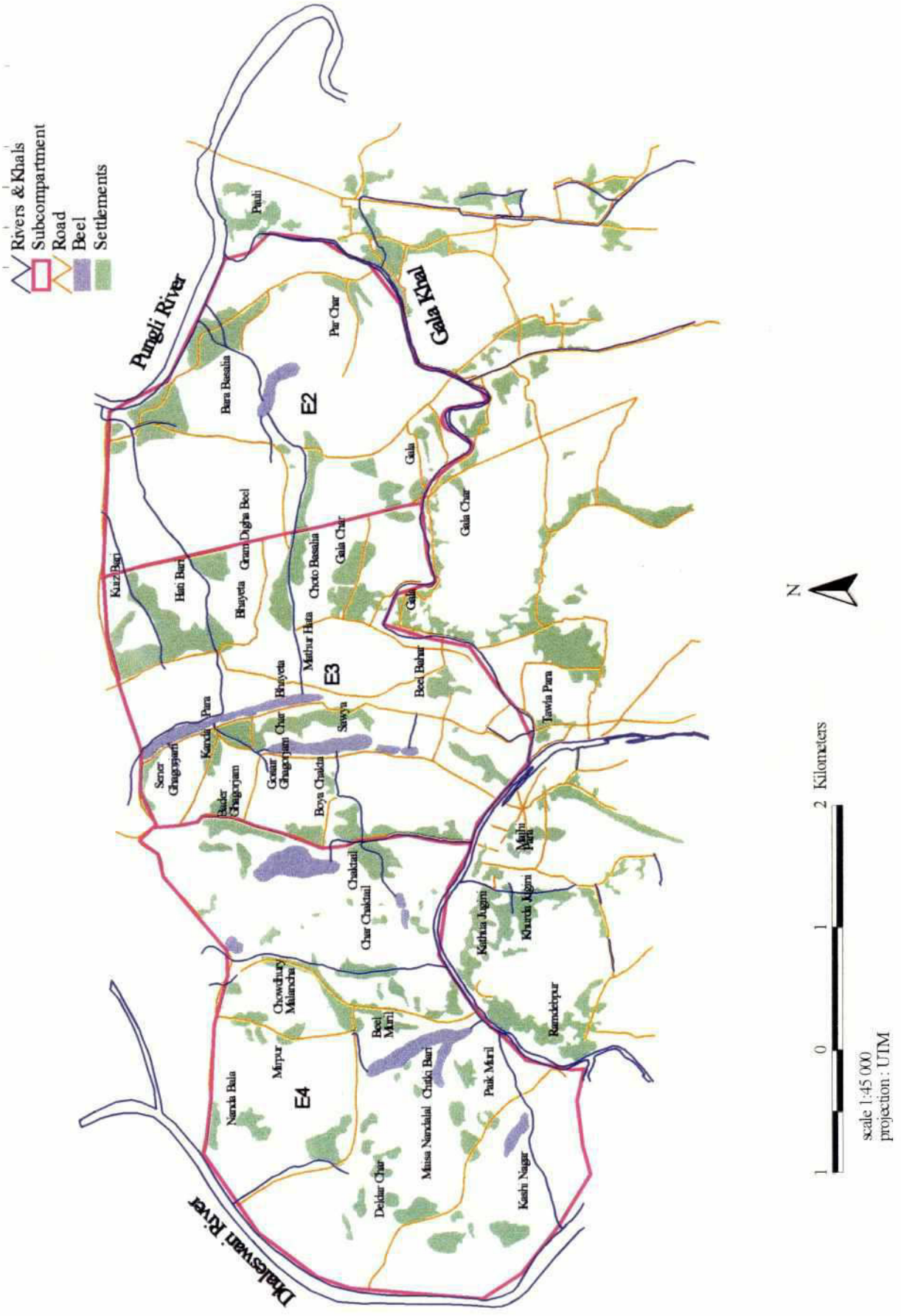


Compartmentalization Pilot Project Tangail

September, 96 c:\win32app\cppdata\Cluster4.apr

Northern Adjacent Area : Topographical Features

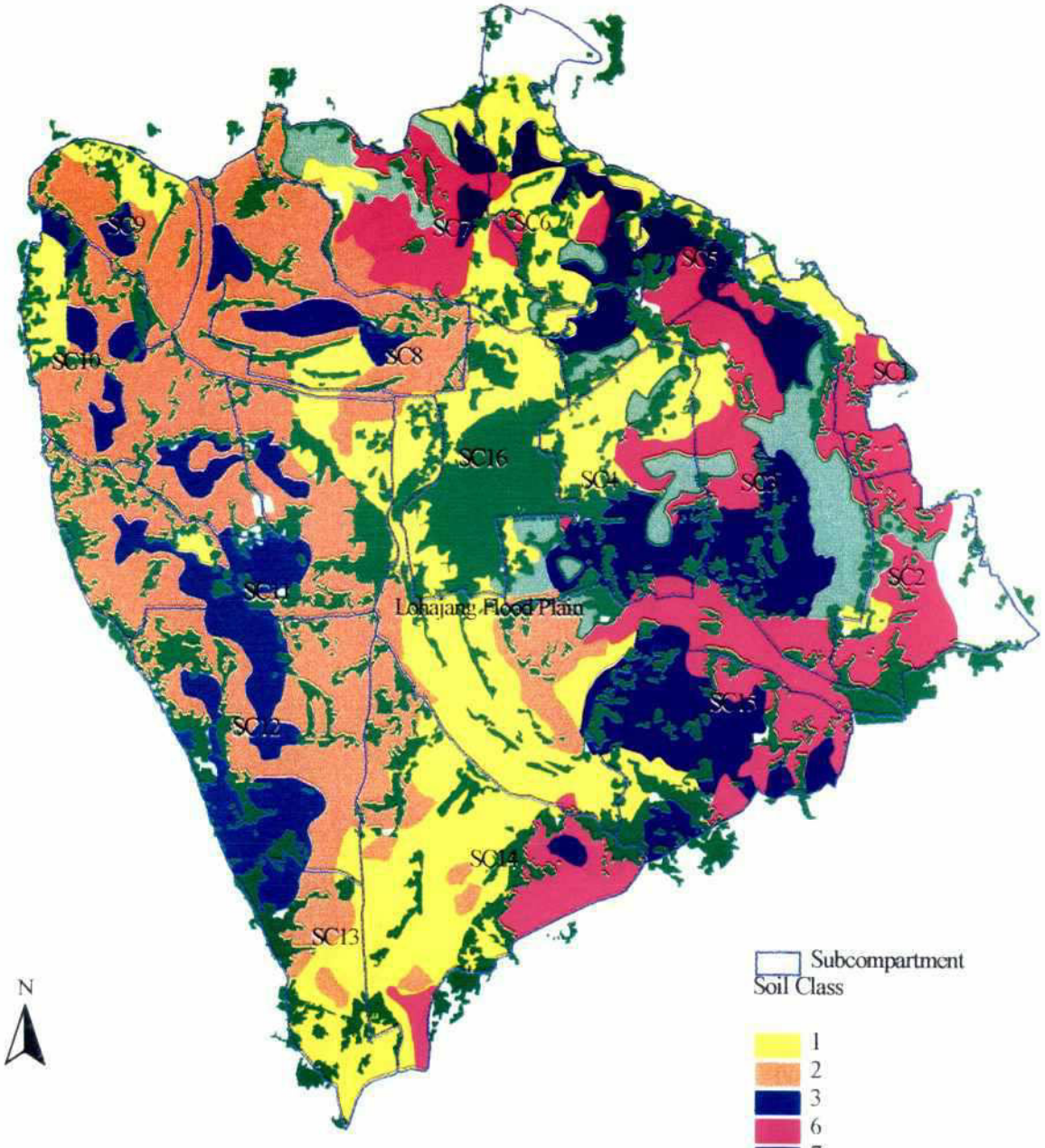
Map 10



Compartmentalization Pilot Project Tangail

Land Type based on Soil

Map 11



1 0 1 2 3 Kilometers

scale 1:100 000
projection : UTM

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

Compartmentalization Pilot Project Tangail

September, 96 c:\win32app\ppdata\Soil.apr (source : SRDI)

Soil classes

The adjacent map is based on soil maps prepared recently (1992) by the SRDI, Dhaka.

In the Tangail Pilot Project area, following major soil associations can be identified:

The Sonatala-Dhamrai association (1, 2, 3, 6 & 7) covers most of the gently undulating area in the north western parts of the project area. Soils are mostly grey to brownish silt loams; silty sandy loam on the permeable top of the ridges, becoming more clayey lower on the slope. The area is flooded to shallow, locally to moderate depth, and remains moist fairly long in the dry season. This association has only minor limitations for agricultural development. The land can be classified as agriculturally good.

Like the Sonatala-Dhamrai association the Dhamrai-Sabhar Bazar association (2 & 3) is situated on the High Jamuna Floodplain in the western and south-western parts of the project area. On top of the ridges, soils are permeable sandy loam to grey silt loam, changing progressively into heavier and less permeable silty clay loam and silt clay in basins and depressions. The major limitation for agricultural development is the moderate depth of flood over most of the basins and part of the ridges. The land can be classified as good to moderately good agricultural land.

The Silmandi-Sabhar Bazar association (6, 7, 8) is located on the Low Jamuna Floodplain in the eastern and southern parts of the project area. It consists of numerous basins and an intricate network of relatively high floodplain areas, occupying about equal proportions. The major soils of the floodplain ridges consist of grey to brownish silt loam to silty clay loam. Along the Lohajang river there are some recent silt deposits. Top soils in the basins and depressions are impermeable grey clay to silty clay; the more larger, nearly level basin areas have usually more firm silty clay to clay sub-soils. Much of the area is flooded to moderate depth, the basin areas for 4-7 months. The soils remain moist long into the dry season. Only the highest areas become dry by the middle of the dry season. The major limitation for agricultural development is the moderate to sometimes great flood depths in the basins and over many of the ridges. The land can be classified as good to moderately good agricultural land.

Three-Tier Local Water Management Institutions

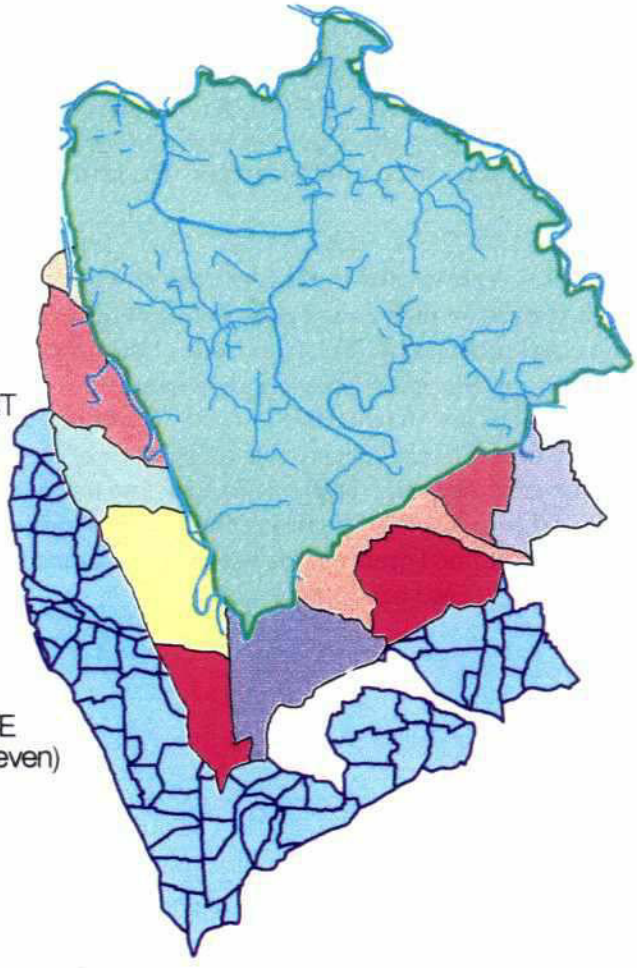
Map 12

TIERS

COMPARTMENT
(One)

SUBCOMPARTMENT
(Sixteen)

CHAWK/VILLAGE
(One hundred and eleven)



COMMITTEES

Compartmental Water Management Committe (CWMC)-Project Council

79 members
42 representatives from SWMCs (Interest group + UP)
3 representatives from adjacent area
2 representatives from NGOs
16 representatives from Govt. Organizations
4 representatives from Local Govt.
12 women UP members

Subcompartmental Water Management Committe (SCWMC)

17- 19 members
9 representatives from farmers, fishermen, landless & women
1- 2 representatives from NGOs
3- 4 representatives from Govt. Organizations
4 representatives from Union Parishad

Water Users Group (WUG)

Farmers : 9-member Chawk Committee
Women : Existing BRDB/NGO groups
Landless : Existing BRDB/NGO groups
Fishermen : Existing cooperatives

September, 96 c:\win32app\cppdata\Instit.apr

Three tier water management institutional structure

Although more consultation and more detailed investigation are still required to fine-tune the institutional setting, the outline of the institutional arrangements for this compartment is clear.

The main characteristics of the proposed institutional arrangements are:

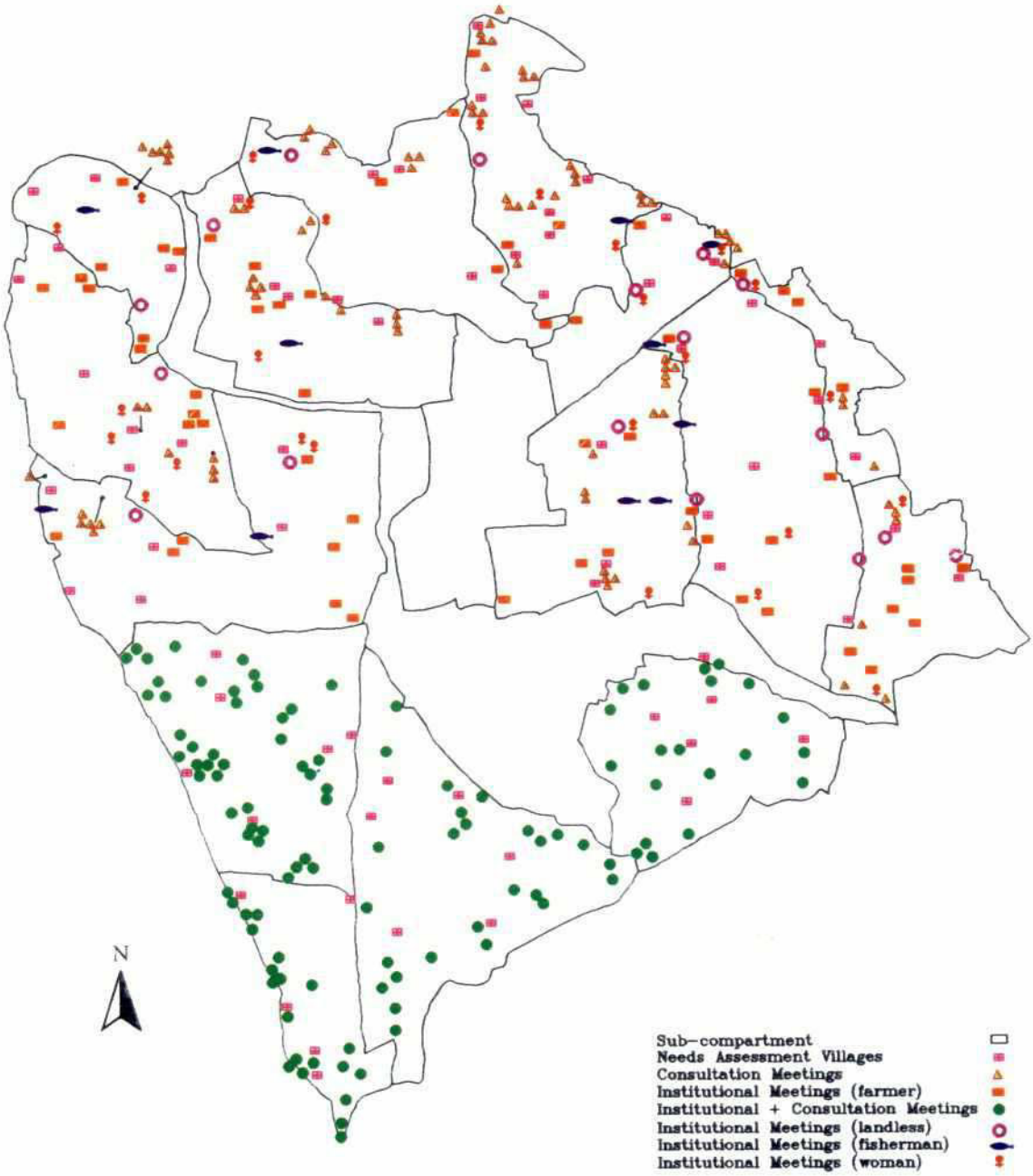
- A three tier system of representation and management related to water management within hydrologically defined areas;
- Three parties are recognised and encouraged to participate and contribute: a) interest groups b) technical departments c) local government;
- Non Government Organisations are explicitly recognised as a valuable part of Bangladesh society, that should participate in and contribute to these institutions.

More specifically the following arrangements are proposed (see Map 12):

- Water Users Groups (WUGs) at the 'Chawk' level made up by a functionally and socio-economically defined category of people. Essentially these are relatively homogeneous groups, as far as their interest in water management is concerned. In CPP one Sub-Compartment consists of 5 to 15 Water Users Groups.
- Sub-Compartmental Water Management Committees (SCWMCs): made up by representatives of the above WUGs, selected field staff of Govt. & Non Govt. agencies and 3 Union Parishad Members. This Committee will essentially be in charge of water management at this level, will facilitate local resource mobilization and upward representation.
- A Compartment Water Management Committee (CWMC)/ Project Council(PC) will be in charge of water management at the compartmental level. It is composed of representatives of the SCWMCs, technical departments, NGOs and local government.

Needs Assessment Villages and Meeting Places

Map 13



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projection : UTM

Compartmentalization Pilot Project Tangail

September, 96 c:\acad12\files\tangail\consult.dwg

People's participation

People's participation in CPP is defined as "involving people in all phases of compartmentalization, with the aim that they will operate and maintain these compartments, so as to ensure sustainable development." The first step in the process of people's participation were the needs assessment meetings. In a later stage consultation and institutional meetings were held. Locations where these meetings were held are presented in Map 13

The following stake holder groups were organised in order to get involved in this process

Farmers Water Users groups (each represented in the SCWMC).

In a chawk a Chawk Representative Farmers Committee is formed. Representatives of the farmers have been selected in such a way that:

- the farmers owning plots in the chawk and share croppers are represented;
- rich, marginal and small farmers;
- farmers from high, medium and low lands in the chawk.

Fishermen Water Users Groups (Representatives elected at Sub-compartment level from existing fishermen associations; 2 per SC).

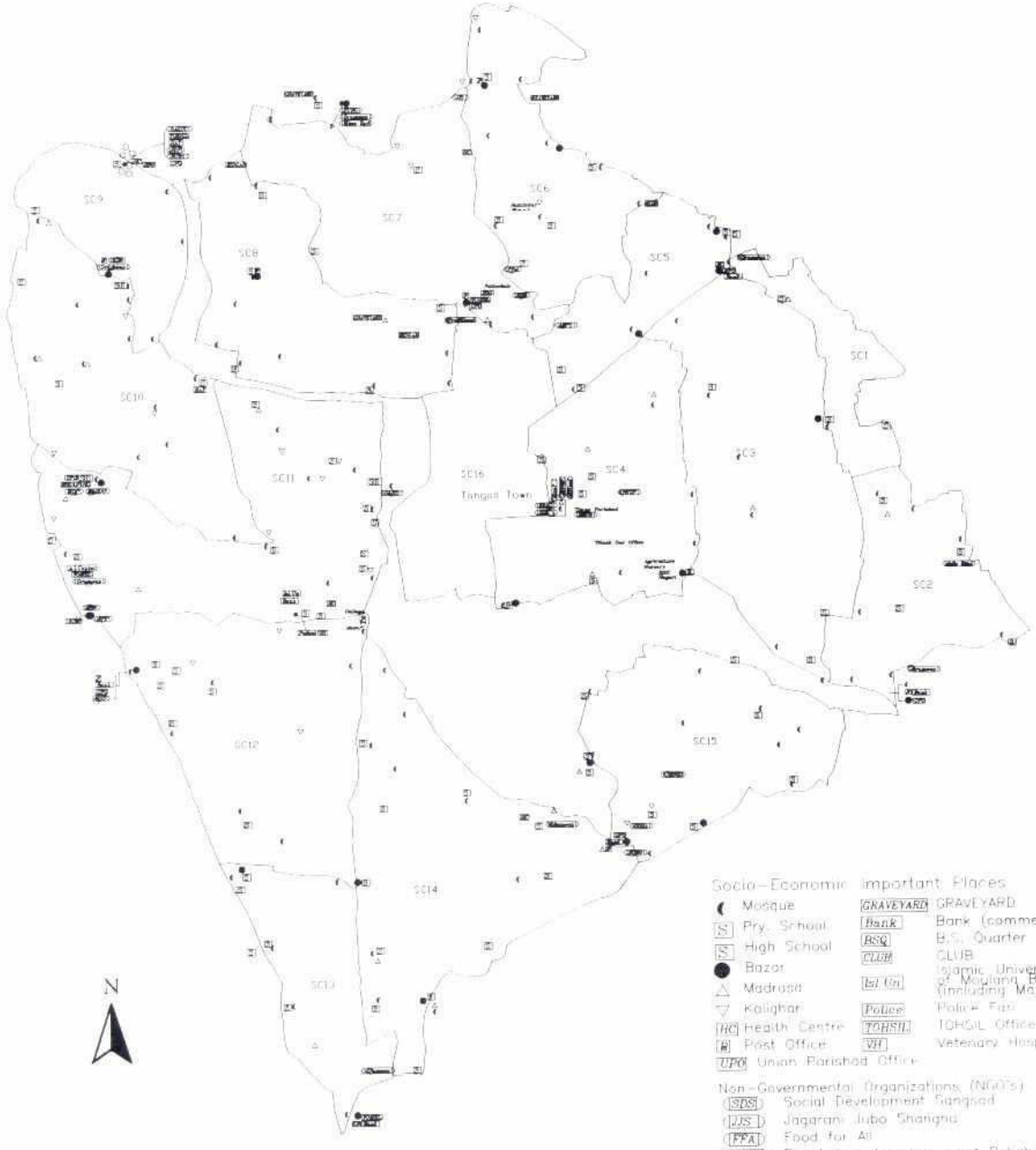
The formation of Water Users Groups for fishermen is easier than that of other groups, as the fishermen community in the project area is already grouped under formal cooperative societies. Leading persons of these registered cooperatives under Cooperative departments are the ultimate representatives at the SC level.

Women & Landless Water Users Group: (Representatives elected at SC level through series of meeting with BRDB/NGO groups; 2 women and 2 landless per SC);

Formation of Water Users Groups for women and landless is based on the need to include these socio-economic disadvantaged groups in the project. BRDB and the NGOs are the main agents forming groups for women and landless1. Ultimate interest of the groups will be dealt with at the SC level.

Socio-Economic Important Places

Map 14



Socio-Economic Important Places

Mosque	GRAVEYARD	GRAVEYARD
Pry. School	Bank	Bank (commercial)
High School	BSQ	B.S. Quarter
Bazar	CLUB	CLUB
Madrasa	Isl Un	Islamic University of Moulana Bhasani (including Mazar)
Kalighar	Police	Police Fari
HC Health Centre	TOHSIL	TOHSIL Office
P Post Office	VH	Veterary Hospital
UPO Union Parishad Office		

Non-Governmental Organizations (NGO's)

- SDS Social Development Sangsad
- JJS Jagaran Jubo Shangha
- FFA Food for All
- BURO Bangladesh Unemployment Rehabilitation Org
- ASPO Artho Shamaje Paribesh Unnayan
- Nijera Kari Nijera Kari
- Pratidhoni Pratidhoni
- Grameen Bank Grameen Bank
- SDP Social Development Programme
- SPP Samaj Proggoti Parishad
- GAHD General Approach of Human Development
- RASDO Rural Agricultural Society Development Organ
- Jautho Uddag Jautho Uddag
- BRAC Bangladesh Rural Advancement Committee
- IREC Integrated Rural Education Council
- BRDB Bangladesh Rural Development Board
- PSUP Pushpak Shamaj Unnayan Prokalpo
- CoaP Coalition Project
- SRMRT Social Reanimat and Welfare Organization for Tottared
- SCF(Aus) Save The Children
- SSS Society for Social Service
- USHA Unity of Social and Human Advancement
- UBNIG Unnayan Bikalpa Niti Nirdharani Gabeshana

1 0 1 2 3 Kilometers

scale 1:100 000
projection : UTM

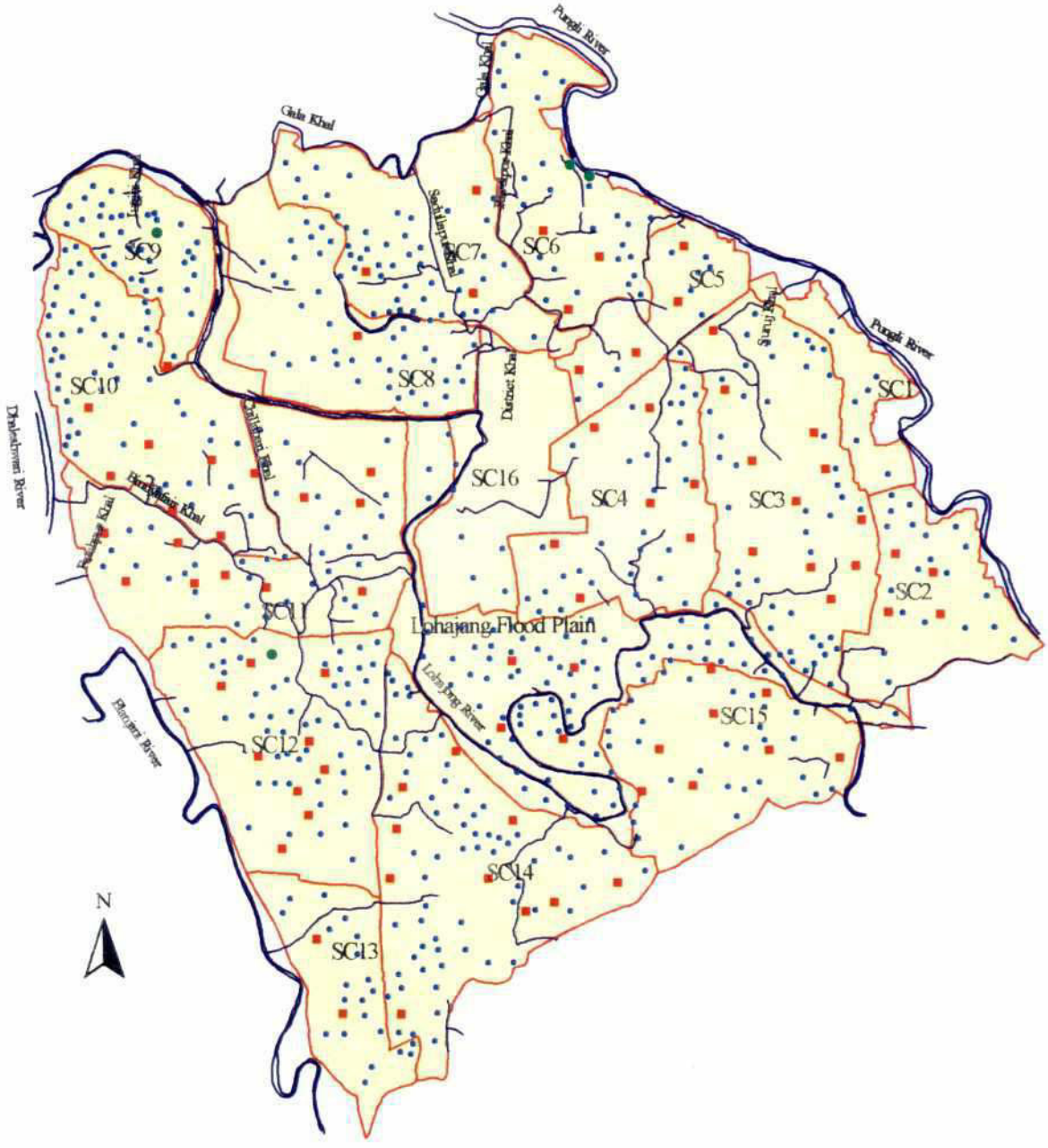
Compartmentalization Pilot Project Tangail

September, 96 c:\acad12\files\tangail\socio.dwg

Socio-economic institutions

The organisation of farmers in a viable institution requires a large input in the terrain of organisation, training, and just meeting people. With respect to this it was important to identify the location of existing organisations and infrastructure that could help CPP in carrying out such an extensive training and organisation programme. On map 14, offices of several NGOs, Public agencies, schools, mosques and other public buildings are indicated.

With the involvement of people in the maintenance of embankments (Embankment Maintenance Groups), and in future other financial activities, commercial banks are increasingly important and these are also indicated on the map.



Compartmentalization Pilot Project Tangail

September, 96 c:\wm32app\cppdata\irmp.apr

Irrigation survey 1995

An irrigation survey of the project area entailing DTWs, STWs, LLPs and other mode of existing irrigation system and their coverage, ownerships, equipments rental and problems etc. has been conducted.

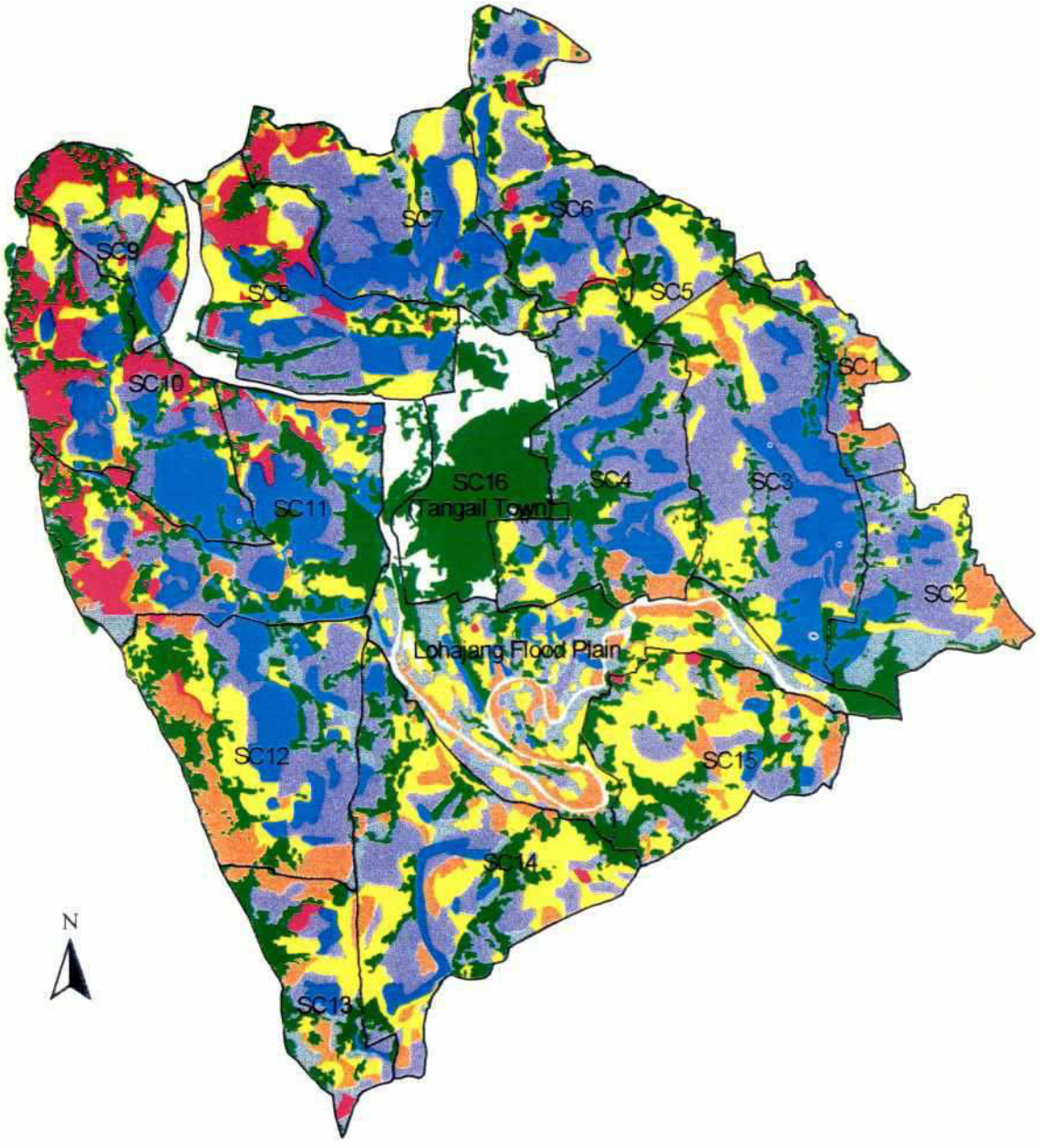
Irrigation facilities of the project area in 1995 dry season is 619 Nos STW, 84 Nos. DTW and 4 Nos. LLP obtained from CPP surveyed data 1995.

TABLE 15.1: NUMBER OF IRRIGATION FACILITIES PER SUB-COMPARTMENT

Sub-Compartment	Wells and Pumps		
	STW	DTW	LLP
1	6	0	0
2	20	4	0
3	41	11	0
4	30	7	0
5	9	4	0
6	27	3	2
7	49	3	0
8	37	1	0
9	34	1	1
10	54	7	0
11	39	10	0
12	55	9	1
13	21	2	0
14	61	10	0
15	22	8	0
16	4	0	0
LFP	110	4	0
Total	**619**	**84**	**4**

Monsoon Landuse (base)

Map 16



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September, 96 c:\win32app\cppdata\croptot.apr

Farming systems

Farm households in the CPP area can be divided in pure share-croppers (0.2-0.5 ha), marginal farmers (0.5-1.0 ha), small farmers (1.0-2.5 ha), medium farmers (2.5-5.0 ha) and large farmers (> 5.0 ha).

'Farmers' with less than 0.2 acre of arable land were not considered farming households in the household survey, although this group contains 70% of the rural households. With a total of 27,789 rural households this means that in the project area around 8,400 (30%) of farming households are 'settled'. It also appears that 1.59% of all the existing rural households (5.3% of these 30% farm households) own about 21% of the net cultivated area.

The farming population in the area of Tangail is not only a very heterogeneous group with regard to the area of owned land but also with regard to other resources, objectives, norm and value system, knowledge, etc..

Major characteristics indicating the diversity in farming are:

- the cropping pattern: rice-cultivators versus crop diversifying farmers
- the cultivated landtype: low land cultivators versus high land cultivators
- the farm size: large farmers versus small and marginal farmers
- the primary occupation: full-time farmers versus part-time farmers, and
- the location: project area versus adjacent area

TABLE 16.1: AREAS WITH DIFFERENT MONSOON CROPS FOR ENTIRE COMPARTMENT

SC No	TAman (HYV) ha	TAman (Local) ha	D.W Aman ha	Sugarcane ha	Total crop area ha	Water Area ha	Not Cultivated ha	Gross Cultivable A. ha
SC 1	5	38	61	58	162	12	17	191
SC 2	0	57	184	49	290	61	87	438
SC 3	0	172	449	44	665	259	7	931
SC 4	0	72	326	38	436	143	0	579
SC 5	3	98	129	1	1553	26	5	262
SC 6	22	114	264	10	2944	92	21	523
SC 7	43	110	258	9	420	190	60	670
SC 8	89	167	169	9	434	170	38	642
SC 12	9	168	233	177	587	183	45	815
SC 13	17	80	83	78	258	34	40	332
SC 14	3	316	346	112	777	80	6	863
SC 15	8	275	105	87	475	26	49	550
LFP	1	241	82	158	482	52	479	1013

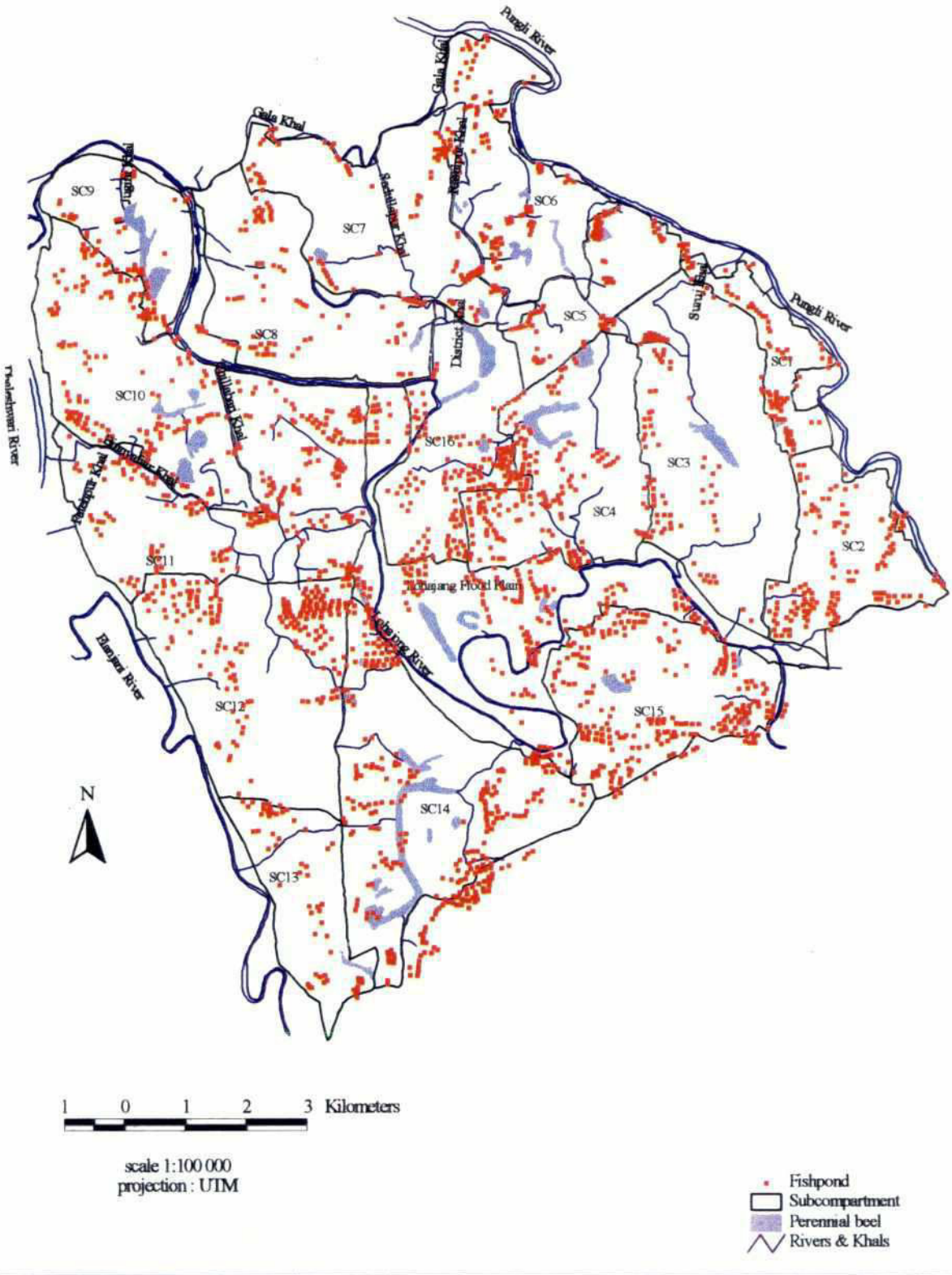
ERRATUM :

Some statistics on monsoon crops in three sub-compartments are missing in table 16.1. They should be read like the table given below :

SC No	TAman (HYV) ha	TAman (Local) ha	D.W Aman ha	Sugarcane ha	Total crop area ha	Water Area ha	Not Cultivated ha	Gross Cultivable A. ha
SC 9	83	84	67	4	238	19	31	288
SC 10	187	108	130	9	434	229	19	682
SC 11	118	123	176	71	488	274	68	830

Fishponds

Map 17



Compartmentalization Pilot Project Tangail

Fisheries in CPP

To assess the total fish production in the CPP area, before and after introduction of the project interventions, a catch assessment survey was carried out. These catches were combined with the inundated areas as calculated by a hydrological model (MIKE 11) in order to predict the total fish production in CPP, and to evaluate the impact of the project interventions. The predicted annual loss due to water management interventions is 42 metric tons. As 50% of the floodplain fish is caught by subsistence fishermen, these losses will have a serious impact on the nutritional status of about 17,000 households and on the living standards of 260 professional fishermen as well.

To compensate for the losses, mitigation measures were formulated:

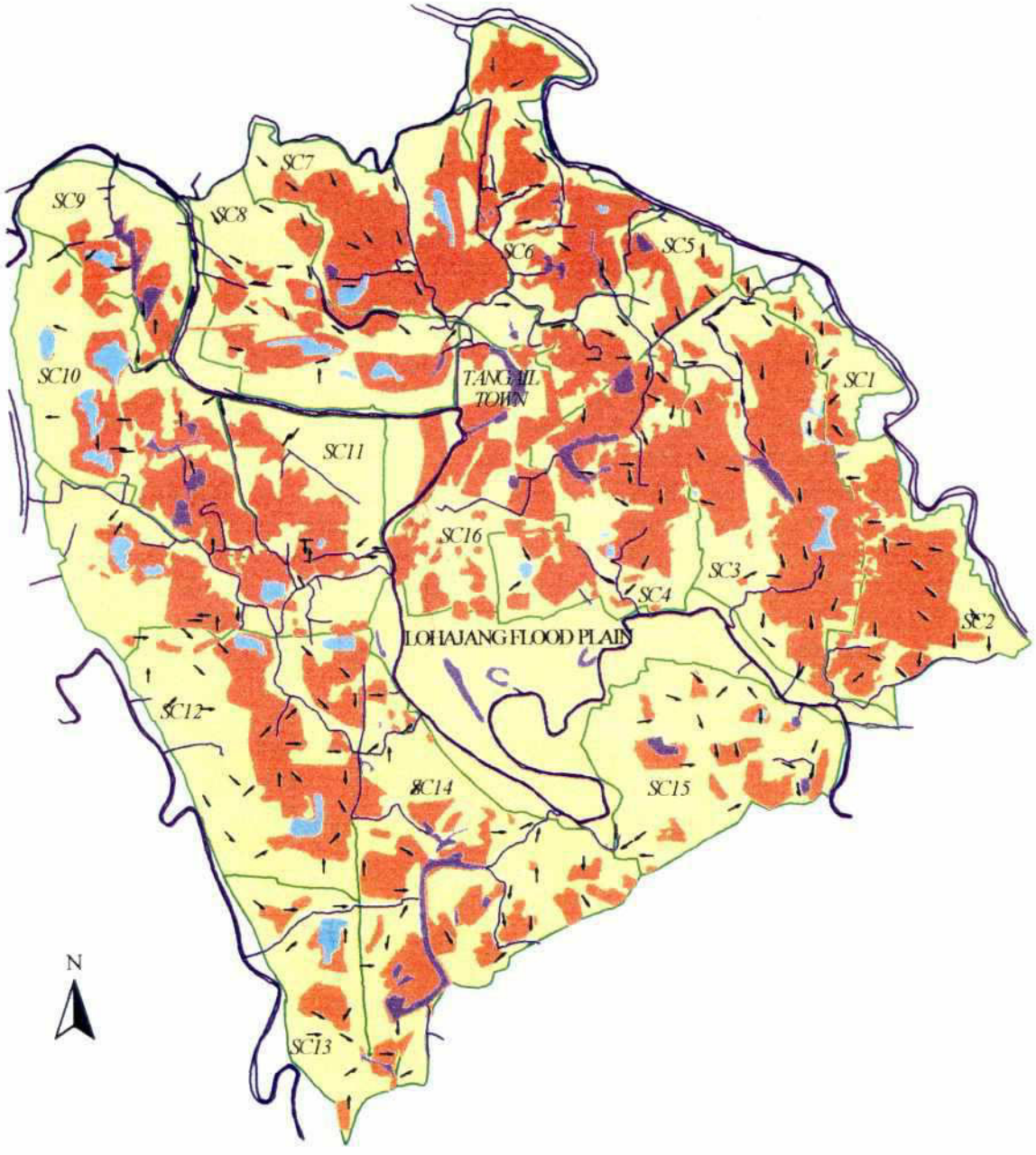
- **Increase the concentration of hatchlings.** In order to increase the concentration of hatchlings in the Lohajang river it has been proposed to remove a sand rim at the mouth of this river which obstructs the migration of carp hatchlings during the first flood period. Furthermore, it has been advised to construct overshot regulators in order to minimize hatchling mortality as they pass through a structure. In this respect some preliminary mortality studies have been carried out.
- **Maintain fish production in beels.** Beel resident fish species were found to start reproducing when the water level in the beels rises with minimal 1-1.5 m, during the pre-monsoon period. If this rise is not attained in time, the reproduction will be delayed which results to a shorter growing season and hence less production. Therefore it has been advised to construct sill levels of 1-1.5 m above the average driest beel water level in khals that drain perennial beels in order to maintain the necessary water rise for reproduction. This is known as 'the beel concept' in the project.
- **Improve production in fish ponds**. A pond survey (see map 17) revealed that the majority of pond operators use traditional culture methods resulting in production levels not exceeding 1200 kg/ha/yr. It has been proved in other projects that the production could be doubled with appropriate measures. With this in mind, CPP has implemented an aqua culture extension and training programme for the 2953 ponds and pagars in the CPP area.. The ponds which were covered in this first phase doubled their production due to introduction of semi-intensive culture practices.

TABLE 17.1: DISTRIBUTION OF PONDS IN DIFFERENT SUB-COMPARTMENTS

SC No	*Small Pond*		*Medium Pond*		*Large Pond*		*Total*	
	No.	**Area (ha)**	**No.**	**Area (ha)**	**No.**	**Area (ha)**	**No.**	**Area (ha)**
SC1	35	0.70	19	1.38	5	1.35	59	3.43
SC2	53	1.21	71	5.59	32	11.61	156	18.41
SC3	53	1.18	46	3.62	9	2.79	108	7.60
SC4	65	1.41	76	6.16	19	7.62	160	15.19
SC5	54	1.21	36	2.87	13	3.23	103	7.31
SC6	28	0.59	46	3.99	8	2.57	82	7.14
SC7	31	0.69	47	4.10	21	6.34	99	11.14
SC8	24	0.51	27	2.02	12	3.17	63	5.70
SC9	31	0.83	41	2.99	3	1.02	75	4.84
SC10	44	1.06	37	3.17	8	2.25	89	6.47
SC11	83	2.14	105	8.13	69	26.41	257	36.69
SC12	177	3.22	78	5.80	33	9.82	288	18.84
SC13	50	1.01	24	1.90	6	1.42	80	4.33
SC14	257	4.98	113	8.14	27	6.78	397	19.90
SC15	171	3.38	96	7.24	26	7.57	293	18.20
SC16	150	3.01	129	10.57	74	22.82	353	36.40
LFP	183	3.46	91	6.68	17	5.07	291	15.20
Total:	1489	30.59	1082	84.36	382	121.82	2953	236.77

Impeded Drainage

Map 18



1 0 1 2 3 Kilometers

scale 1:100 000
projection : UTM

- Post monsoon drainage flow
- Perennial beel
- Non Perennial beel
- Rivers & Khals
- Drainage Congestion
- Sub-compartment

Compartmentalization Pilot Project Tangail

Drainage congestion

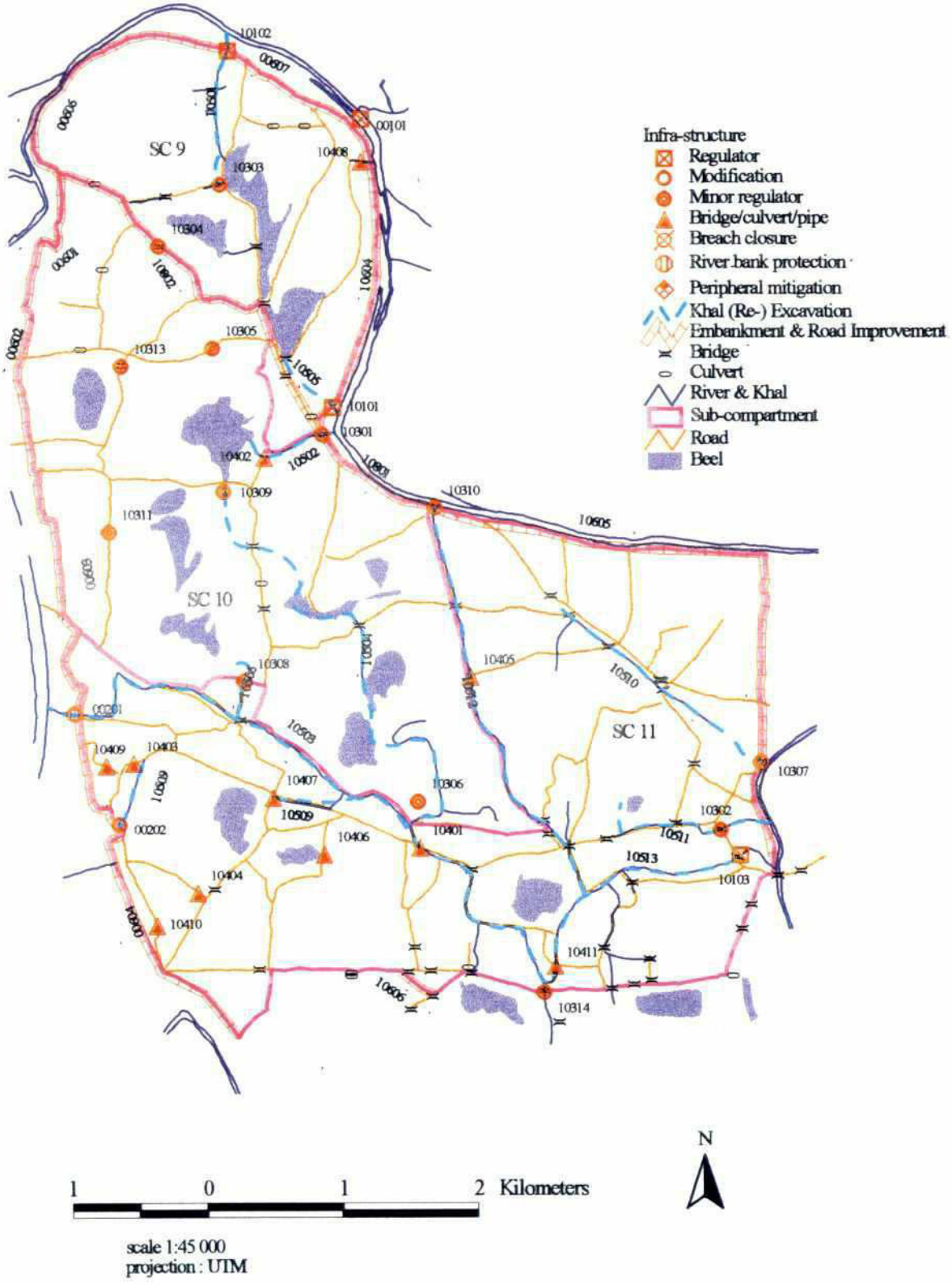
An important objective of the CPP is to reduce the drainage congestion of the area. In October 1993 a survey was done which identified the areas that were at that moment fallow because of flooding, i.e. they were too deeply inundated to have been planted with deep water aman. This was considered an appropriate criterion for drainage congestion, considering that 1993 was a rather dry year.

TABLE 18.1: AREA DRAINAGE CONGESTION PER SUB-COMPARTMENT

SC No	Sub-compartment Area	Area Congested	
No.	hectare	hectare	%
1	247	56	23
2	544	271	50
3	1116	630	56
4	804	407	51
5	369	135	37
6	669	330	49
7	796	432	54
8	778	235	30
9	402	86	21
10	876	355	41
11	1167	346	30
12	1037	222	21
13	457	94	21
14	1186	325	27
15	767	124	16
16	619	228	37
TOTAL	**13200**	**4276**	**100**

Total congested area in CPP (excluding Lohajang flood plain and Tangail town) = 4048 hectares.

Total congested area in Tangail town = 228 hectares.



Compartmentalization Pilot Project Tangail

Water management in the Tangail compartment

General

Although water management also encompasses irrigation in the dry season, the compartmentalization concept concerns the monsoon season, and the focus of CPP is on the monsoon. Flood control and controlled flooding are typically wet season activities, and drainage too is basically a wet season activity. The main objective is drainage in the pre- and post monsoon, controlled flooding in the early flood season, and flood control when needed in later stages, when water levels reach even higher values.

Main system

Tangail Compartment is at present surrounded by embankments that can withstand a flood with a return period of 12 years. Nevertheless, the water management is only ensured for floods (water levels) with a return period of 5 years. Above a certain level, target water levels cannot be maintained (will be exceeded) and parts of the agricultural land will be inundated.

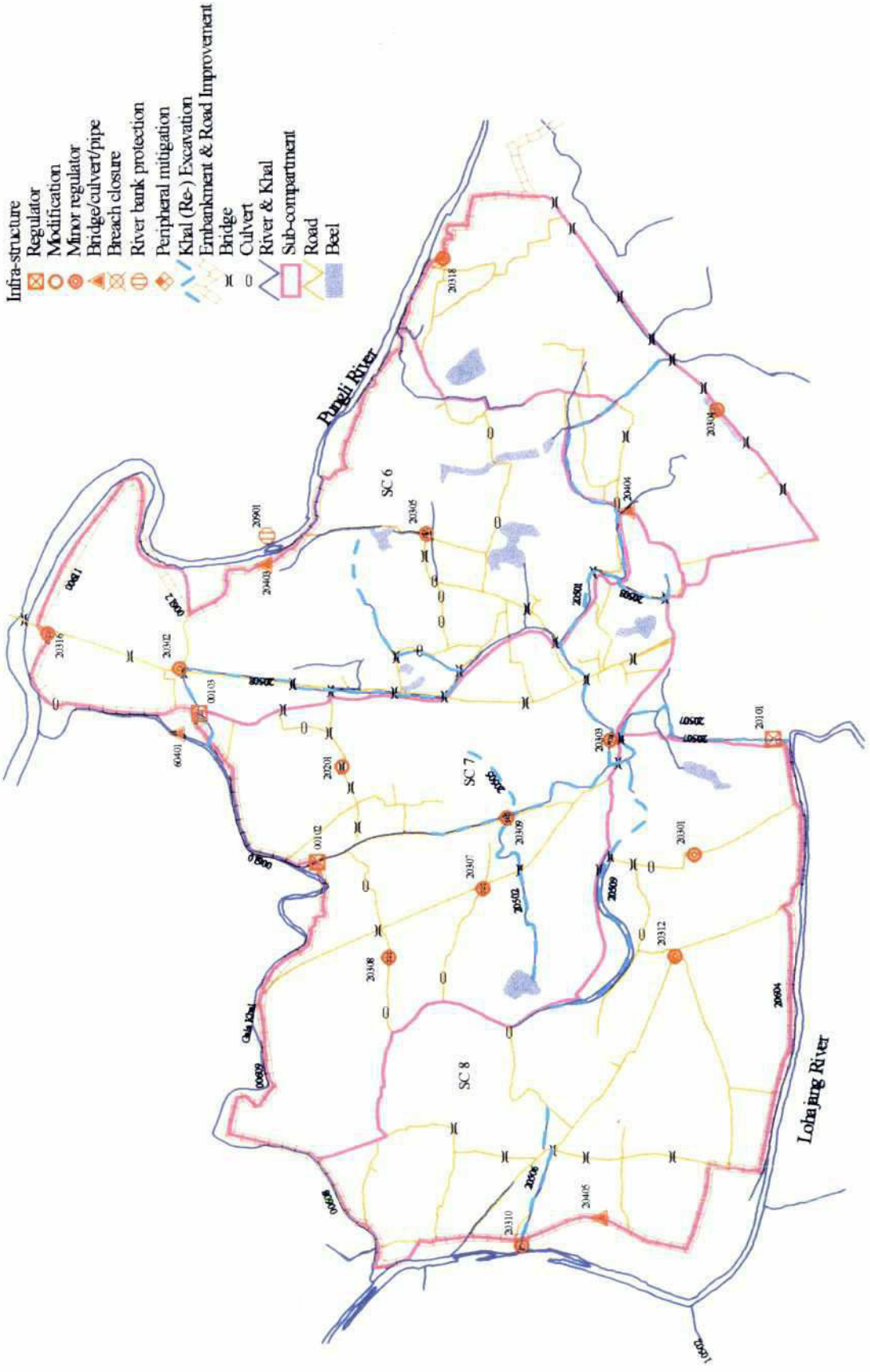
The Lohajang river is allowed into the project through a gated regulator at the northern side, sometimes for the supply of water but mainly for drainage. By lowering the water level of the Lohajang the river will act as a drain for the numerous outlets that discharge into it. In the peripheral embankment on the northern, western and eastern sides of the project area, gated inlets are built to allow water into the compartment. The inlets and the main regulator have to be operated in concert. In general when the main regulator has to be closed to enable the outlets to drain out water, the peripheral inlets need to be closed as well. In case of long lasting high floods, flood water may enter the project from the open southern side (the open embankment) as back flow, and some parts of the compartment may be flooded.

Water management: water levels in the field

Inside the compartment, water management aims at water level control for optimum agricultural and fish production. The ultimate objective is water level control at field level (and at beel level). For this purpose the compartment is divided in sub-compartments, systems and chawks. One water level is to be maintained in one chawk: the target water level. This does not mean that one inundation depth is maintained within one chawk: through on-farm water management measures, water levels within a chawk will differ and the elevation of the fields differs (see also Annex B).

At system level one water level is to be maintained at the structure; this will lead to a range of target water levels that can be maintained in the different chawks.

The sub-compartment consists of a number of systems, and is both a hydrological unit and a water management related administrative unit. Different water levels are maintained at the different structures within one sub-compartment. Water management in the entire sub-compartment is controlled by the SCWMC.



September, 96 c:\win32app\cppdata\Cluster2.apr

Operation: concert between Main regulator, Inlets, and Outlets

Early in the monsoon season water levels in the rivers are still low and only the occasional rain shower has to be drained off: ***local drainage*** is the objective. All gates are to be kept open, but can be closed if local considerations require.

Once the river water levels start to increase, inlets (and some outlets) are opened (or remain open) and water enters the compartment: ***controlled flooding*** is the objective. Siltation is allowed to take place on the field, and the entry of fish into the compartment is facilitated. The water control structures between sub-compartments and systems are operated as required, to facilitate an even distribution of the silt laden river floods over the compartment, and to deal with rain showers. A level of flooding which will give maximum benefits to both agriculture and fisheries is the objective.

In a later stage the emphasis shifts from controlled flooding to ***water level control.*** The Main regulator will be (partly) closed, lowering the water level in Lohajang river, inlets will be closed, outlets will generally be open when drainage is possible. The water level is lowered to such an extent that land preparation and planting can take place. The objective is to keep the water level close to an optimum level. These levels are dictated by crop requirements in compromise with the physical possibilities of the water management infrastructure and fisheries and environment aspects.

When flood levels in the main river system exceed certain levels, then ***flood control*** is called for: the Main regulator is completely closed (if possible), the inlets are closed, the water control structures operated as required to limit flooding in sub-compartments and systems, outlets will be open, downstream water levels permitting. Some local inundation may occur, particularly as a result of rainfall which cannot be drained off.

Towards the end of the monsoon, once the water levels start to drop, ***early drainage*** of the compartment can start. The improved drainage in the compartment will allow early land preparation for the dry season crops, and early harvesting of aman rice crops.

Water management infrastructure

A large number of interventions was required to enable above water management . In the table an overview of the infrastructure per cluster is presented, in Annex C a more detailed listing can be found.

TABLE 19.1: INFRASTRUCTURE BY CLUSTER

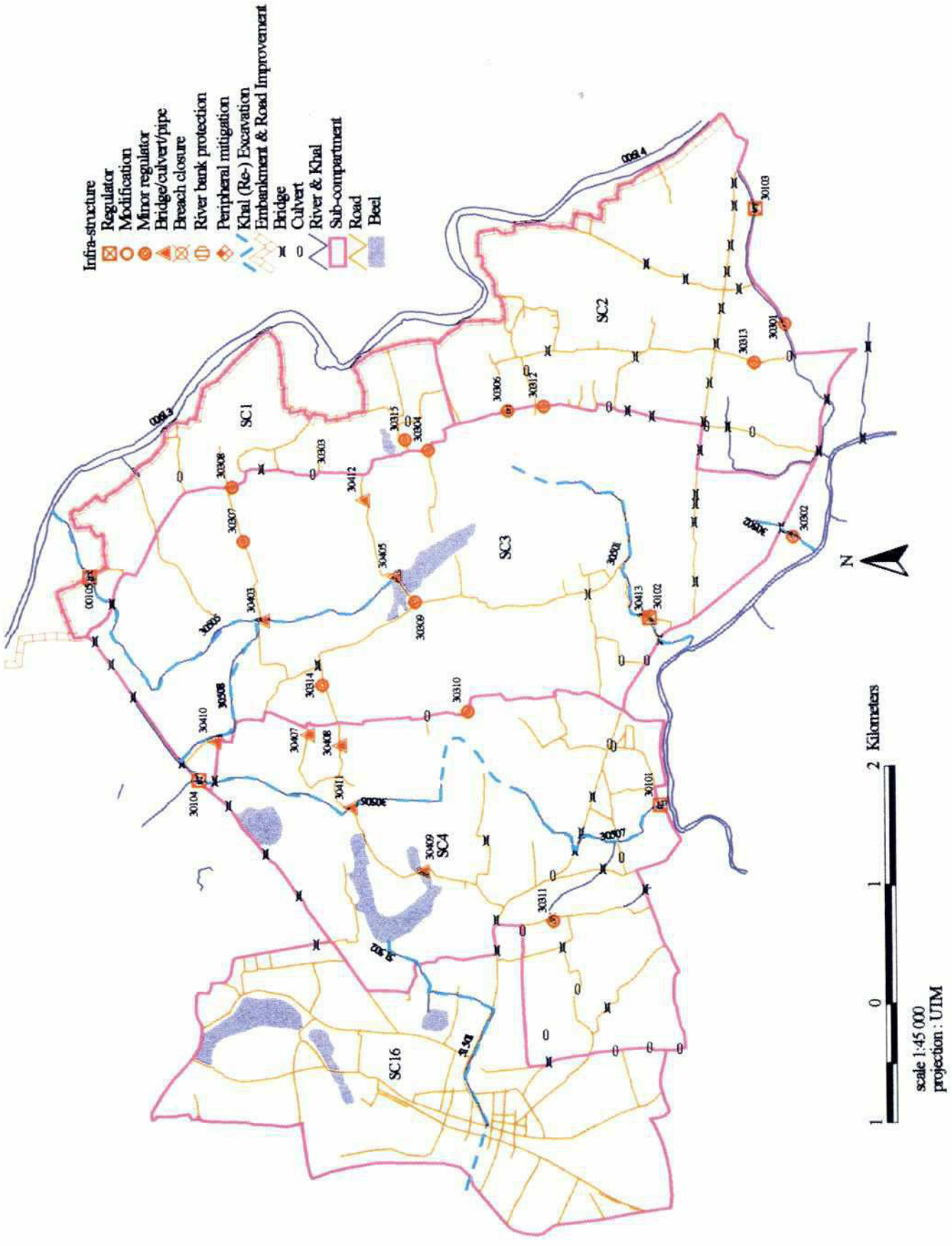
Structure type	Compartment	Cluster 1[b]	Cluster 2	Cluster 3	Cluster 4
Main regulators	1	3	3	5	3
Modified regulators		2	1		3
Minor regulators		13	12	13	13
Bridges/culverts		11	3	3	3
(Re-)excavation of khals (km)		17.0	22.4	14.2	21.9
Upgrading embankments (km)		16.8	18.4	16.0	9.2
Road improvement (km)		4.0	0.3		

Cluster 1[b]

The general direction of flow is north-west to south-east. In Cluster 1[b] water will enter the area from Khorda Jugini inlet on the northern side of the embankment, and the Binnafair and Fatehpur sluices on the western embankment, and will leave the area through the Kagmari and Dithpur outlets, and some smaller outlets: Dannya Chowdury, Dighulia 1 (yet to be built) and 2, Chillabari (also as inlet from Lohajang river), and Santosh (for emergencies, to Cluster 4).

Cluster III & V : Water Management Infrastructure

Map 21



Compartmentalization Pilot Project Tangail

Cluster 2

The general flow direction in cluster 2 is from north to south. Water enters the area through the Sadhullapur and Rasulpur regulators on the northern embankment, and occasionally through the Pauli and Bararia sluices on the northern and eastern embankments. The western half of the cluster drains mainly through the District regulator into the Lohajang river, the eastern part mainly through the Gharinda regulator (yet to be built), and through Gharinda beel water control structure, as well as some small culverts, into cluster 3. The balance between drainage flows from the left and right halves of the area can be controlled by Enayetpur-2 water control structure.

Cluster 3

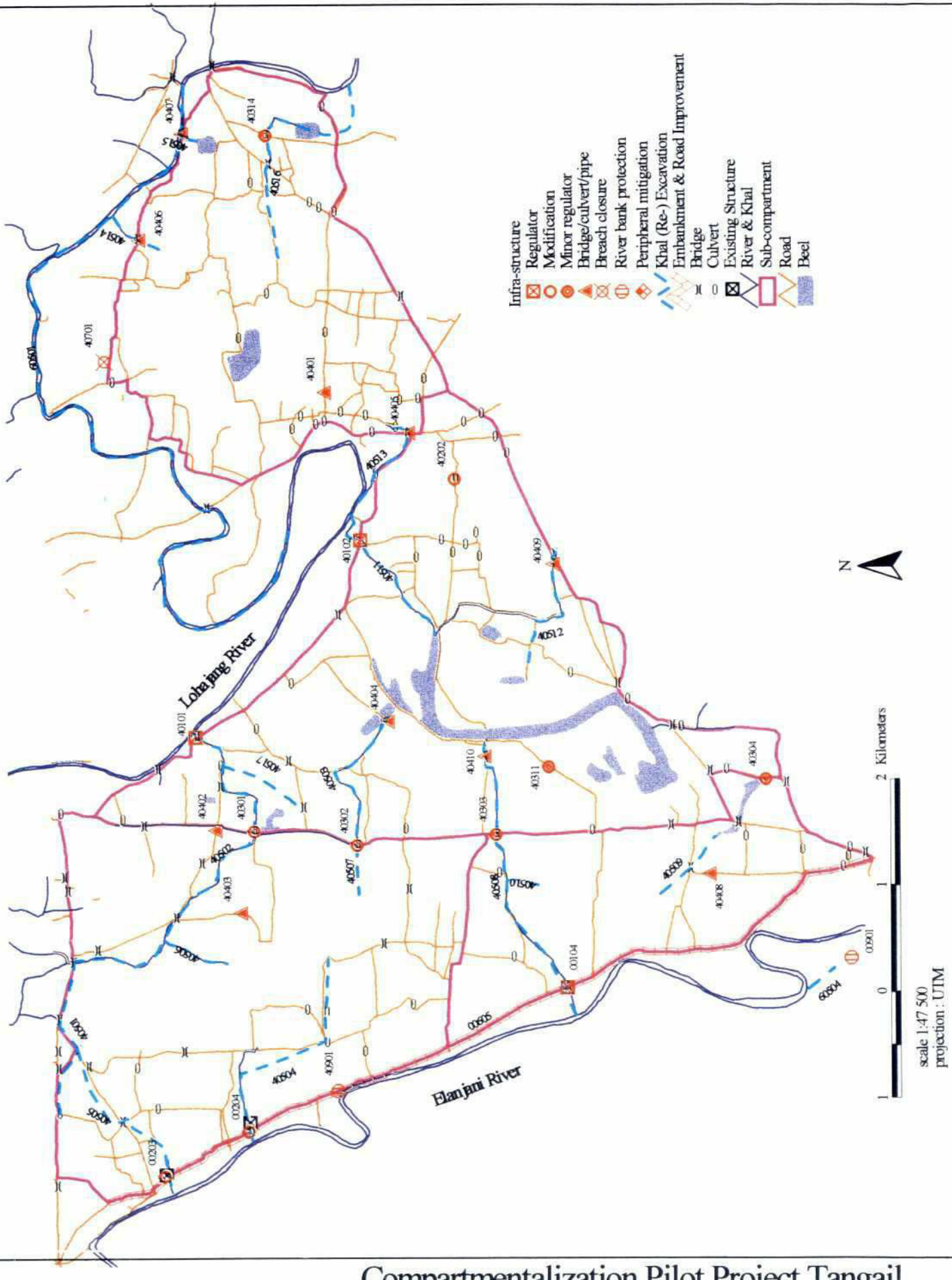
The general flow direction is from north to south. Water enters the area for a great deal from cluster 2 in the north, and additional flows enter the area from the Suruuj inlet on the eastern embankment. Lower areas in the south western part can be flooded through the Nagar Jalfai and Bhatkura outlets on that side, but in general these structures would drain out water. Also some smaller regulators in the eastern half of the area are responsible for the drainage of the area: Paschim Pauli, Karatia and Khudirampur regulators.

Cluster 4

The general flow direction is from west to east in both the western and eastern halves of the area. In the western half water enters the area through the Barabelta, Indrabelta and Baruha inlets, while low areas can be flooded from Aloaraypara and Deojan regulators. Occasionally water may enter the area from cluster 1^b, but this is general an emergency situation and may disrupt water management in the western area. In the eastern area very little water will enter the area except from rainfall. The Kumulli, Khagjana and Birpusia regulators drain out the water from that area. Occasionally water will enter the area through Birpusia regulator.

Cluster IV : Water Management Infra-structure

Map 22



Compartmentalization Pilot Project Tangail

September, 96 c:\win32app\cppdata\Cluster4.apr

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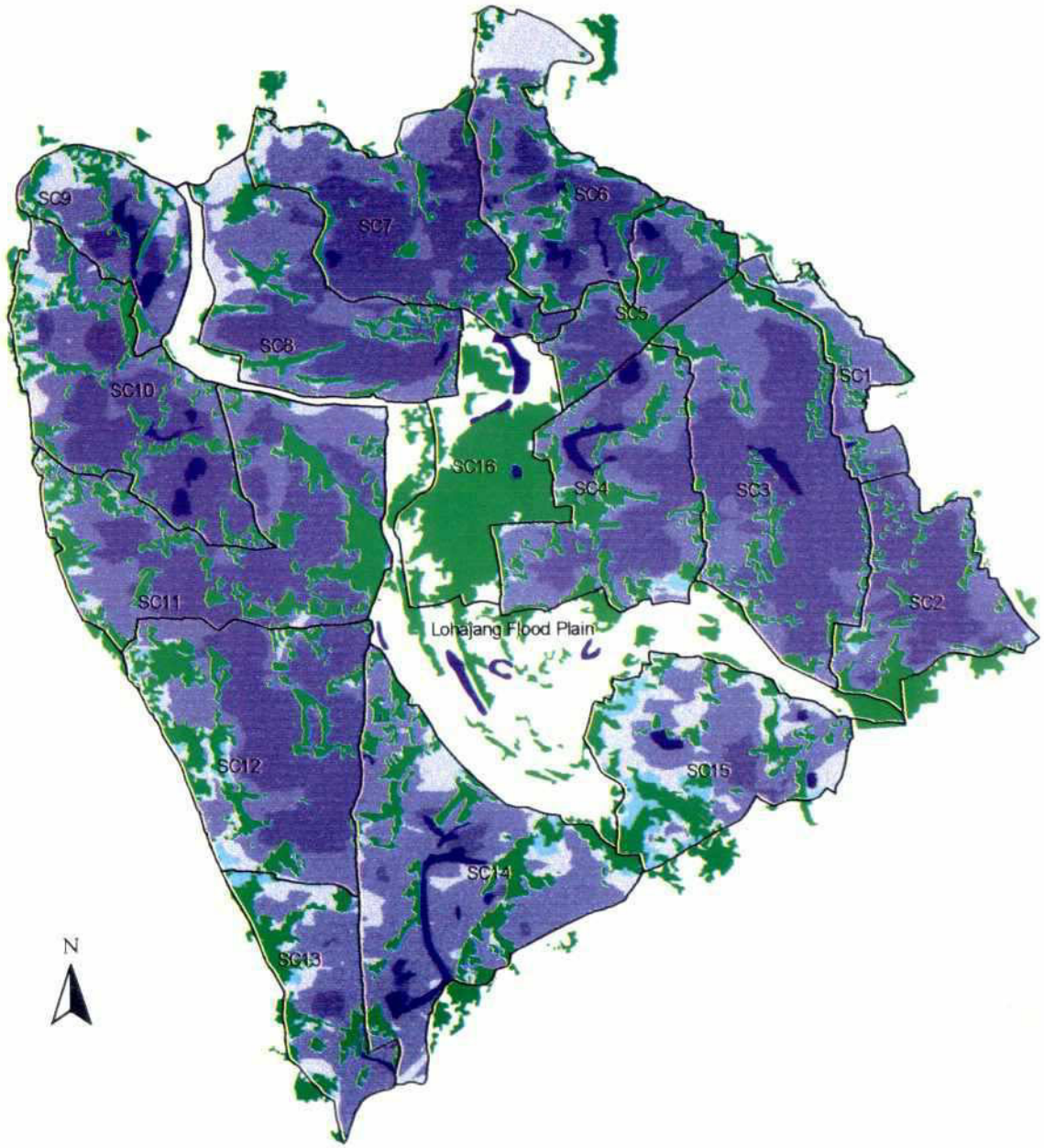
Land Types based on Flood Depth (Base)

Map 23



1 0 1 2 3 Kilometers

scale 1:100 000
projection : UTM

Sub-compartment
Land type (1 in 5 year flood)
F0 (0-30 cm)
F1 (30-90 cm)
F2 (90-180 cm)
F3 (> 180 cm)
Perennial beel
Settlements

Compartmentalization Pilot Project Tangail

September, 96 c:\win32app\cppdata\landclas.apr

Flood management model

In order to study and predict flooding in Bangladesh, mathematical models have been developed and applied at the Surface Water Modelling Centre and other FAP projects:

- National-FMM — A coarse FMM covering the major national and regional rivers.
- NCR-FMM — A detailed FMM for the western part of the North Central Region.
- TC-FMM — A detailed FMM for the Tangail Compartment Pilot Project.

The models, and the TC-FMM in particular, is conceived as a decision support system which integrates the MIKE11 based flood modelling system with a Geographic Information System (GIS). The system indicates flood levels, areas and depths of inundation over the flood plain, and the potential impact on communities in graphical and tabular forms. Flood depths and levels are represented as layers of data in the GIS which can be geographically related and analysed with data from other flood management components. In CPP the detailed FMM has been used for the planning of interventions and for the development of the water management rules

All rivers and the major khal system, important for flooding and drainage of the area, have been included in the TC-FMM. The elevations of the area were extracted from the new FINNMAP DEM (Digital Elevation Model) based on 100 by 200 m spot elevations, which were digitised from 1:10,000 photo maps. In the TC-FMM grid cells of 20 by 20 m. are implemented.. The exact height of the settlements is at present not known. The bed levels of the rivers and khals were also unknown and their elevations in the DEM were for the time being lowered to below dry season levels, i.e. they were always 'wet'.

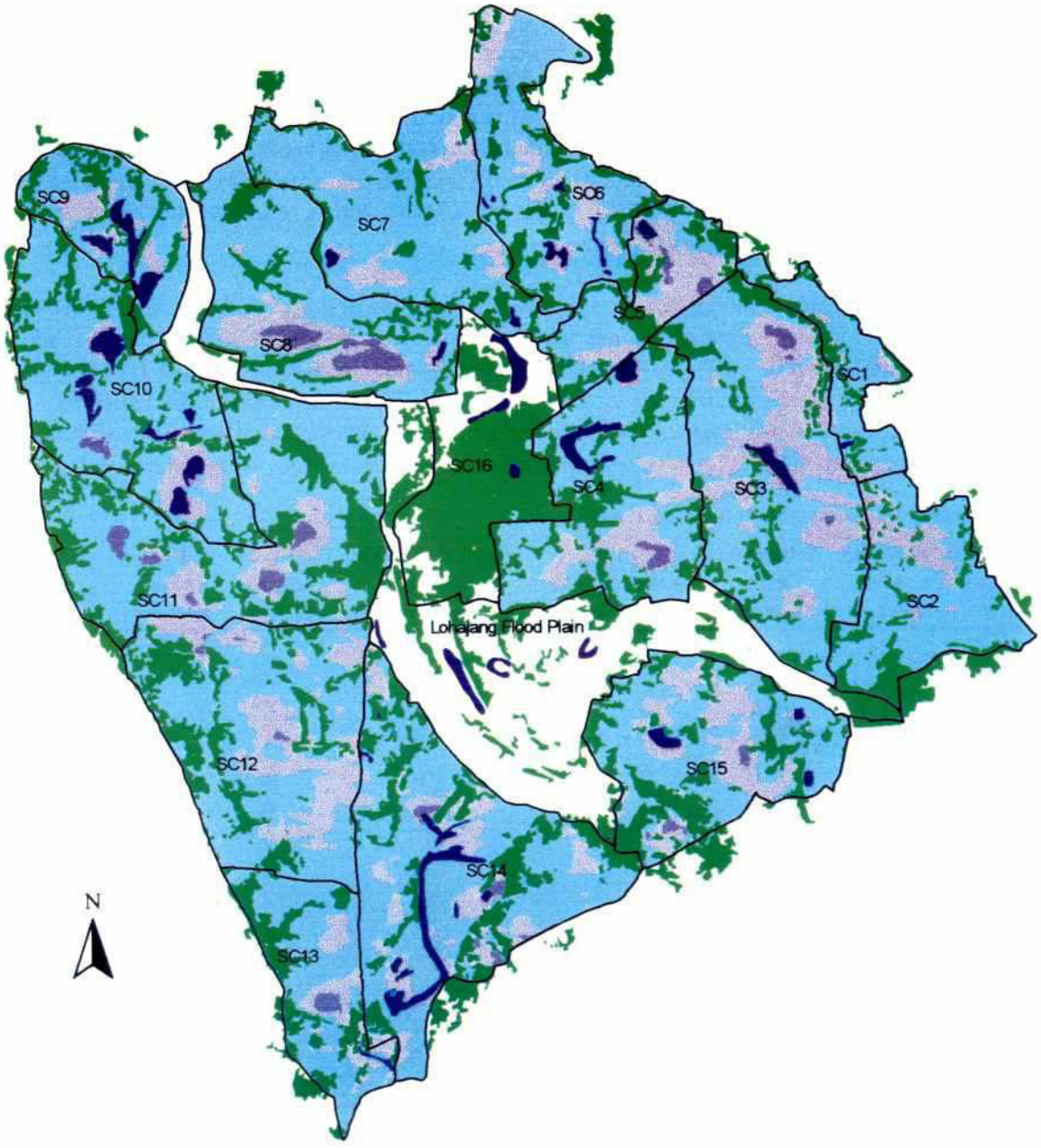
TABLE 23.1: LAND CLASSIFIED ON 1 IN 5 YEAR FLOOD

Subcomp No #	Subcomp Area hectare	Settlement Area hectare	Beel Area hectare	River Area hectare	Gross Cultivable Area hectare	F0 Area hectare	F1 Area hectare	F2 Area hectare	F3 Area hectare
1	247	55	1		191	2	26	131	32
2	544	105			439	4	6	160	269
3	1116	170	15		931	0	8	289	634
4	804	195	31		578	11	18	277	272
5	369	101	6		262	2	2	102	156
6	669	133	13		523	6	128	218	171
7	796	120	6		670	6	49	217	398
8	778	134	3		641	9	79	290	263
9	402	86	28		288	12	78	158	40
10	876	169	25		682	5	70	240	367
11	1167	337			830	9	48	325	448
12	1037	222			815	21	70	252	472
13	457	122	3		332	21	69	220	22
14	1186	260	63		863	15	148	660	40
15	767	203	14		550	72	188	255	35
16	619	431	26	6	156	25	72	59	0
LFP	1366	255	27	72	1013	3	678	210	121
TOTAL	**13200**	**3098**	**261**	**78**	**9763**	**223**	**1737**	**4063**	**3740**

Map 23 and Table 23.1 show the land type distribution, as defined by the Master Plan Organization (MPO) land type categories, based on the 3 day mean maximum with a 1 in 5 year return period. The land elevation coverages and the water levels for 1 in 5 year flood have been taken from TC-FMM.

Land Types based on Flood Depth (With Project)

Map 24



Compartmentalization Pilot Project Tangail

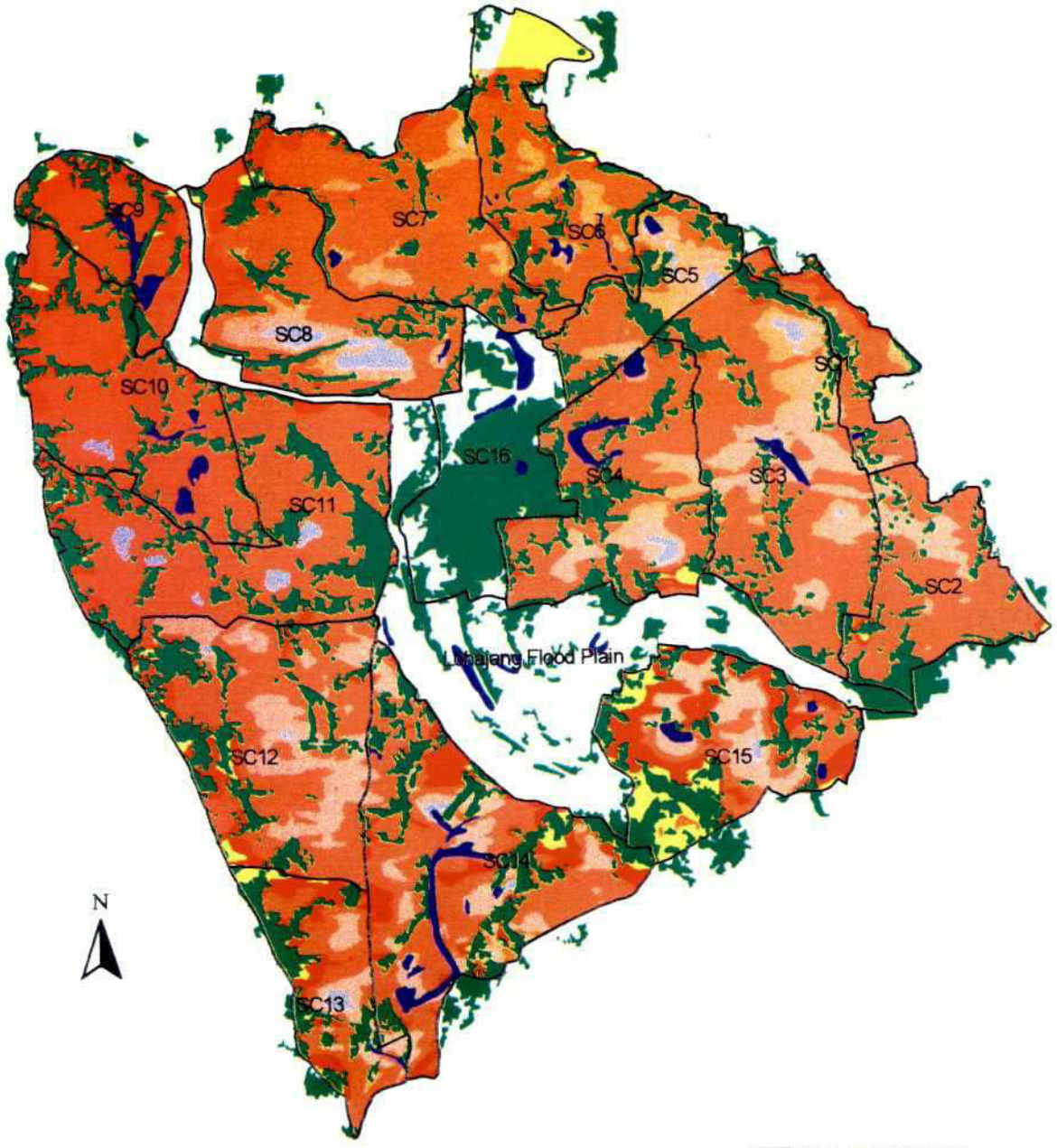
Map 24 and Table 24.1 show land type according to flood depth for the 'with project situation'. For the 'with project scenario', a land classification based on the target water levels for the month of July and August has been used. These two months are the crucial period for the farmers and they decide which crop can be planted type considering the field water levels during these months.

TABLE 24.1: LAND CLASSIFIED ON TARGET WATER LEVELS (JULY-AUGUST)

Subcomp No #	Subcomp Area hectare	Settlement Area hectare	Beel Area hectare	River Area hectare	Gross Cultivable Area hectare	F0 Area hectare	F1 Area hectare	F2 Area hectare	F3 Area hectare
1	247	55	1		191	167	24	0	0
2	544	105			439	369	70	0	0
3	1116	170	15		931	619	300	12	0
4	804	195	31		578	453	114	11	0
5	369	101	6		262	140	112	10	0
6	669	133	13		523	432	91	0	0
7	796	120	6		670	594	75	1	0
8	778	134	3		641	471	118	52	0
9	402	86	28		288	225	53	0	10
10	876	169	25		682	571	68	11	32
11	1167	337			830	686	111	33	0
12	1037	222			815	568	241	6	0
13	457	122	3		332	252	71	9	0
14	1186	260	63		863	666	183	14	0
15	767	203	14		550	384	157	9	0
16	619	431	26	6	156				
LFP	1366	255	27	72	1013				
TOTAL	**13200**	**3098**	**261**	**78**	**9763**	**6597**	**1788**	**168**	**42**

Project Impact on Land Type

Map 25



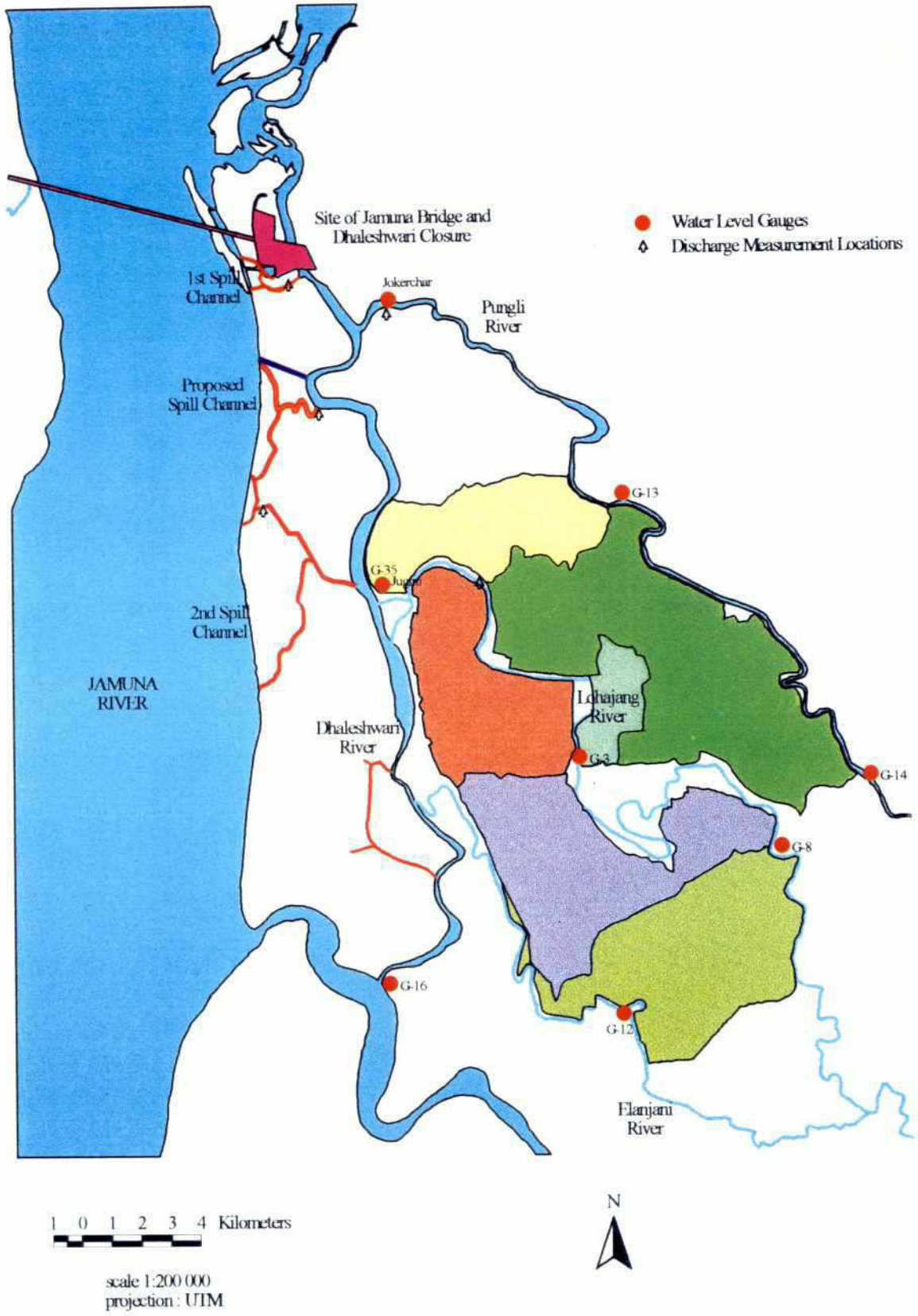
Compartmentalization Pilot Project Tangail

September, 96 c:\win32app\ppdata\landclas.apr

Map 25 and Table 25.1 show the probable impact of the project on flood depth within the CPP Tangail area. The scenario assumes full control, with river water levels with a 1 in 5 year return period.

TABLE 25.1: LAND TYPE CHANGES AS A PROJECT IMPACT

SC no	Subcomp Area	Settlement Area	Gross Cultivable Area	Unchanged F0/F1	Unchanged F2/F3	F1toF0	F3F2toF0	F3F2toF1	F3toF2
#	ha	ha	ha	ha	ha	ha	ha	ha	ha
1	247	55	191	2	0	26	139	24	0
2	544	105	439	4	0	6	359	70	0
3	1116	170	931	0	0	8	611	300	12
4	804	195	578	11	0	19	423	115	10
5	369	101	262	1	0	2	137	111	11
6	669	133	523	79	0	26	331	75	12
7	796	120	670	5	0	49	540	75	1
8	778	134	641	8	0	79	385	118	51
9	402	86	288	12	8	77	190	1	0
10	876	169	682	5	30	70	556	5	16
11	1167	337	830	9	0	49	742	0	30
12	1037	222	815	21	0	70	477	240	7
13	457	122	332	21	0	69	162	70	10
14	1186	260	863	15	7	148	504	182	7
15	767	203	550	92	5	168	144	137	4
16	619	431	156	NA	NA	NA	NA	NA	NA
LFP	1366	255	1013	NA	NA	NA	NA	NA	NA
Total	**13200**	**3098**	**9763**	**285**	**50**	**866**	**5700**	**1523**	**171**



Compartmentalization Pilot Project Tangail

Hydrometric network

For the preparation of the model and the planning and design a large number of hydrological data were required. Gauges were installed on a number of important rivers in and around the compartment and mainly daily water levels were measured. In a later stage, when water management testing started, more gauges were installed. In Table 26.1 an overview is given on the number of gauges that have been installed over the years.

General (or historical) gauges were installed to produce data for hydraulic modelling, hydrologic design, etc. During the development of the project, other gauges became necessary to prepare for and monitor water management testing. In Cluster Ib, before the physical interventions and institutional setup were completed, already some specific data collecting started for the preparation of the water management testing: water management gauges were installed in the monsoon of 1995 at locations where interventions were planned. Once the infrastructure was ready and testing really started these gauges were replaced by structural gauges: two per structure. In 1996, when also Cluster 2 and 3 entered the water management testing programme, the number was further increased.

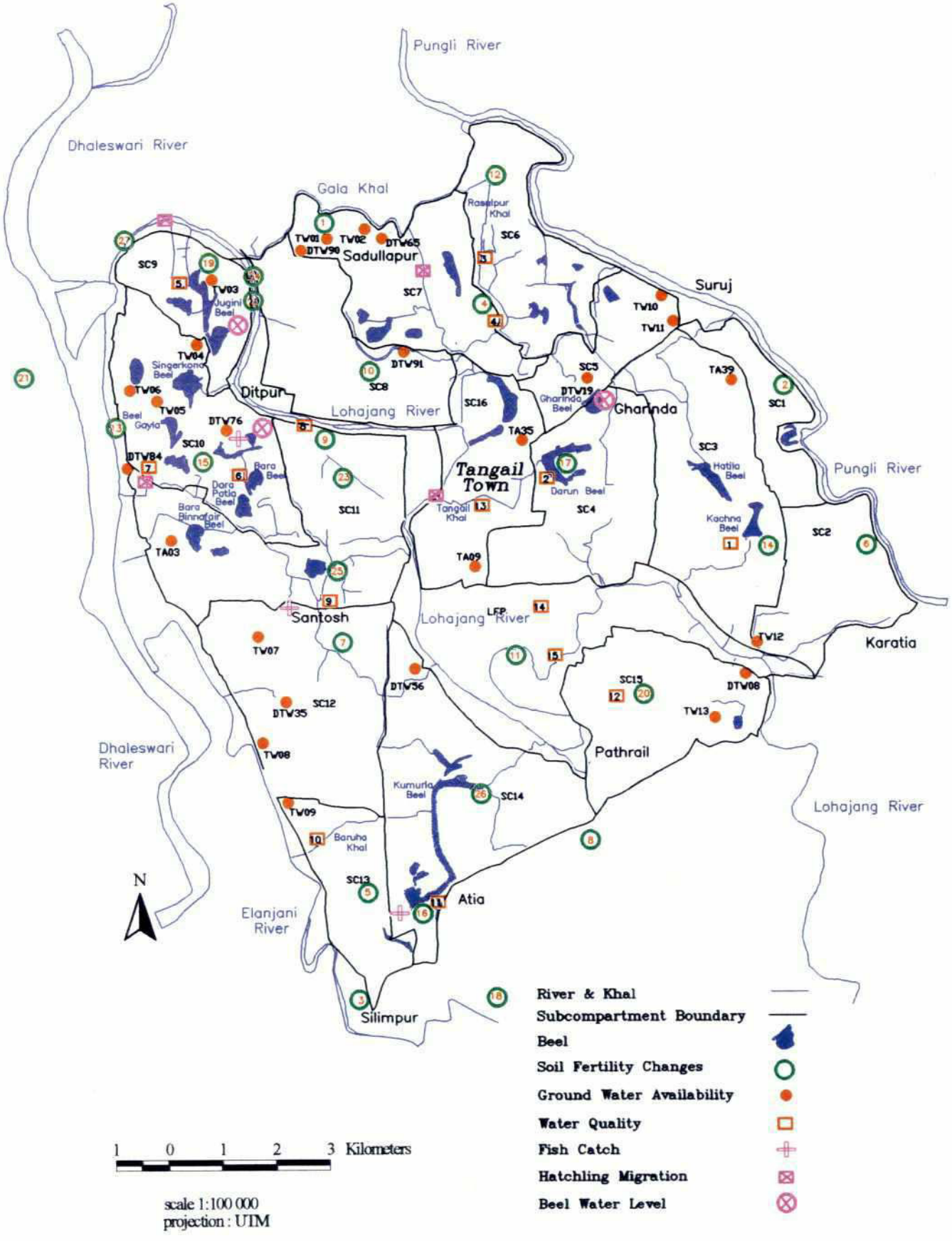
TABLE 26.1: YEAR, TYPE AND NUMBER OF GAUGES IN AND AROUND TANGAIL COMPARTMENT.

Year	Type of gauges			Total number of gauges
	General	Water Management	Operation and testing	
1991	4	0	0	4
1992	21	0	0	21
1993	32	10	0	42
1994	32	10	0	42
1995	33	10	28	71
1996	38	0	89	127

In Map 26 some gauges on major rivers in and around the compartment are give. In Annex D some data collected at these gauges are presented.

Environmental & Fisheries Monitoring Sites

Map 27



Compartmentalization Pilot Project Tangail

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Monitoring of environment and fisheries

On the sites indicated on Map 27 a number of environmental and fisheries variables are monitored.

Soil Fertility Changes Monitoring :

Indicators:	pH, potassium, ammonium-nitrogen, phosphorus, zinc, sulfur, boron, organic matter, residual pesticide.
Site:	Total 27 (3 on non-flooded agricultural land, 15 on flooded agricultural land, 3 on agricultural land with high input of agro-chemical, 2 on vegetable gardens and 4 on river/khal/beel sediment)
Frequency:	Twice in year

Ground Water Availability Monitoring :

Indicator:	Depth in static ground water level below surface
Site:	Total 26 (13 DPHE tubewells, 9 BADC deep tubewells and 4 BWDB observation wells)
Frequency:	Yearly/monthly/weekly

Water Quality Monitoring :

Indicators:	Temperature, pH, ammonia, iron, zinc, chromium, dissolved oxygen, chemical oxygen demand, fecal coliform bacteria.
Site:	Total 15 (8 in recreational water, 2 in drinking water, 2 in irrigation water, 2 in fishing water, and 1 in handloom effluent)
Frequency:	Monthly

Monitoring of water levels in Beels:

Indicator:	Water levels
Site:	Ghotokbari, Gharinda and Agbetur Kum beels
Frequency:	Weekly

Monitoring of fish catch:

Indicators:	Catches (kg/fisherman), number of fishermen (no/ha), species composition of the catch, length frequency data for some selected species, gear type, mesh size, fishermen type
Sites:	Ghotokbari, Gharinda and Rhakit Belta beels, in Atia floodplain, the Lohajang river and Gaizabari Khal
Frequency:	Catches, length frequency and species composition, twice a month; number of fishermen, weekly; gear type, mesh size fishermen type, seasonally

Monitoring of hatchling migration:

Indicators:	Hatchling concentrations, hatchling composition in groups, detailed species composition hatchling mortality rates.
Sites:	Four locations, hatchling mortality rates only at main regulator and Binnafair inlet.
Frequency:	Daily, during monsoon season.
Method:	Specially designed nets are placed for about 60 minutes. Number of hatchlings/hour and current velocity are measured and from this the concentration in no/m^3 is calculated.

Annex A Land use by chawk

TABLE: A-1: LAND USE BY CHAWK

	Chawk no.	Area hectare	Beel Area hectare	Settlement Area hectare	Gross Cultivable Area hectare
	1A	144		42	102
	1B	55		7	48
	1C	16		5	11
	1D	57	16	16	25
	1E	55	12	7	36
	1F	59		1	58
	IG	17		8	9
	SYSTEM 1	**403**	**28**	**86**	**289**
SC 9 (SYSTEM 1)		**403**	**28**	**86**	**289**
	2A	63		14	49
	2B	45		16	29
	2C	28		12	16
	SYSTEM 2	**136**	**0**	**42**	**94**
	3A	55		14	41
	3B	106		25	81
	3C	61	2	8	51
	3D	27		5	22
	3E	61	6	10	45
	3F	204	17	34	153
	SYSTEM 3	**514**	**25**	**96**	**393**
	4A	49		13	36
	4B	177		18	159
	SYSTEM 4	**226**	**0**	**31**	**195**
SC 10 (SYSTEM 2, 3, 4)		**876**	**25**	**169**	**682**
	5A	40		22	18
	5B	26		10	16
	5C	20		9	11
	5D	84		21	63
	5E	30		4	26
	5F	33		15	18
	SYSTEM 5	**232**	**0**	**81**	**151**
	6A	39		3	36
	6B	92		12	80
	6C	70		23	47
	6D	29		8	21
	6E	60		15	45
	SYSTEM 6	**290**	**0**	**61**	**229**
	7A	45		10	35
	7B	38		19	19
	7C	95		20	75
	7E	22		5	17
	7F	63		22	41
	7G	74		36	38
	7H	31		14	17
	7J	100		14	86
	7K	47		10	37
	SYSTEM 7	**645**	**0**	**195**	**450**
SC 11 (SYSTEM 5, 6, 7)		**1167**	**0**	**337**	**830**

	Chawkname	Area hectare	Beel Area hectare	Settlement Area hectare	Gross Cultivable Area hectare
	8A	27		3	24
	SYSTEM 8	**27**	**0**	**3**	**24**
	9A	66		22	44
	9B	105		14	91
	9C	53		11	42
	9D	27		0	27
	9E	48		4	44
	9F	37		6	31
	9G	105		16	89
	9H	16		2	14
	9J	79		17	62
	9K	29		1	28
	9L	80		10	70
	9M	107	3	28	75
	SYSTEM 9	**751**	**3**	**131**	**617**
SC 8 (SYSTEM 8, 9)		**778**	**3**	**134**	**641**
	10A	138		20	118
	10B	30		7	23
	10C	11		4	7
	10D	79		6	73
	10E	199		24	175
	10F	10		4	6
	10G	71		8	63
	10H	39		5	34
	10J	130	3	16	111
	10K	20		3	17
	10L	21		7	14
	10M	26	3	9	14
	10N	22		7	15
	SYSTEM 10	**796**	**6**	**120**	**670**
SC 7 (SYSTEM 10)		**796**	**6**	**120**	**670**
	11A	46		11	35
	11B	89		6	83
	11C	32		7	25
	11D	179	2	37	140
	11E	18	1	6	11
	11F	20		5	15
	11H	139	2	29	108
	11J	131	8	26	97
	SYSTEM 11	**669**	**13**	**133**	**523**
SC 6 (SYSTEM 11)		**669**	**13**	**133**	**523**
	12A	31		12	19
	12B	132	1	36	95
	SYSTEM 12	**163**	**1**	**48**	**114**
	13A	206	5	53	148
	SYSTEM 13	**206**	**5**	**53**	**148**
SC 5 (SYSTEM 12, 13)		**369**	**6**	**101**	**262**

	Chawkname	Area hectare	Beel Area hectare	Settlement Area hectare	Gross Cultivable Area hectare
	14A	14		2	12
	14B	37		12	25
	14C	19		4	15
	14D	79		19	60
	SYSTEM 14	**149**	**0**	**37**	**112**
	15A	98	1	18	79
	SYSTEM 15	**98**	**1**	**18**	**79**
SC 1 (SYSTEM 14, 15)		**247**	**1**	**55**	**191**
	16A	52		8	44
	16B	57		10	47
	16C	36		6	30
	SYSTEM 16	**145**	**0**	**24**	**121**
	17A	89		6	83
	17B	125		15	110
	SYSTEM 17	**214**	**0**	**20**	**193**
	18A	43		8	35
	18B	113		39	74
	18C	29		14	15
	SYSTEM 18	**185**	**0**	**61**	**124**
SC 2 (SYSTEM 16, 17, 18)		**544**	**0**	**105**	**439**
	19A	224		48	176
	19B	39		9	30
	19C	150	3	18	129
	19D	86		4	82
	19E	309	12	25	272
	19F	40		17	23
	SYSTEM 19	**848**	**15**	**121**	**712**
	20A	97		18	79
	SYSTEM 20	**97**	**0**	**18**	**79**
	21A	171		31	140
	SYSTEM 21	**171**	**0**	**31**	**140**
SC 3 (SYSTEM 19, 20, 21)		**1116**	**15**	**170**	**931**
	22A	58		18	40
	22B	185	29	38	118
	22C	268	2	50	216
	22D	32		11	21
	22E	78		22	56
	22F	37		18	19
	22G	62		11	51
	22H	42		13	29
	22J	43		14	29
	SYSTEM 22	**804**	**31**	**195**	**579**
SC 4 (SYSTEM 22)		**804**	**31**	**195**	**578**
	23A	97		42	55
	23B	86		25	61
	23C	24		4	20
	23D	303		48	255
	23E	135		22	113
	SYSTEM 23	**645**	**0**	**141**	**504**

	Chawkname	Area hectare	Beel Area hectare	Settlement Area hectare	Gross Cultivable Area hectare
	24A	119		45	74
	24B	63		17	46
	24C	140		5	135
	24D	70		14	56
	SYSTEM 24	**392**	**0**	**81**	**311**
SC 12 (SYSTEM 23, 24)		**1037**	**0**	**222**	**815**
	25A	108		43	65
	SYSTEM 25	**108**	**0**	**43**	**65**
	26A	96		16	80
	26B	97		18	79
	26C	63		26	37
	26D	93	3	19	71
	SYSTEM 26	**349**	**3**	**79**	**267**
SC 13 (SYSTEM 25, 26)		**457**	**3**	**122**	**332**
	27A	33		11	22
	27B	40	0	20	20
	27C	88		31	57
	SYSTEM 27	**161**	**0**	**62**	**99**
	28A	45		22	23
	28B	122	5	30	87
	28C	118		20	98
	28D	63	4	1	58
	28E	96	2	8	86
	28F	69		11	58
	28G	189	50	21	118
	28H	35		1	34
	SYSTEM 28	**737**	**61**	**114**	**562**
	29A	69		21	48
	29D	71	2	32	37
	29C	148		31	117
	SYSTEM 29	**288**	**2**	**84**	**202**
SC 14 (SYSTEM 27, 28, 29)		**1186**	**63**	**260**	**863**
	30A	123		67	56
	SYSTEM 30	**123**	**0**	**67**	**56**
	31A	54		10	44
	31B	189		46	143
	31C	112	9	24	79
	31D	129		16	113
	31E	125	3	32	90
	SYSTEM 31	**609**	**12**	**128**	**469**
	32A	35	2	8	25
	SYSTEM 32	**35**	**2**	**8**	**25**
SC 15 (SYSTEM 30, 31, 32)		**767**	**14**	**203**	**550**

Annex B Water management levels

Water management

Better water management in CPP type schemes (FCD schemes) means that water levels in an area have to be maintained within an optimum range. This can be ensured in two ways:

- Maintain an *optimum water level* in the chawk or command area;
  This would in practice mean a compromise between different water management objectives such as fisheries and agriculture.

- Limit the chance of exceedence of a certain water level, *the (maximum) permissible water level* in the chawk or command area;

  This is perhaps even more important, as the water depth should not exceed certain critical levels during specific growth stages.

The combination of the two will result in a more secure environment for agriculture within Tangail Compartment. To achieve this, tables of agricultural *permissible water levels* were prepared (for an example see Table B-1).

TABLE B-1: EXAMPLE MAXIMUM PREMISSIBLE WATER LEVELS PER CHAWK: SUB-COMPARTMENT 9.

chawk u/s	GCA (ha)	crop	1 -30 Aug.	1-15 Sep.	16-30 Sep.	1-15 Oct.	16 Oct.-15 Nov.
			drainage	water level control	water level control	water level control	drainage
1a	102	HYV ext.	11.55	11.55	11.70	11.70	11.90
1b	48	HYV ext.	10.65	10.65	10.80	10.80	11.00
1c	11	HYV ext.	11.35	11.35	11.50	11.50	11.70
1d	25	HYV ext.	11.15	11.15	11.30	11.30	11.50
1e	36	HYV ext.	10.85	10.85	11.00	11.00	11.20
1f	58	HYV ext.	11.10	11.10	11.25	11.25	11.45
1g	9	HYV in.	10.65	10.65	10.80	10.80	11.00

Calculation of permissible water levels

First the *permissible field water depth* and *permissible water levels* need to be determined. The procedure followed to obtain these levels is as follows

- Determine the target crop: the main crop that is to be grown in the chawk.
- Determine the base level (the average elevation of the land on which this crop is to be planted). Knowledge of the elevation on which the target crop is growing in the chawks is required; area elevation curves and contour maps can be consulted.
- Use *flood depth tolerance* of major crops to determine the *permissible field water depth* on this land, and add this to the base level, this yields the *permissible water levels*.

Fit the requested agricultural *permissible water levels* to the water management (physical) constraints. Two periods are recognized and described in the previous chapters: the initial period of 'controlled flooding' (Figure B-1) and the period of 'water level control' (Figure B-2).

TABLE B-2: OPERATION RULES - INDICATION OF WATER LEVELS FOR CLUSTER IB-IV, WITHIN WATER MANAGEMENT CONSTRAINTS; I[b]

chawk u/s	NCA (ha)	crop	agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt	
			1 -30 aug drainage				1-15 sep water level control				16-30 sep water level control				1-15 oct water level control				16 oct-15 nov drainage			
1e	36	HYV ext.	10.85	10.80	10.65		10.85	10.80	10.65		11.00	10.95	10.75		11.00	10.95	10.75		11.20	11.15	10.85	
1f	58	HYV ext.	11.10	10.80	10.65	30	11.10	10.80	10.65	30	11.25	10.95	10.75	30	11.25	10.95	10.75	30	11.45	11.15	10.85	30
1g	9	HYV in.	10.65	10.80	10.65	-15	10.65	10.80	10.65	-15	10.80	10.95	10.75	-15	10.80	10.95	10.75	-15	11.00	11.15	10.85	-15
5a	18	HYV ext.	10.95	10.10	9.95	85	10.95	10.10	9.95	85	11.10	10.25	10.05	85	11.10	10.25	10.05	85	11.30	10.40	10.10	80
5b	16	HYV ext.	10.85	10.10	9.95	75	10.85	10.10	9.95	75	11.00	10.25	10.05	75	11.00	10.25	10.05	75	11.20	10.40	10.10	80
5c	11	HYV in.	10.35	10.10	9.95	25	10.35	10.10	9.95	25	10.50	10.25	10.05	25	10.50	10.25	10.05	25	10.70	10.40	10.10	30
5d	63	HYV ext.	10.35	10.10	9.95	25	10.35	10.10	9.95	25	10.50	10.25	10.05	25	10.50	10.25	10.05	25	10.70	10.40	10.10	30
5e	26	HYV ext.	10.85	10.10	9.95	75	10.85	10.10	9.95	75	11.00	10.25	10.05	75	11.00	10.25	10.05	75	11.20	10.40	10.10	80
5f	18	HYV ext.	10.35	10.10	9.95	25	10.35	10.10	9.95	25	10.50	10.25	10.05	25	10.50	10.25	10.05	25	10.70	10.40	10.10	30
6a	36	HYV in.	10.15	10.10	9.95		10.15	10.10	9.95		10.30	10.25	10.05		10.30	10.25	10.05		10.50	10.40	10.10	
6b	80	HYV ext.	10.45	10.10	9.95	35	10.45	10.10	9.95	35	10.60	10.25	10.05	35	10.60	10.25	10.05	35	10.80	10.40	10.10	40
6c	47	HYV in.	10.15	10.10	9.95		10.15	10.10	9.95		10.30	10.25	10.05		10.30	10.25	10.05		10.50	10.40	10.10	
6d	21	LV in.	10.35	10.10	9.95	25	10.50	10.10	9.95	40	10.50	10.25	10.05	25	10.70	10.25	10.05	45	10.90	10.40	10.10	50
6e	45	HYV ext.	10.85	10.10	9.95	75	10.85	10.10	9.95	75	11.00	10.25	10.05	75	11.00	10.25	10.05	75	11.20	10.40	10.10	80
7f	41	HYV in.	10.15	10.10	9.95		10.15	10.10	9.95		10.30	10.25	10.05		10.30	10.25	10.05		10.50	10.40	10.10	
7g	38	HYV in.	9.65	10.10	9.75	-45	9.65	10.10	9.75	-45	9.80	10.25	9.85	-45	9.80	10.25	9.85	-45	10.00	10.40	9.90	-40
7h	17	HYV in.	9.65	10.10	9.75	-45	9.65	10.10	9.75	-45	9.80	10.25	9.85	-45	9.80	10.25	9.85	-45	10.00	10.40	9.90	-40
3b	81	HYV ext.	10.65	10.65	10.50		10.65	10.65	10.50		10.80	10.80	10.60		10.80	10.80	10.60		11.00	10.80	10.60	20
7b	19	HYV ext.	10.15	10.10	9.95		10.15	10.10	9.95		10.30	10.25	10.05		10.30	10.25	10.05		10.50	10.40	10.10	
7c	75	HYV ext.	10.35	10.10	9.95	25	10.35	10.10	9.95	25	10.50	10.25	10.05	25	10.50	10.25	10.05	25	10.70	10.40	10.10	30
7d	85	HYV in.	9.55	10.10	9.85	-55	9.55	10.10	9.85	-55	9.70	10.25	9.95	-55	9.70	10.25	9.95	-55	9.90	10.40	10.00	-50
7e	17	HYV in.	9.90	10.10	9.95	-20	9.90	10.10	9.95	-20	10.05	10.25	10.05	-20	10.05	10.25	10.05	-20	10.25	10.40	10.10	-15
7f	41	HYV in.	10.15	10.10	9.95		10.15	10.10	9.95		10.30	10.25	10.05		10.30	10.25	10.05		10.50	10.40	10.10	
7a	35	HYV ext.	10.35	10.35	10.20		10.35	10.35	10.20		10.50	10.50	10.30		10.50	10.50	10.30		10.70	10.70	10.40	
7j	86	LV ext.	10.50	10.35	10.20	15	10.65	10.35	10.20	30	10.65	10.50	10.30	15	10.85	10.50	10.30	35	11.05	10.70	10.40	35
7k	37	LV ext.	10.50	10.35	10.20	15	10.65	10.35	10.20	30	10.65	10.50	10.30	15	10.85	10.50	10.30	35	11.05	10.70	10.40	35
1a	102	HYV ext.	11.55	11.55	11.40		11.55	11.55	11.40		11.70	11.70	11.50		11.70	11.70	11.50		11.90	11.90	11.60	
1b	48	HYV ext.	10.65	10.80	10.65	-15	10.65	10.80	10.65	-15	10.80	10.95	10.75	-15	10.80	10.95	10.75	-15	11.00	11.15	10.85	-15
1c	11	HYV ext.	11.35	10.80	10.65	55	11.35	10.80	10.65	55	11.50	10.95	10.75	55	11.50	10.95	10.75	55	11.70	11.15	10.85	55
1d	25	HYV ext.	11.15	10.80	10.65	35	11.15	10.80	10.65	35	11.30	10.95	10.75	35	11.30	10.95	10.75	35	11.50	11.15	10.85	35
2a	49	HYV ext.	10.85	10.80	10.65		10.85	10.80	10.65		11.00	10.95	10.75		11.00	10.95	10.75		11.20	11.15	10.85	
2b	29	HYV ext.	10.85	10.80	10.65		10.85	10.80	10.65		11.00	10.95	10.75		11.00	10.95	10.75		11.20	11.15	10.85	
2c	16	HYV ext.	10.75	10.80	10.65		10.75	10.80	10.65		10.90	10.95	10.75		10.90	10.95	10.75		11.10	11.15	10.85	
3c	51	HYV ext.	10.00	10.20	9.95	-20	10.00	10.20	9.95	-20	10.15	10.35	10.05	-20	10.15	10.35	10.05	-20	10.35	10.50	10.10	-15
3d	22	HYV ext.	10.35	10.20	10.05	15	10.35	10.20	10.05	15	10.50	10.35	10.15	15	10.50	10.35	10.15	15	10.70	10.50	10.20	20
3e	45	HYV ext.	10.25	10.20	9.95		10.25	10.20	9.95		10.40	10.35	10.05		10.40	10.35	10.05		10.60	10.50	10.10	
3f	153	HYV ext.	9.55	10.20	9.95	-65	9.55	10.20	9.95	-65	9.70	10.35	10.05	-65	9.70	10.35	10.05	-65	9.90	10.50	10.10	-60
4b	159	HYV ext.	10.25	10.25	10.00		10.25	10.25	10.00		10.40	10.40	10.10		10.40	10.40	10.10		10.60	10.60	10.20	
3h	81	HYV ext.	10.65	10.65	10.50		10.65	10.65	10.50		10.80	10.80	10.60		10.80	10.80	10.60		11.00	11.00	10.70	
4a	36	HYV ext.	11.15	11.15	11.00		11.15	11.15	11.00		11.30	11.30	11.10		11.30	11.30	11.10		11.50	11.50	11.20	
7c	75	HYV ext.	10.35	10.35	10.20		10.35	10.35	10.20		10.50	10.50	10.30		10.50	10.50	10.30		10.70	10.70	10.40	
3a	41	HYV ext.	10.95	10.95	10.80		10.95	10.95	10.80		11.10	11.10	10.90		11.10	11.10	10.90		11.30	11.30	11.00	

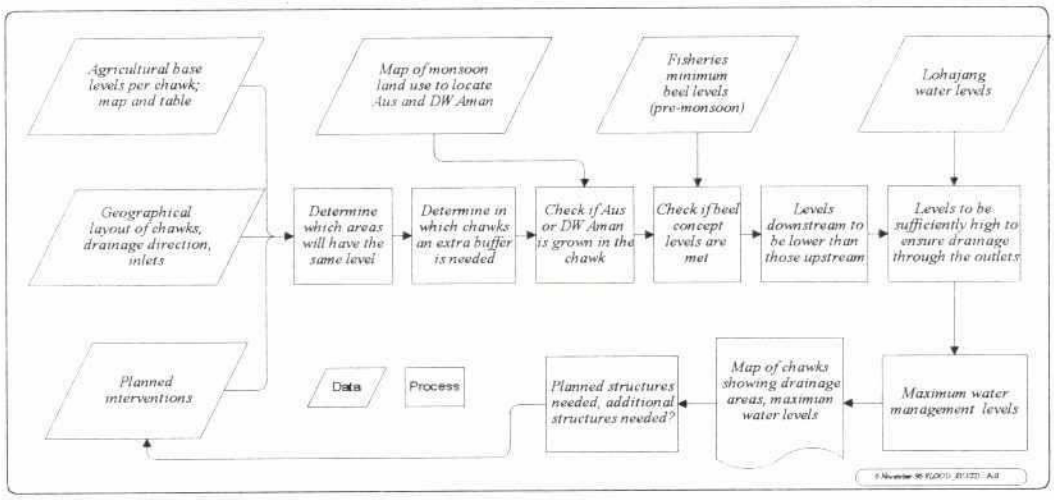
agri	maximum allowable level for indicated crop
wmax	maximum water level possible within water management constraints
wmopt	target level; taking the average of wmax and the base level and subtracting the buffer
	agri - wmax: water level higher, more than 30 cm
	agri - wmax: water level higher between 10 and 30 cm
	agri - wmax: difference less than 10 cm
	agri - wmax: water level lower, between 10 and 30 cm
	agri - wmax: water level lower, more than 30 cm

Procedure to determine the maximum water level under flooding conditions

The objective is controlled flooding from the Lohajang river through the outlets is, and controlled flooding from the inlets on the periphery (in particular of the higher lands); water levels should not be so high as to hamper crop growth.

- Take a map showing (drainage) flow direction, chawk names and boundaries, khals, beels, and planned water management structures. Study flow (drainage) patterns.
- Take the median Lohajang water levels at each outlet that can be expected in July, under a pre-determined water management regime; these are the *minimum levels*, this means that *maximum water management levels* upstream of an outlet cannot be lower, because drainage would not be possible. However, flooding through outlets is possible by temporary increasing the water level in the Lohajang (upstream water levels of the main regulator permitting), or in the early stages of controlled flooding, when fields are still filling up and the water levels in the fields are still lower than the Lohajang water levels.
- Determine the agricultural base levels per chawk.
- Check if Aus or DW Aman is to be grown in the chawk.
- Determine whether a buffer is needed; allocate 10 cm to low chawks that may have difficulties in drainage.

FIGURE B-1: PROCEDURE TO DETERMINE MAXIMUM WATER MANAGEMENT LEVELS, FLOODING PERIOD



- Take the agricultural base level, subtract the buffer. If Aus/DW Aman is present in the chawk, and DW Aman is not the target crop, add 10 cm (simulating maximum tolerable level for Aus/DW Aman, which is usually sown/planted on lower levels), otherwise add 50 cm for optimum controlled flooding.
- Take the lowest of the above levels as the level for one system.
- Check the beel levels required to satisfy the beel concept. If the beel concept is violated (i.e. water level is too low) and the difference is small, fisheries get priority, a higher agricultural flooding target should be set; if the difference is too large (depends on area-elevation curve), agriculture should be the first priority.
- Use map to see if flood water from the rivers (inlets on embankment) can reach the chawks.

TABLE B-2: OPERATION RULES - INDICATION OF WATER LEVELS FOR CLUSTER IB-IV, WITHIN WATER MANAGEMENT CONSTRAINTS; II

chawk u/s	NCA (ha)	crop	agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt	
			1 -30 aug				1-15 sep				16-30 sep				1-15 oct				16 oct-15 nov			
			drainage				water level control				water level control				water level control				drainage			
9m	76	LV ext	9.95	10.15	9.90	-20	10.10	10.30	10.00	-20	10.10	10.30	10.00	-20	10.30	10.50	10.10	-20	10.50	10.70	10.20	-20
9a	44	HYV ext	11.30	10.15	10.00	115	11.30	10.30	10.10	100	11.45	10.30	10.10	115	11.45	10.50	10.20	95	11.65	10.70	10.30	95
9b	91	HYV ext	11.05	10.15	10.00	90	11.05	10.30	10.10	75	11.20	10.30	10.10	90	11.20	10.50	10.20	70	11.40	10.70	10.30	70
9c	42	HYV ext	10.55	10.15	10.00	40	10.55	10.30	10.10	25	10.70	10.30	10.10	40	10.70	10.50	10.20	20	10.90	10.70	10.30	20
9k	28	HYV in.	10.80	10.15	10.00	65	10.80	10.30	10.10	50	10.95	10.30	10.10	65	10.95	10.50	10.20	45	11.15	10.70	10.30	45
10e	175	LV ext	10.40	10.15	10.00	25	10.55	10.30	10.10	25	10.55	10.30	10.10	25	10.75	10.50	10.20	25	10.95	10.70	10.30	25
10f	6	LV ext	10.50	10.15	10.00	35	10.65	10.30	10.10	35	10.65	10.30	10.10	35	10.85	10.50	10.20	35	11.05	10.70	10.30	35
9l	70	LV ext	10.80	10.70	10.55	10	10.95	10.70	10.55	25	10.95	10.85	10.65	10	11.15	10.85	10.65	30	11.35	11.00	10.70	35
9d	27	HYV ext	10.55	10.70	10.55	-15	10.55	10.70	10.55	-15	10.70	10.85	10.65	-15	10.70	10.85	10.65	-15	10.90	11.00	10.70	-10
11b	83	LV ext	11.00	11.00	10.85	0	11.15	11.15	10.95	0	11.15	11.15	10.95	0	11.35	11.35	11.05	0	11.55	11.55	11.15	0
11a	35	LV ext	11.00	11.00	10.85	0	11.15	11.15	10.95	0	11.15	11.15	10.95	0	11.35	11.35	11.05	0	11.55	11.55	11.15	0
9m	76	LV ext	9.95	10.15	9.90	-20	10.10	10.30	10.00	-20	10.10	10.30	10.00	-20	10.30	10.50	10.10	-20	10.50	10.70	10.20	-20
9a	44	HYV ext	11.30	10.15	10.00	115	11.30	10.30	10.10	100	11.45	10.30	10.10	115	11.45	10.50	10.20	95	11.65	10.70	10.30	95
9b	91	HYV ext	11.05	10.15	10.00	90	11.05	10.30	10.10	75	11.20	10.30	10.10	90	11.20	10.50	10.20	70	11.40	10.70	10.30	70
9c	42	HYV ext	10.55	10.15	10.00	40	10.55	10.30	10.10	25	10.70	10.30	10.10	40	10.70	10.50	10.20	20	10.90	10.70	10.30	20
9k	28	HYV in.	10.80	10.15	10.00	65	10.80	10.30	10.10	50	10.95	10.30	10.10	65	10.95	10.50	10.20	45	11.15	10.70	10.30	45
10e	175	LV ext	10.40	10.15	10.00	25	10.55	10.30	10.10	25	10.55	10.30	10.10	25	10.75	10.50	10.20	25	10.95	10.70	10.30	25
10f	6	LV ext	10.50	10.15	10.00	35	10.65	10.30	10.10	35	10.65	10.30	10.10	35	10.85	10.50	10.20	35	11.05	10.70	10.30	35
12b	95	LV ext	9.80	9.80	9.65	0	9.95	9.80	9.65	15	9.95	9.95	9.75	0	10.15	9.95	9.75	20	10.35	10.15	9.85	20
12a	19	HYV ext	10.30	9.80	9.65	50	10.30	9.80	9.65	50	10.45	9.95	9.75	50	10.45	9.95	9.75	50	10.65	10.15	9.85	50
11d	140	HYV ext	10.15	10.15	10.00	0	10.15	10.15	10.00	0	10.30	10.30	10.10	0	10.30	10.30	10.10	0	10.50	10.50	10.20	0
11c	25	HYV in.	10.65	10.15	10.00	50	10.65	10.15	10.00	50	10.80	10.30	10.10	50	10.80	10.30	10.10	50	11.00	10.50	10.20	50
11e	11	LV in.	9.90	10.15	10.00	-25	10.05	10.15	10.00	-10	10.05	10.30	10.10	-25	10.25	10.30	10.10	-5	10.45	10.50	10.20	-5
11f	15	HYV ext	10.15	10.15	10.00	0	10.15	10.15	10.00	0	10.30	10.30	10.10	0	10.30	10.30	10.10	0	10.50	10.50	10.20	0
10d	73	HYV ext	10.90	10.90	10.75	0	10.90	10.90	10.75	0	11.05	11.05	10.85	0	11.05	11.05	10.85	0	11.25	11.25	10.95	0
10h	34	LV ext	10.15	10.15	10.00	0	10.30	10.30	10.10	0	10.30	10.30	10.10	0	10.50	10.50	10.20	0	10.70	10.70	10.30	0
10a	118	HYV ext	10.65	10.65	10.50	0	10.65	10.65	10.50	0	10.80	10.80	10.60	0	10.80	10.80	10.60	0	11.00	11.00	10.70	0
10g	63	LV in.	10.15	10.15	10.00	0	10.30	10.30	10.10	0	10.30	10.30	10.10	0	10.50	10.50	10.20	0	10.70	10.70	10.30	0
10b	23	HYV in.	10.80	10.15	10.00	65	10.80	10.30	10.10	50	10.95	10.30	10.10	65	10.95	10.50	10.20	45	11.15	10.70	10.30	45
10j	111	LV in.	10.05	10.15	9.90	-10	10.20	10.30	10.00	-10	10.20	10.30	10.00	-10	10.40	10.50	10.10	-10	10.60	10.70	10.20	-10
8a	24	HYV ext	11.30	11.30	11.15	0	11.30	11.30	11.15	0	11.45	11.45	11.25	0	11.45	11.45	11.25	0	11.65	11.65	11.35	0
9j	62	HYV in.	10.80	10.70	10.55	10	10.80	10.70	10.55	10	10.95	10.85	10.65	10	10.95	10.85	10.65	10	11.15	11.00	10.70	15
9h	14	HYV in.	11.30	10.70	10.55	60	11.30	10.70	10.55	60	11.45	10.85	10.65	60	11.45	10.85	10.65	60	11.65	11.00	10.70	65
9g	89	HYV ext	10.55	10.70	10.55	-15	10.55	10.70	10.55	-15	10.70	10.85	10.65	-15	10.70	10.85	10.65	-15	10.90	11.00	10.70	-10
9e	44	HYV in.	11.50	10.70	10.55	80	11.50	10.70	10.55	80	11.65	10.85	10.65	80	11.65	10.85	10.65	80	11.85	11.00	10.70	85
9f	31	HYV ext	10.55	10.70	10.55	-15	10.55	10.70	10.55	-15	10.70	10.85	10.65	-15	10.70	10.85	10.65	-15	10.90	11.00	10.70	-10
9c	42	HYV ext	10.55	10.15	10.00	40	10.55	10.30	10.10	25	10.70	10.30	10.10	40	10.70	10.50	10.20	20	10.90	10.70	10.30	20
11j	97	LV ext	9.65	9.80	9.65	-15	9.80	9.80	9.65	0	9.80	9.95	9.75	-15	10.00	9.95	9.75	0	10.20	10.15	9.85	-5
11g	9	HYV ext	10.15	9.80	9.65	35	10.15	9.80	9.65	35	10.30	9.95	9.75	35	10.30	9.95	9.75	35	10.50	10.15	9.85	35
11h	108	LV ext	9.65	9.80	9.65	-15	9.80	9.80	9.65	0	9.80	9.95	9.75	-15	10.00	9.95	9.75	0	10.20	10.15	9.85	-5
10m	14	HYV ext	9.90	9.80	9.65	0	9.90	9.80	9.65	0	10.05	9.95	9.75	10	10.05	9.95	9.75	10	10.25	10.15	9.85	10
10n	15	HYV in.	10.15	9.80	9.65	35	10.15	9.80	9.65	35	10.30	9.95	9.75	35	10.30	9.95	9.75	35	10.50	10.15	9.85	35
13a	148	HYV in.	10.55	10.55	10.40	0	10.55	10.55	10.40	0	10.70	10.70	10.50	0	10.70	10.70	10.50	0	10.90	10.90	10.60	0
10c	7	LV ext	10.65	10.15	10.00	50	10.80	10.30	10.10	50	10.80	10.30	10.10	50	11.00	10.50	10.20	50	11.20	10.70	10.30	50
10k	17	LV in.	9.65	10.15	10.00	-50	9.80	10.30	10.10	-50	9.80	10.30	10.10	-50	10.00	10.50	10.20	-50	10.20	10.70	10.30	-50
10l	14	LV in.	9.65	10.15	10.00	-50	9.80	10.30	10.10	-50	9.80	10.30	10.10	-50	10.00	10.50	10.20	-50	10.20	10.70	10.30	-50

agri	maximum allowable level for indicated crop
wmax	maximum water level possible within water management constraints
wmopt	target level; taking the average of wmax and the base level and subtracting the buffer
	agri - wmax: water level higher, more than 30 cm
	agri - wmax: water level higher between 10 and 30 cm
	agri - wmax: difference less than 10 cm
	agri - wmax: water level lower, between 10 and 30 cm
	agri - wmax: water level lower, more than 30 cm

Procedure to determine the optimum water management level for water level control and drainage

The objective is to control water levels as to facilitate drainage. Flooding from the Lohajang river would generally not be allowed. Flooding from the periphery would be rarely practised.

- Take a map showing (drainage) flow direction, chawk names and boundaries, khals, beels, and planned water management structures. Study flow (drainage) patterns.
- Take expected median Lohajang water levels during the monsoon; these are the *minimum levels*, this means that the *maximum water management levels* upstream of the outlet cannot be lower.
- Determine for all chawks in each system the (August-September) agricultural *permissible water levels*, and find the best compromise; rather too low than too high. The lowest is taken for all the chawks in the system. In practice the critical period is between mid-July and end August, perhaps early September. The resulting levels are the *maximum water management levels*.
- The *optimum water management level* is found by taking half the difference between the *maximum water management level* and the agricultural base level. It can then be corrected for the relative location of the chawk(s) within the area. If located in a low area for which drainage can be expected to be difficult, the buffer should be larger (e.g. increase with 5-10 cm).
- Results are to be checked for conformance to the *beel concept*.

FIGURE B-2: PROCEDURE TO DETERMINE WATER MANAGEMENT LEVELS, WATER LEVEL CONTROL PERIOD

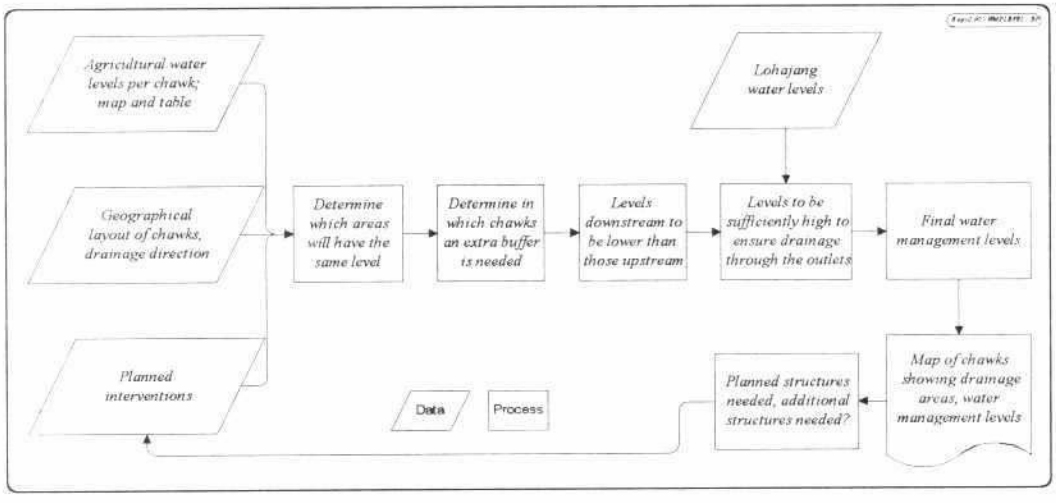


TABLE B-2: OPERATION RULES - INDICATION OF WATER LEVELS FOR CLUSTER Ib-IV, WITHIN WATER MANAGEMENT CONSTRAINTS; III

chawk u/s	NCA (ha)	crop	agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt	
			1 -30 aug drainage				1-15 sep water level control				16-30 sep water level control				1-15 oct water level control				16 oct-15 nov drainage			
22e	56	LV in.	9.80	9.50	9.25	30	9.95	9.60	9.30	35	9.95	9.60	9.30	35	10.15	9.80	9.40	35	10.35	10.00	9.50	35
22a	40	LV ext.	9.55	9.50	9.25	5	9.70	9.60	9.30	10	9.70	9.60	9.30	10	9.90	9.80	9.40	10	10.10	10.00	9.50	10
22b	118	LV ext.	9.55	9.50	9.25	5	9.70	9.60	9.30	10	9.70	9.60	9.30	10	9.90	9.80	9.40	10	10.10	10.00	9.50	10
22c	216	LV ext.	9.30	9.50	9.25	-20	9.45	9.60	9.30	-15	9.45	9.60	9.30	-15	9.65	9.80	9.40	-15	9.85	10.00	9.50	-15
22d	21	HYV in.	9.55	9.50	9.25	5	9.55	9.60	9.30	-5	9.70	9.60	9.30	10	9.70	9.80	9.40	-10	9.90	10.00	9.50	-10
22f	19	LV in.	9.05	9.50	9.25	-45	9.20	9.60	9.30	-40	9.20	9.60	9.30	-40	9.40	9.80	9.40	-40	9.60	10.00	9.50	-40
19f	23	HYV in.	9.30	9.25	9.00	5	9.30	9.40	9.10	-10	9.45	9.40	9.10	5	9.45	9.60	9.20	-15	9.65	9.60	9.20	5
19c	129	LV ext.	9.30	9.25	9.00	5	9.45	9.40	9.10	5	9.45	9.40	9.10	5	9.65	9.60	9.20	5	9.85	9.60	9.20	25
19e	272	LV in.	9.05	9.25	9.00	-20	9.20	9.40	9.10	-20	9.20	9.40	9.10	-20	9.40	9.60	9.20	-20	9.60	9.60	9.20	0
17b	110	HYV in.	9.15	9.25	9.10	-10	9.15	9.25	9.10	-10	9.30	9.25	9.10	5	9.30	9.40	9.20	-10	9.50	9.60	9.30	-10
17a	83	LV ext.	9.15	9.25	9.10	-10	9.30	9.25	9.10	5	9.30	9.25	9.10	5	9.50	9.40	9.20	10	9.70	9.60	9.30	10
18a	35	LV in.	9.15	9.25	9.10	-10	9.30	9.40	9.20	-10	9.30	9.40	9.20	-10	9.50	9.60	9.30	-10	9.70	9.60	9.30	10
17a	83	LV ext.	9.15	9.25	9.10	-10	9.30	9.40	9.20	-10	9.30	9.40	9.20	-10	9.50	9.60	9.30	-10	9.70	9.60	9.30	10
21a	140	HYV ext.	9.05	9.25	9.00	-20	9.05	9.25	9.00	-20	9.20	9.35	9.05	-15	9.20	9.35	9.05	-15	9.40	9.50	9.15	-10
nb																						
15a	79	LV ext.	9.40	9.40	9.25	0	9.55	9.55	9.35	0	9.55	9.55	9.35	0	9.75	9.75	9.45	0	9.95	9.95	9.55	0
16a	44	LV ext.	9.15	9.25	9.10	-10	9.30	9.40	9.20	-10	9.30	9.40	9.20	-10	9.50	9.60	9.30	-10	9.70	9.60	9.30	10
19a	176	HYV in.	9.90	9.90	9.75	0	9.90	9.90	9.75	0	10.05	10.05	9.85	0	10.05	10.05	9.85	0	10.25	10.25	9.95	0
14d	60	LV ext.	9.90	9.90	9.75	0	10.05	10.05	9.85	0	10.05	10.05	9.85	0	10.25	10.25	9.95	0	10.45	10.45	10.05	0
14a	12	HYV in.	10.15	9.90	9.75	25	10.15	10.05	9.85	10	10.30	10.05	9.85	25	10.30	10.25	9.95	5	10.50	10.45	10.05	5
14b	25	HYV ext.	10.15	9.90	9.75	25	10.15	10.05	9.85	10	10.30	10.05	9.85	25	10.30	10.25	9.95	5	10.50	10.45	10.05	5
14c	15	HYV in.	10.15	9.90	9.75	25	10.15	10.05	9.85	10	10.30	10.05	9.85	25	10.30	10.25	9.95	5	10.50	10.45	10.05	5
19d	82	LV ext.	8.80	9.25	9.00	-45	8.95	9.40	9.10	-45	8.95	9.40	9.10	-45	9.15	9.60	9.20	-45	9.35	9.60	9.20	-25
20a	79	HYV in.	9.65	9.65	9.50	0	9.65	9.65	9.50	0	9.80	9.80	9.60	0	9.80	9.80	9.60	0	10.00	10.00	9.70	0
22g	51	LV ext.	8.80	9.50	9.25	-70	8.95	9.60	9.30	-65	8.95	9.60	9.30	-55	9.15	9.80	9.40	-65	9.35	10.00	9.50	-65
22h	29	LV ext.	9.55	9.50	9.25	5	9.70	9.60	9.30	10	9.70	9.60	9.30	10	9.90	9.80	9.40	10	10.10	10.00	9.50	10
22j	29	HYV in.	9.80	9.50	9.25	30	9.80	9.60	9.30	20	9.95	9.60	9.30	35	9.95	9.80	9.40	15	10.15	10.00	9.50	15
16c	30	LV ext.	9.15	9.25	9.10	-10	9.30	9.40	9.20	-10	9.30	9.40	9.20	-10	9.50	9.40	9.20	10	9.70	9.70	9.35	0
16b	47	HYV in.	9.40	9.25	9.10	15	9.40	9.40	9.20	0	9.55	9.40	9.20	15	9.55	9.40	9.20	15	9.75	9.70	9.35	5
18b	74	LV ext.	9.40	9.40	9.25	0	9.55	9.55	9.35	0	9.55	9.55	9.35	0	9.75	9.75	9.45	0	9.95	9.95	9.55	0
18c	15	LV in.	9.40	9.40	9.25	0	9.55	9.55	9.35	0	9.55	9.55	9.35	0	9.75	9.75	9.45	0	9.95	9.95	9.55	0
19b	30	LV ext.	9.40	9.40	9.25	0	9.55	9.55	9.35	0	9.55	9.55	9.35	0	9.75	9.75	9.45	0	9.95	9.95	9.55	0
15a	79	LV ext.	9.40	9.40	9.25	0	9.55	9.55	9.35	0	9.55	9.55	9.35	0	9.75	9.75	9.45	0	9.95	9.95	9.55	0

agri	maximum allowable level for indicated crop
wmax	maximum water level possible within water management constraints
wmopt	target level; taking the average of wmax and the base level and subtracting the buffer
	agri - wmax: water level higher, more than 30 cm
	agri - wmax: water level higher between 10 and 30 cm
	agri - wmax: difference less than 10 cm
	agri - wmax: water level lower, between 10 and 30 cm
	agri - wmax: water level lower, more than 30 cm

TABLE B-2: OPERATION RULES - INDICATION OF WATER LEVELS FOR CLUSTER IB-IV, WITHIN WATER MANAGEMENT CONSTRAINTS; IV

chawk u/s	NCA (ha)	crop	agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt		agri	wmax	wmopt	
			1-30 aug drainage				1-15 sep water level control				16-30 sep water level control				1-15 oct water level control				16 oct-15 nov drainage			
27b	20	LV in.	9.75	9.90	9.75	-15	9.90	9.90	9.75	0	9.90	10.05	9.85	-15	10.10	10.05	9.85	5	10.30	10.25	9.95	5
27c	57	HYV in.	9.85	9.90	9.75	-5	9.85	9.90	9.75	-5	10.00	10.05	9.85	-5	10.00	10.05	9.85	-5	10.20	10.25	9.95	-5
23d	255	LV ext.	9.65	9.90	9.75	-25	9.80	9.90	9.75	-10	9.80	10.05	9.85	-25	10.00	10.05	9.85	-5	10.20	10.25	9.95	-5
23e	113	LV in.	9.65	9.90	9.75	-25	9.80	9.90	9.75	-10	9.80	10.05	9.85	-25	10.00	10.05	9.85	-5	10.20	10.25	9.95	-5
23a	55	HYV ext.	10.75	9.90	9.75	85	10.75	9.90	9.75	85	10.90	10.05	9.85	85	10.90	10.05	9.85	85	11.10	10.25	9.95	85
23b	61	HYV ext.	10.25	9.90	9.75	35	10.25	9.90	9.75	35	10.40	10.05	9.85	35	10.40	10.05	9.85	35	10.60	10.25	9.95	35
23c	20	HYV in.	10.15	9.90	9.75	25	10.15	9.90	9.75	25	10.30	10.05	9.85	25	10.30	10.05	9.85	25	10.50	10.25	9.95	25
28a	23	HYV in.	10.40	9.75	9.60	65	10.40	9.90	9.70	50	10.55	9.90	9.70	65	10.55	10.05	9.75	50	10.75	10.25	9.85	50
28b	87	HYV in.	10.15	9.75	9.60	40	10.15	9.90	9.70	25	10.30	9.90	9.70	40	10.30	10.05	9.75	25	10.50	10.25	9.85	25
28c	98	LV ext.	9.65	9.75	9.60	-10	9.80	9.90	9.70	-10	9.80	9.90	9.70	-10	10.00	10.05	9.75	-5	10.20	10.25	9.85	-5
28d	58	LV ext.	9.65	9.75	9.60	-10	9.80	9.90	9.70	-10	9.80	9.90	9.70	-10	10.00	10.05	9.75	-5	10.20	10.25	9.85	-5
28e	86	HYV in.	10.15	9.75	9.60	40	10.15	9.90	9.70	25	10.30	9.90	9.70	40	10.30	10.05	9.75	25	10.50	10.25	9.85	25
28f	58	HYV in.	10.15	9.75	9.60	40	10.15	9.90	9.70	25	10.30	9.90	9.70	40	10.30	10.05	9.75	25	10.50	10.25	9.85	25
28g	118	LV ext.	9.30	9.75	9.50	-45	9.45	9.90	9.60	-45	9.45	9.90	9.60	-45	9.65	10.05	9.65	-40	9.85	10.25	9.75	-40
28h	34	LV ext.	9.90	9.75	9.60	15	10.05	9.90	9.70	15	10.05	9.90	9.70	15	10.25	10.05	9.75	20	10.45	10.25	9.85	20
24a	74	Sugar	12.15	9.75	9.60	240	12.15	9.90	9.70	225	12.30	9.90	9.70	240	12.30	10.05	9.75	225	12.50	10.25	9.85	225
24b	46	HYV in.	10.15	9.75	9.60	40	10.15	9.90	9.70	25	10.30	9.90	9.70	40	10.30	10.05	9.75	25	10.50	10.25	9.85	25
24c	135	LV ext.	9.70	9.75	9.50	-5	9.85	9.90	9.60	-5	9.85	9.90	9.60	-5	10.05	10.05	9.65	0	10.25	10.25	9.75	0
24d	56	LV ext.	10.05	9.75	9.60	30	10.20	9.90	9.70	30	10.20	9.90	9.70	30	10.40	10.05	9.75	35	10.60	10.25	9.85	35
26b	79	HYV in.	10.15	9.75	9.60	40	10.15	9.90	9.70	25	10.30	9.90	9.70	40	10.30	10.05	9.75	25	10.50	10.25	9.85	25
26c	37	Sugar	12.15	9.75	9.60	240	12.15	9.90	9.70	225	12.30	9.90	9.70	240	12.30	10.05	9.75	225	12.50	10.25	9.85	225
26d	71	LV ext.	10.30	9.75	9.60	55	10.45	9.90	9.70	55	10.45	9.90	9.70	55	10.65	10.05	9.75	60	10.85	10.25	9.85	60
29b	37	HYV in.	9.90	9.75	9.60	15	9.90	9.90	9.70	0	10.05	9.90	9.70	15	10.05	10.05	9.75	0	10.25	10.25	9.85	0
29c	117	HYV in.	9.90	9.75	9.60	15	9.90	9.90	9.70	0	10.05	9.90	9.70	15	10.05	10.05	9.75	0	10.25	10.25	9.85	0
30a	56	HYV in.	10.65	10.65	10.50	0	10.65	10.65	10.50	0	10.80	10.80	10.60	0	10.80	10.80	10.60	0	11.00	11.00	10.70	0
31a	44	LV ext.	9.45	9.45	9.30	0	9.60	9.60	9.40	0	9.60	9.60	9.40	0	9.80	9.80	9.50	0	10.00	10.00	9.60	0
29a	48	HYV in.	10.40	10.40	10.25	0	10.40	10.40	10.25	0	10.55	10.55	10.35	0	10.55	10.55	10.35	0	10.75	10.75	10.45	0
25a	65	LV in.	10.15	10.10	9.95	5	10.30	10.10	9.95	20	10.30	10.25	10.05	5	10.50	10.25	10.05	25	10.70	10.45	10.15	25
26a	80	HYV ext.	10.05	10.10	9.85	-5	10.05	10.10	9.85	-5	10.20	10.25	9.95	-5	10.20	10.25	9.95	-5	10.40	10.45	10.05	-5
27a	22	HYV in.	10.15	10.15	10.00	0	10.15	10.15	10.00	0	10.30	10.30	10.10	0	10.30	10.30	10.10	0	10.50	10.50	10.20	0
32a	25	HYV in.	9.90	9.90	9.75	0	9.90	9.90	9.75	0	10.05	10.05	9.85	0	10.05	10.05	9.85	0	10.25	10.25	9.95	0
31e	90	LV in.	10.15	10.15	10.00	0	10.30	10.15	10.00	15	10.30	10.30	10.10	0	10.50	10.30	10.10	20	10.70	10.50	10.20	20
31b	143	HYV in.	10.15	10.15	10.00	0	10.15	10.15	10.00	0	10.30	10.30	10.10	0	10.30	10.30	10.10	0	10.50	10.50	10.20	0
31c	79	HYV in.	10.15	10.15	10.00	0	10.15	10.15	10.00	0	10.30	10.30	10.10	0	10.30	10.30	10.10	0	10.50	10.50	10.20	0
31d	113	LV in.	10.15	10.15	10.00	0	10.30	10.15	10.00	15	10.30	10.30	10.10	0	10.50	10.30	10.10	20	10.70	10.50	10.20	20

agri	maximum allowable level for indicated crop
wmax	maximum water level possible within water management constraints
wmopt	target level; taking the average of wmax and the base level and subtracting the buffer
	agri - wmax: water level higher, more than 30 cm
	agri - wmax: water level higher between 10 and 30 cm
	agri - wmax: difference less than 10 cm
	agri - wmax: water level lower, between 10 and 30 cm
	agri - wmax: water level lower, more than 30 cm

Annex C Detailed list of interventions in CPP.

Code	WorkName	Location	
Map: Cluster Ib			
Cluster Ia			
Construction of regulator (1)			
00101	Lohajang Main Inlet	Jugini	
		Total for Construction of regulator (1):	1
Modification (2)			
00201	Binnafair Sluice Modification	Binnafair	
00202	Fatehpur Sluice Modification	Fatehpur	
		Total for Modification (2):	2
Upgrading of compartmental embankment (6)			
00601	Ramdevpur - Silimpur Resec Km 0.00-1.40	Ramdevpur to Gop	
00602	Ramdevpur - Silimpur Resec Km 1.40-1.89	Gopalpur to Dhala	
00603	Ramdevpur - Silimpur Resec Km 1.89-4.84	Dhalan to Binnafai	
00604	Fatehpur Advanced Embankment Km 4.837-7.042	Fatehpur	
00606	Ramdevpur to Rasulpur Resec Km 0.00-1.10	Ramdevpur - Khor	
00607	Ramdevpur to Rasulpur Resectioning Km 1,10-3.06	Khorda Jugini - Ka	
		Total for Upgrading of compartmental embankment (6):	6
		Total of interventions for cluster Ia:	9
Cluster Ib			
Construction of regulator (1)			
10101	Dithpur Outlet	Dithpur	
10102	Khorda Jugini Inlet	Jugini	
10103	Kagmari Outlet	Kagmari	
		Total for Construction of regulator (1):	3
Minor regulator (CDO/Weir) (3)			
10301	Dannya Chowdhury CDO	Dannya Chowdhur	
10302	Dighulia-1 CDO	Dighulia	
10303	Krishnapur WCS	Khrishnapur	
10304	Beel Baghil WCS	Beel Baghil	
10305	Edgah Maidan WCS	Edgah Maidan	
10306	Bhangabari CDO	Bhangabari	
10307	Dighulia-2 CDO	Dighulia	
10308	Rampal CDO	Rampal	
10309	Singerkona Beel WCS	Singerkona Beel	
10310	Chillabari CDO	Chillabari	
10311	Chowbari WCS	Chowbari	
10313	Sapua WCS	Sapua	
10314	Santosh Regulator	Santosh	
		Total for Minor regulator (CDO/Weir) (3):	13
Bridge/Culverts/Irr. pass/Drain pipe (4)			
10401	Ghoramara Bridge over Binnafair khal	Ghoramara	
10402	Singerkona Dhannya Chowdhury Bridge	Singerkona Dhann	
10403	Alishakanda Culvert	Alishakanda	
10404	Fatehpur Anehola Road Culvert	Fatehpur Anehola	
10405	Panchkahunia Bridge over Chillabari Khal	Panchkahunia - Ch	
10406	Choto Binnafair Culvert	Chuto Binnafair	
10407	Charpara Culvert	Charpara	
10408	Kathuajugini Culvert	Kathuajugini	
10409	Moishakanda Culvert	Moishakanda	
10410	Fatehpur Culvert	Fatehpur	
10411	Gaizabari Bridge near Santosh	Santosh	
		Total for Bridge/Culverts/Irr. pass/Drain pipe (4):	11

Code	WorkName	Location	
Excavation/Re-excavation of canal (5)			
10501	Jugini Khal	Jugini Khal	
10502	Singarkona Dhannya Choudhury Khal	Singarkona - Dhan	
10503	Binnafair Khal, Dhaleswari to Rampal & on to Santos	Binnafair Khal	
10504	Singerkona Beel - Binnafair Khal Link Canal	Singerkona - Binna	
10505	Dithpur Khal Reexcavation	Dithpur	
10506	Rampal Khal Re-excavation	Rampal Khal	
10509	Fatehpur Khal	Chutobinnafair	
10510	Khanpur Borrowpit Extension	Khanpur, Digulia	
10511	Dighulia khal	Kalipur	
10512	Chillabari Khal	Chillabari to Sakrai	
10513	Gaizabari Khal	Santosh to Kagmar	
		Total for Excavation/Re-excavation of canal (5):	***11***
Upgrading of compartmental embankment (6)			
10604	Dithpur to Main Inlet Embankment	Dithpur to Main Inl	
10605	Pardigulia to Sarutia to Chillabari SC Embankment	Pardighulia to Saru	
10606	Rakhitbelta SC Embankment	Rakhitbelta	
		Total for Upgrading of compartmental embankment (6):	***3***
Access road improvement (8)			
10801	Approach Road on Chillabari & Dhannya Chy CD	Chillabari to Dhan	
10802	Dithpur to Shibpur Road	Dithpur to Shibpur	
		Total for Access road improvement (8):	***2***
		Total of interventions for cluster Ib:	***43***

Cluster VI

River bank protection (9)			
60901	Pardighulia Protective Work	Pardighulia	
60903	Protective Work near Rafat Textile Mills	Tangail Town on L	
		Total for River bank protection (9):	***2***
		Total of interventions for cluster VI:	***2***

Map: Cluster II

Cluster Ia

Construction of regulator (1)			
00102	Sadullapur Regulator	Sadullapur	
00103	Rasulpur Inlet	Rasulpur	
		Total for Construction of regulator (1):	***2***
Upgrading of compartmental embankment (6)			
00601.0	Rasulpur-Selina (New) Km 0.00-4.35	Rasulpur-Selina	
00608	Ramdevpur to Rasulpur Resectioning Km 3.06-3.90	Kathua Jugini - Pic	
00609	Ramdevpur to Rasulpur Resectioning Km 3.90 -6.77	Pichuria-Gala	
00610	Ramdevpur to Rasulpur Resec (Km 6.77-9.53)	Gala to Rasulpur	
00611	Rasulpur to Selina (New & Resec) Km 0.00-4.35	Rasulpur-Selina	
00612	Rasulpur to Selina (Resec) Km 4.35-5.09	Rasulpur-Selina	
		Total for Upgrading of compartmental embankment (6):	***6***
		Total of interventions for cluster Ia:	***8***

Cluster II

Construction of regulator (1)			
20101	District Regulator	near Dist. HQ	
		Total for Construction of regulator (1):	***1***
Modification (2)			
20201	Gate fitting at Sadullapur culvert	Sadullapur	
		Total for Modification (2):	***1***

Code	WorkName	Location	
Minor regulator (CDO/Weir) (3)			
20301	Enayetpur WCS-1	Enayetpur	
20302	Salina Regulator	Selina	
20303	Enayetpur WCS-2	Enayetpur	
20304	Beel Garindha WCS	Garindha	
20305	Agbetur WCS	Agbetur	
20307	Bhatchanda WCS-1	Bhatchanda	
20308	Bhatchanda WCS-2	Bhatchanda	
20309	Magurhata WCS	Magurhata	
20310	Dharerbari WCS	Dharerbari	
20312	Char Kagmara WCS	Char Kagmara	
20316	Pauli Gated Pipe Culvert	Pauli	
20318	Bararia Sluice	Bararia	
		Total for Minor regulator (CDO/Weir) (3):	***12***
Bridge/Culverts/Irr. pass/Drain pipe (4)			
20403	Pass Betur Irrigation Pass	Pass Betur	
20404	Kandila Bridge	Pass Betur	
20405	Dharerbari Pipe Culvert	Dharerbari	
		Total for Bridge/Culverts/Irr. pass/Drain pipe (4):	***3***
Excavation/Re-excavation of canal (5)			
20501	Sadullapur Khal	Sadullapur	
20502	Magurhata Khal	Magurhata	
20503	Deolakandila Khal	Deolakandila	
20505	Dhopa Chara beel -Sadullapur Khal Link Canal	Dhopa Chara beel -	
20506	Dharerbari Khal (part)	Dharerbari Khal (p	
20507	District Khal	District Khal	
20508	Rasulpur Khal	Rasulpur	
20509	Bamni khal	Bamni	
		Total for Excavation/Re-excavation of canal (5):	***8***
Upgrading of compartmental embankment (6)			
20604	SC Embkt Dharerbari to District Regulator	Dharerbari to Distr	
		Total for Upgrading of compartmental embankment (6):	***1***
Access road improvement (8)			
20801	Access road over District Regulator	District Regulator	
20802	Access road at Rasulpur Bridge	Rasulpur	
		Total for Access road improvement (8):	***2***
River bank protection (9)			
20901	Pasbetur Groyne	Groyne at Pasbetur	
		Total for River bank protection (9):	***1***
		Total of interventions for cluster II:	***29***
Cluster VI			
Bridge/Culverts/Irr. pass/Drain pipe (4)			
60401	Rasulpur bridge	Rasulpur	
		Total for Bridge/Culverts/Irr. pass/Drain pipe (4):	***1***
		Total of interventions for cluster VI:	***1***
Map: Cluster III			
Cluster Ia			
Construction of regulator (1)			
00105	Suruuj Inlet	Suruuj	
		Total for Construction of regulator (1):	***1***

Code	WorkName	Location	
Upgrading of compartmental embankment (6)			
00613	Selina to Nathkhola (Resec) Km 0.00-14.27	Selina to Nathkhol	
00614	Dhapnagar to Nathkhola (New) Km 14.27-15.39	Dhapnagar - Nathk	
		Total for Upgrading of compartmental embankment (6):	***2***
		Total of interventions for cluster Ia:	***3***

Cluster III

Construction of regulator (1)			
30101	Jalfai Outlet	Jalfai	
30102	Bhatkura Outlet	Bhatkura	
30103	Paschim Pauli Regulator	Paschim Pauli	
30104	Garindha Bifurcation Structure	Garindha	
		Total for Construction of regulator (1):	***4***
Minor regulator (CDO/Weir) (3)			
30301	Karatia WCS	Karatia	
30302	Khudirampur WCS	Khudirampur	
30304	Birnali WCS-1	Birnali	
30306	Namdarkumulli WCS	Namdar Kumulli (	
30307	Niogi Joair WCS	Niogi Joair	
30308	Gosaijoair WCS	Gosaijoair	
30309	Hatila WCS	Hatila	
30310	Poila WCS	Poila	
30311	Mirer Betka WCS	Mirer Betka	
30312	Namdar Kumulli Moddhyapara WCS	Namdar Kumulli (	
30313	Karatia Choudhurypara WCS	Karatia Choudhury	
30314	Dharat WCS (Designed as Box Culvert)	Dharat	
30315	Birnali gated pipe culvert WCS-2	Birnali	
		Total for Minor regulator (CDO/Weir) (3):	***13***
Bridge/Culverts/Irr. pass/Drain pipe (4)			
30403	Golabari Box Culvert	Golabari	
30405	Hatila Box Culvert	Hatila	
30407	Dharat Pipe Culvert (Designed WCS)	Dharat	
30408	Sarutia Pipe Culvert	Sarutia	
30409	Darun Box Culvert	Darun	
30410	Aultia pipe culvert	Aultia	
30411	Sarutia Box Culvert	Sarutia , Garinda k	
30412	Gosaijoiar Box Culvert	Sarutia , Garinda k	
30413	Bhatkura Pipe Culvert	Near Bhatkura Reg	
		Total for Bridge/Culverts/Irr. pass/Drain pipe (4):	***9***
Excavation/Re-excavation of canal (5)			
30501	Bhatkura Khal	Bhatkura Khal	
30502	Khudirampur Khal	Khudirampur Khal	
30505	Suruuj Khal (part)	Suruj Khal	
30506	Gharinda Khal upto Jalpai	Garindha	
30507	Jalpai Khal	Jalpai	
30508	Golabari Khal	Golabari	
		Total for Excavation/Re-excavation of canal (5):	***6***
		Total of interventions for cluster III:	***32***

Cluster V

Tangail Town Development (15)			
51501	Tangail khal (Pucca drain)		
51502	Tangail khal (earthen drain)	Tangail Town	
51503	Internal drain in cluster V	Tangail Town	
		Total for Tangail Town Development (15):	***3***
		Total of interventions for cluster V:	***3***

Code	WorkName	Location	
Map: Cluster IV			
Cluster Ia			
Construction of regulator (1)			
00104	Baruha Inlet	Baruha	
		Total for Construction of regulator (1):	*1*
Modification (2)			
00203	Indrobelta Sluice Modification	Indrobelta	
00204	Barabelta Sluice Modification	Barabelta	
		Total for Modification (2):	*2*
Upgrading of compartmental embankment (6)			
00605	Ramdevpur - Silimpur Resec Km 7.042-16.275 km	Charabari Embank	
		Total for Upgrading of compartmental embankment (6):	*1*
		Total of interventions for cluster Ia:	*4*
Cluster IV			
Construction of regulator (1)			
40101	Aloaraypara Regulator	Aloaraypara	
40102	Deojan Regulator	Deojan	
		Total for Construction of regulator (1):	*2*
Modification (2)			
40202	Supply of 1 gate on ext. culvert Mongalhaor-Pathrail	Mongalhaor-Pathra	
		Total for Modification (2):	*1*
Minor regulator (CDO/Weir) (3)			
40301	Aloa Bhabani WCS	Aloa Bhabani	
40302	Berabuchna WCS	Berabuchna	
40303	Burburia WCS	Burburia	
40304	Bara Atia WCS	Bara Atia	
40311	Bandabari Gated Pipe Culvert	Bandabari	
40314	Birpusia WCS	Birpusia	
		Total for Minor regulator (CDO/Weir) (3):	*6*
Bridge/Culverts/Irr. pass/Drain pipe (4)			
40401	Ring Pipe on Chandi-Karatia road	Chandi-Karatia roa	
40402	Aloabhabani Pipe Culvert-1	Aloabhabani	
40403	Aloabhabani Pipe Culvert-2	Aloabhabani	
40405	Pathrail Gated Pipe Culvert	Pathrail	
40406	Kumuli Gated Pipe Culvert	Kumuli	
40407	Khagjana Gated Pipe Culvert	Khagjana	
40408	Mahmudpur Gated Pipe Culvert	Mahmudpur	
40409	Kandoor Gated Pipe Culvert	Kandoor	
40410	Kumuria Gated Pipe Culvert	Kumuria	
		Total for Bridge/Culverts/Irr. pass/Drain pipe (4):	*9*
Excavation/Re-excavation of canal (5)			
40501	Sontosh Khal	Sontosh	
40502	Aloa Khal	Aloa	
40503	Berabuchna-kumari Khal	Berabuchna-Kuma	
40504	Barabelta Khal	Barabelta	
40505	Indrabelta Khal	Indrabelta	
40506	Katakhali Link Canal	Katakhali	
40507	Bagerchara Link Canal	Bagerchara	
40508	Baruha Khal	Baruha	
40509	Mahmudpur Link Canal	Mahmudpur	
40510	Baruha Link Canal	Baruha	
40511	Deojan Khal	Deojan	

Code	WorkName	Location	
40512	Dosagia Khal	Dosagia	
40513	Pathrail Khal	Pathrail	
40514	Kumuli Khal	Kumuli	
40515	Khagjana Khal	Khagjana	
40516	Birpusia khal	Birpusia	
40517	Kumarpara Link Canal	Kumargara	
		Total for Excavation/Re-excavation of canal (5):	*17*
Breach closure (7)			
40701	Closing of 3 breaches in northern boundary of SC15	Northern boundary	
		Total for Breach closure (7):	*1*
		Total of interventions for cluster IV:	*36*

Cluster VI

Excavation/Re-excavation of canal (5)

60501	Lohajang River	Lohajang River (L	
60504	Gunikishore Loop cutting	Gunikishore	
		Total for Excavation/Re-excavation of canal (5):	*2*
River bank protection (9)			
60904	Gunikishore Protective Work	Gunikishore, on El	
		Total for River bank protection (9):	*1*
		Total of interventions for cluster VI:	*3*

Map: not in map

Cluster Ia

Upgrading of compartmental embankment (6)

00615	Khaladbari Embankment	Khaladbari	
00616	Rupshijatra-Silimpur Embankment	Rupshijatra-Silimp	
00617	Rupshijatra Embankment	Rupshijatra	
		Total for Upgrading of compartmental embankment (6):	*3*
O&M during construction (13)			
01301	Main Inlet Repair	Main Inlet	
		Total for O&M during construction (13):	*1*
		Total of interventions for cluster Ia:	*4*

Cluster Ib

Access road improvement (8)

10803	Tangail Access Road	Between Chillabari	
		Total for Access road improvement (8):	*1*
		Total of interventions for cluster Ib:	*1*

Cluster IV

Bridge/Culverts/Irr. pass/Drain pipe (4)

40404	Chinakhola Foot Bridge	Chinakhola	
		Total for Bridge/Culverts/Irr. pass/Drain pipe (4):	*1*
O&M during construction (13)			
41302	Beltasharai Protective Work	Beltasharai	
		Total for O&M during construction (13):	*1*
		Total of interventions for cluster IV:	*2*

Cluster VI

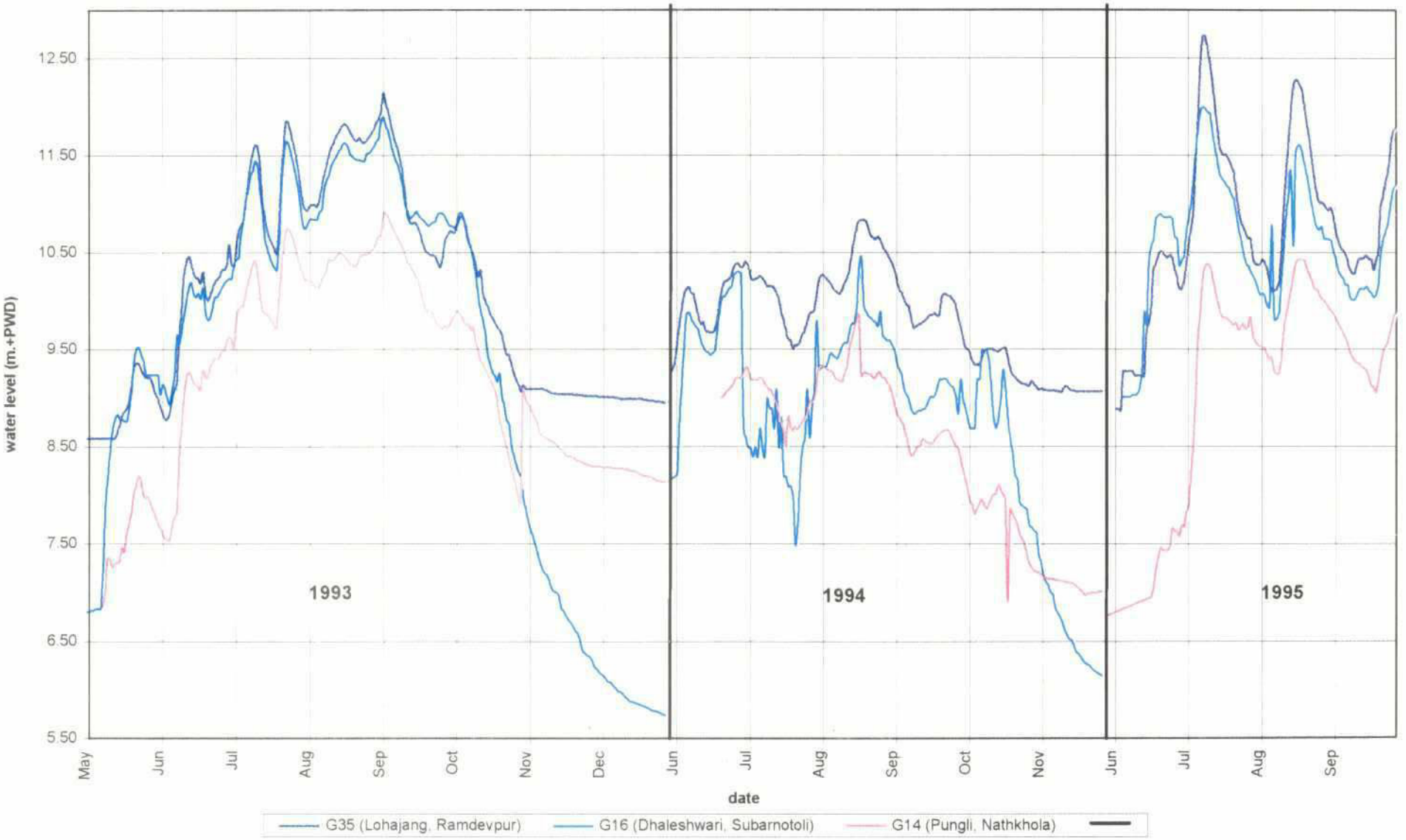
Excavation/Re-excavation of canal (5)

60506	Ainapur- Sayabeel Khal	Sayabeel (SC E3)	
60507	Bara Basalia Khal (eastern part)	Bara Basalia	
		Total for Excavation/Re-excavation of canal (5):	*2*

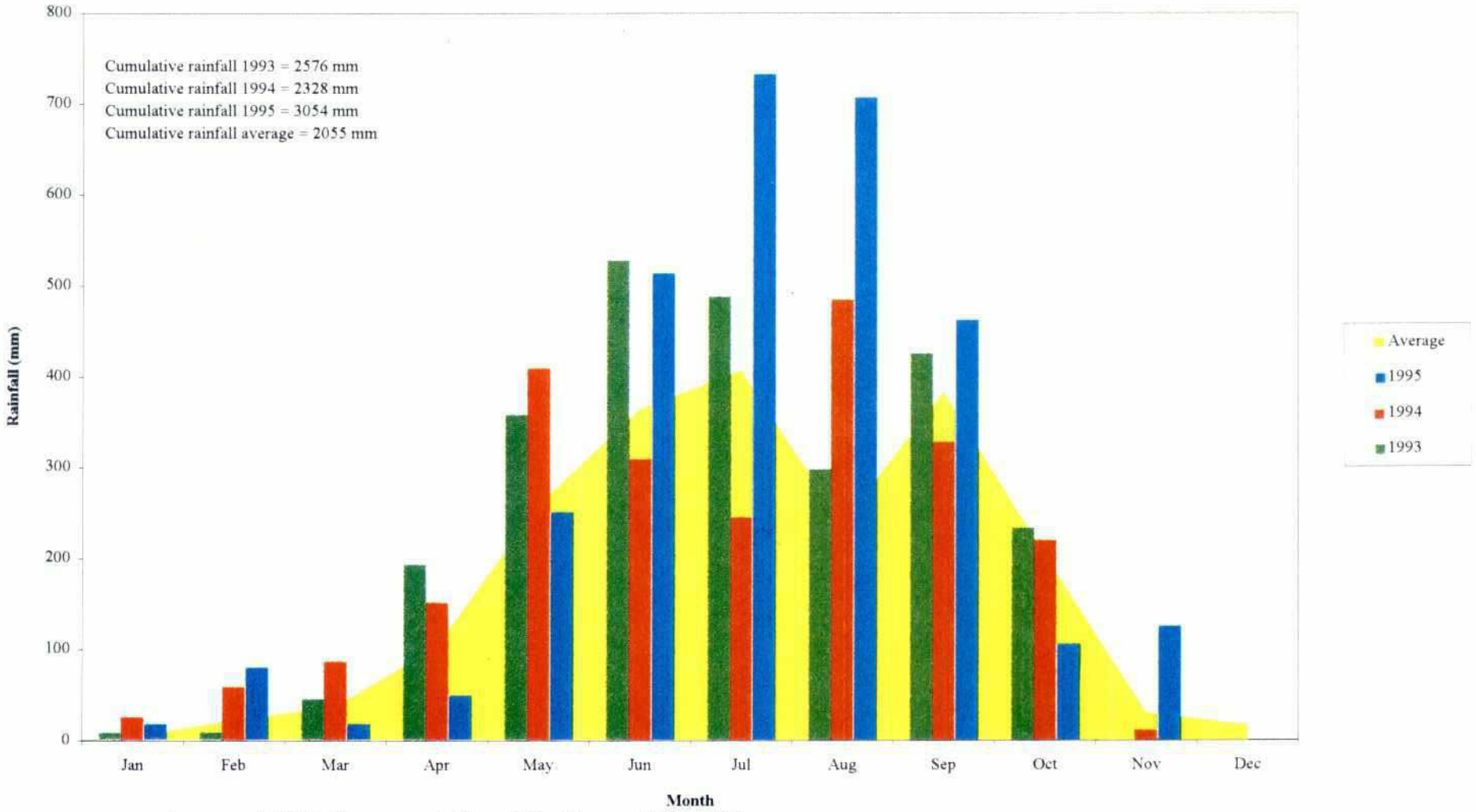
Code	WorkName	Location	
Fish farm earthwork (10)			
61001	Rupshi Jatra Baor Development	Rupshi Jatra (Goni	
		Total for Fish farm earthwork (10):	***1***
Meeting place construction (11)			
61102	Gala Khal	Gala	
61104	Basalia Pri. School Field (Refuge Shelter)	Basalia	
61105	Agrani High School (Refuge Shelter)	Maisa Nandalal	
61106	Maisasek Eiodgah Maidan (Refuge Shelter)	Maisa Nandalal	
61107	Dhalan Govt. Pri. School (Refuge Shelter)	Dhalan	
61108	Alishakanda South Govt. Pri. School (Refuge Shelter)	Alishakanda	
61109	Alishakanda North Govt. Pri. School (Refuge Shelter)	Alishakanda	
61110	Gosaijoar Hat Premise (Refuge Shelter)	Gosaijoar	
61111	Dhulatia Hafezia Madrasa (Refuge Shelter)	Dhulatia	
61112	Karatia Jute & Cattle Market(Refuge Shelter)	Karatia	
61113	Deojan Girls High School (Refuge Shelter)	Deojan	
61114	Baratia Chinakhola Pri. School (Refuge Shelter)	Baratia	
61115	Khagjana Madrasa (Refuge Shelter)	Khagjana	
61116	Pakullah Paschim Misurita Pri. School (Refuge Shelter	Pakullah	
61117	Baruha School Play Ground (Refuge Shelter)	Baruha	
61118	Pakullah Govt. Pri. School Field (Refuge Shelter)	Pakullah	
61119	Gaizabari Play Ground (Refuge Shelter)	Gaizabari	
61120	Nonduria Eidgah Maidan (Refuge Shelter)	Nonduria	
61121	Hinga Nagar Govt. Pri. School (Refuge Shelter)	Hinga Nagar	
		Total for Meeting place construction (11):	***19***
Peripherial mitigation (12)			
61201	Foot Bridge at Gosai Gagorjan	Gosai Gagorjan	
61202	Foot Bridge at Char Durgapur	Char Durgapur	
61203	Foot Bridge at Beel Muril- Deldar Road	Beel Muril- Deldar	
61204	Road resec. Barabasalia Refuge to Barabasalia	Barabasalia	
61205	Road resec. Parchar culvert to Chotobasalia	Chotobasalia	
61206	Road resec. Gala Purbapara to Chotobasalia Purbapara	Chotobasalia	
61207	Road resec. Failarghona Madrasa to Sinegagorjan brid	Failarghona	
61208	Road resec. Galar Char Pri. School to near Md. Ali's h	Galar Char	
61209	Road resec. Beelmuril to Chow. Malancha	Beelmuril	
61210	Road resec. Beelmuril to Deldarchar	Deldarchar	
61211	Road link Maisa Nandalal- Deldarchar	Maisa Nandalal	
		Total for Peripherial mitigation (12):	***11***
O&M during construction (13)			
61301	Supplying, fixing RCC Pilar	CPP area	
		Total for O&M during construction (13):	***1***
		Total of interventions for cluster VI:	***34***
		Total of interventions for Tangail Compartment:	***214***

Annex D Hydro-meteorological data

Water level graph for Lohajang, Dhaleshwari and Pungli



Rainfall at Atia, Tangail (R02)



Average rainfall is the average in Tangail for 10 years (1983-1992).
Data obtained from the Hydrology Department of BWDB.

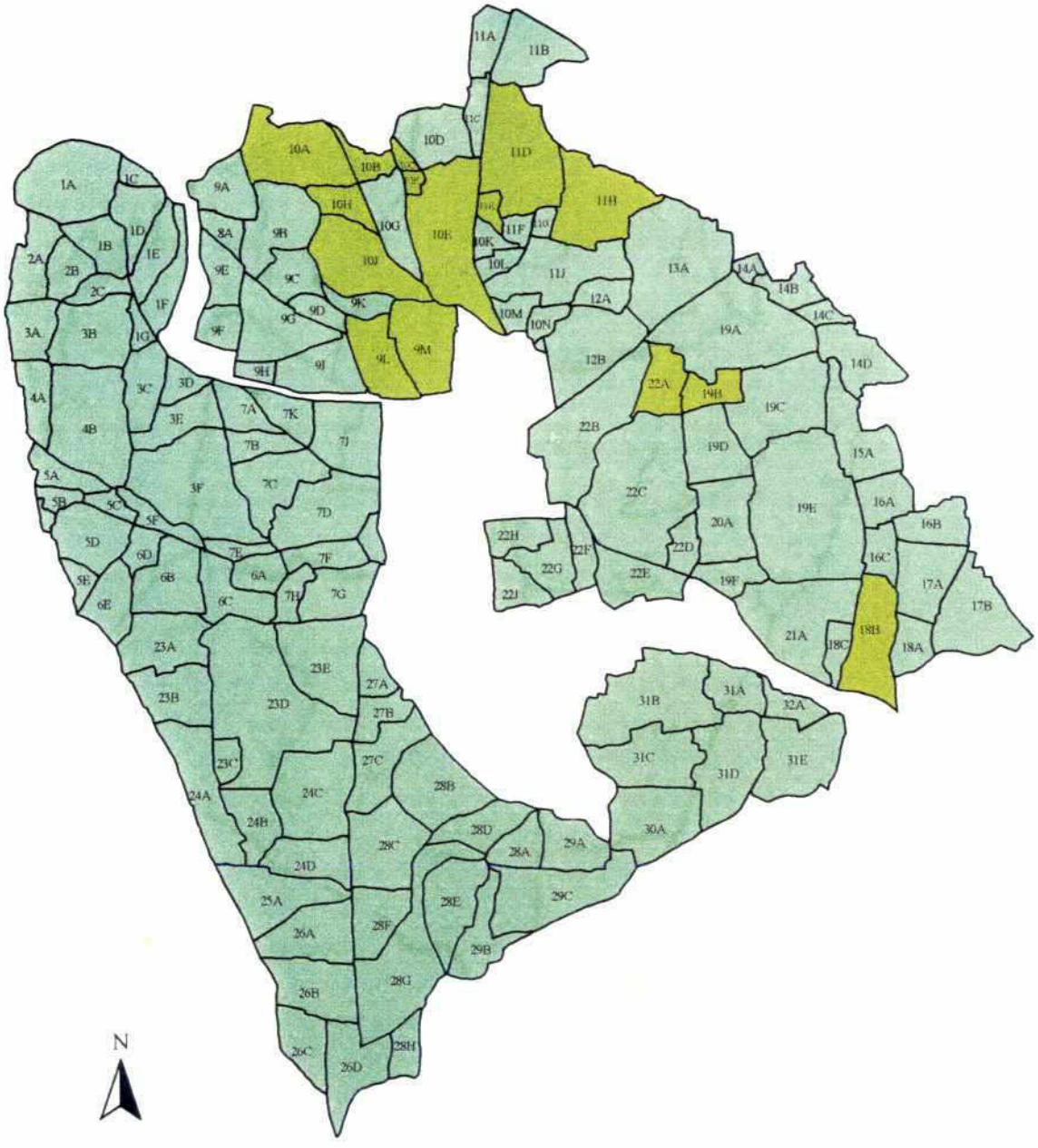
Annex E Progress monitoring

Progress monitoring

Also in progress monitoring CPP used GIS. Every three months updates were prepared of separate maps that depicted the progress of the Chawk committee establishment, the construction of concrete structures and earth works.

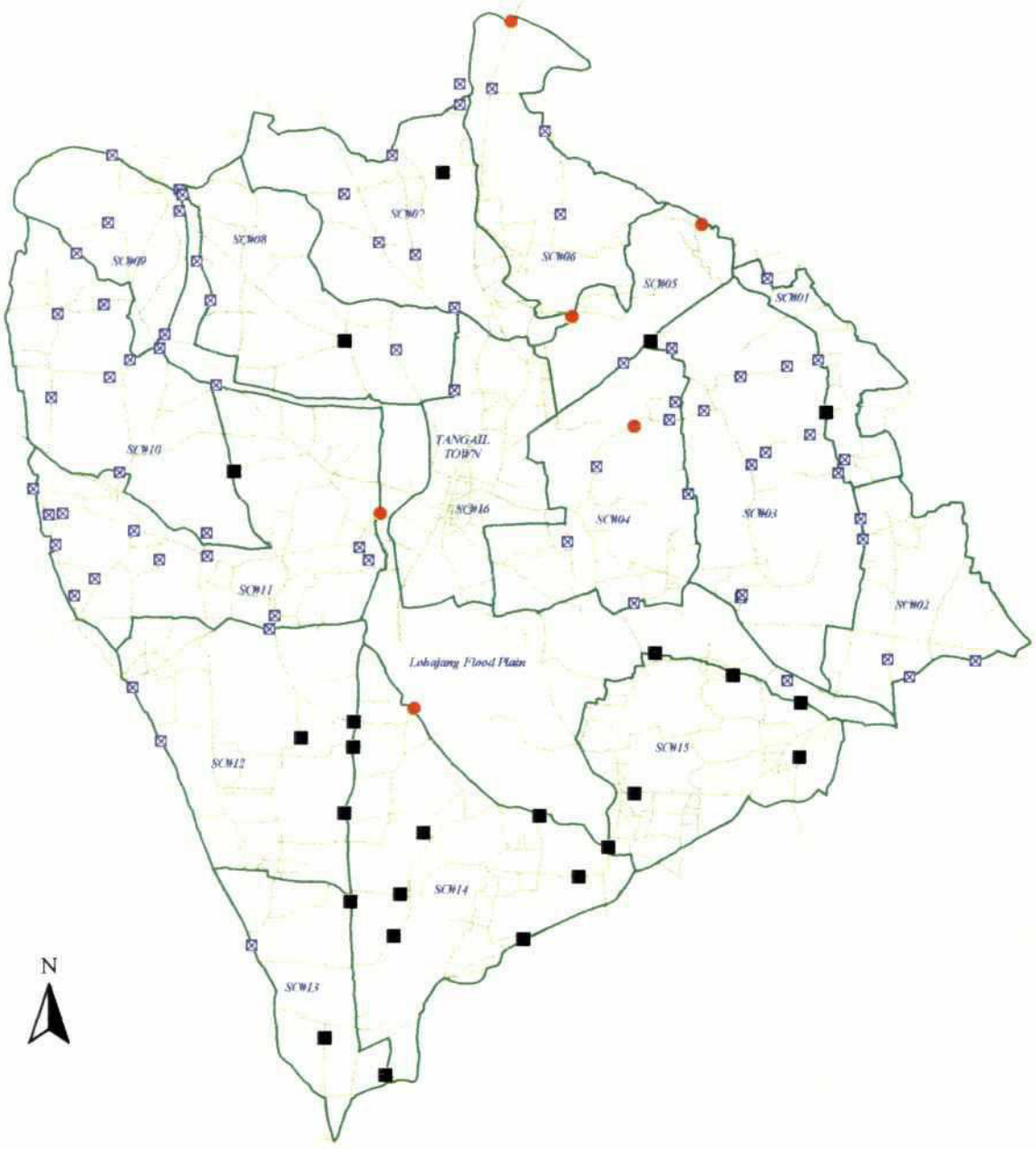
The three maps presented here as an example give the status on 30 June 1996.

Institutional Development, Status July, 96



Compartmentalization Pilot Project Tangail

Physical Progress Structures at 30/6/96



1 0 1 2 3 Kilometers

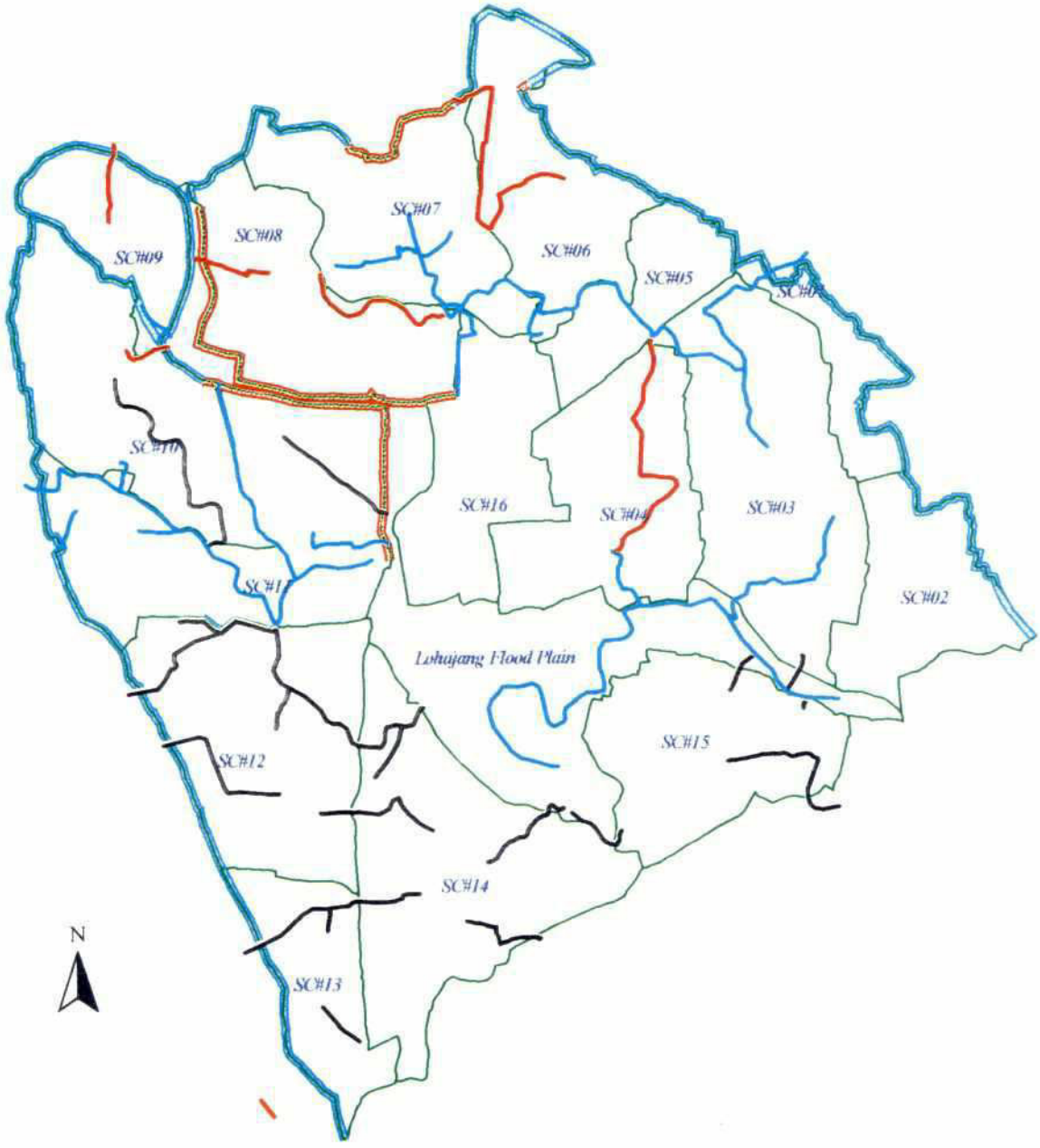
scale 1:100 000
map projection : UTM

Interventions
- Completed
- Ongoing
- Planned
- Subcompartment Boundary
- Road

Compartmentalization Pilot Project Tangail

September, 96 c:\win32app\cppdata\\Physprog.apr

Physical Progress Khals & Embankments at 30/6/96



1 0 1 2 3 Kilometers

scale 1:100 000
map projection : UTM

Khal (Re-) Excavation
Completed
Ongoing
Planned
Embankments & Roads
Completed
Ongoing
Planned
Subcompartment Boundary

Compartmentalization Pilot Project Tangail

September, 96 c:\win32app\cppdata\physprog.apr