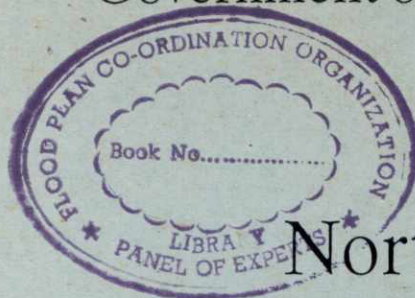


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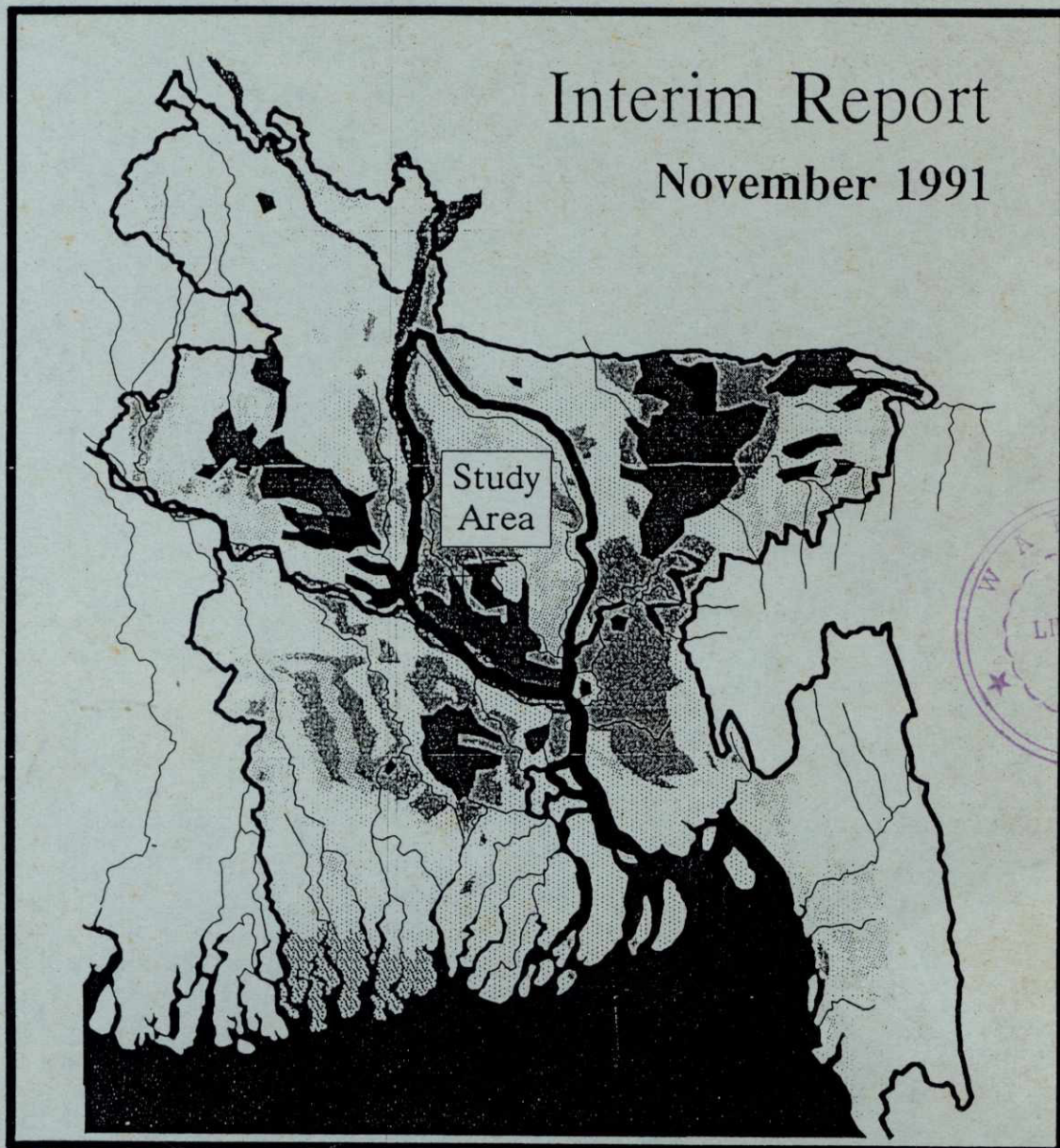
Flood Action Plan

FAP 3

North Central Regional Study

Interim Report

November 1991



Commission of the European Communities
and

Caisse Centrale de Co-operation Economique
Government of France
Project ALA/90/03

Consortium

BCEOM, Compagnie Nationale du Rhône,
Euroconsult, Mott MacDonald International,
Satec Developpement

in association with:

Desh Upodesh
BETS

RECORDED

NORTH CENTRAL REGIONAL STUDY

F. A. P 3

Ministry of Irrigation, Water
Development and Flood Control

PROJECT OFFICE

3/8, BLOCK-C
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To
Mr. A.M.M.Nurul Huq
Chief Engineer
Flood Plain Co-ordination Organization
7, Green Road
Dhaka-1215

Ref: NCRS/1/1
Nov.14, 1991

Dear Mr. Nurul Huq

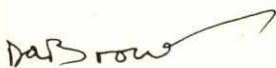
NORTH CENTRAL REGIONAL STUDY, FAP-3 INTERIM REPORT

Please find enclosed our Interim Report for the North Central Regional Study -Phase 2.

The Report contains a Draft Regional Development Plan and carried out a pre-selection of schemes. A preliminary economic analysis has been carried out of these schemes and a ranking given of the order of priority for future investigations at pre-feasibility level.

We look forward to moving on to the next stage of the study, carrying out pre-feasibility studies and preparing the Final Regional Water Development Plan.

Yours faithfully,



D A Brown
Team Leader
FAP-3



CONSORTIUM

BCEOM, COMPAGNIE NATIONALE DU RHONE
EUROCONSULT, MOTT MacDonald INT.
SATEC DEVELOPPEMENT

In association with
BETS (BANGLADESH ENGG. AND TECHNOLOGICAL SERVICES)
DASH UPODESH LIMITED

2

**BANGLADESH
ACTION PLAN FOR FLOOD CONTROL**

NORTH CENTRAL REGIONAL STUDY (FAP-3)

INTERIM REPORT

CONSORTIUM

BCEOM, COMPAGNIE NATIONALE DU RHONE,
EUROCONSULT, MOTT MacDONALD INT.,
SATEC DEVELOPPEMENT

under assignment to

COMMISSION OF THE EUROPEAN COMMUNITIES
and
CAISSE CENTRALE DE CO-OPERATION ECONOMIQUE
GOVERNMENT OF FRANCE

on behalf of
PEOPLE'S REPUBLIC OF BANGLADESH
PROJECT ALA/90/03

in association with

BETS (Bangladesh Engg. and Technological Services)
DESH UPODESH LIMITED
3/8, BLOCK-C LALMATIA, DHAKA

NORTH CENTRAL REGIONAL STUDY - INTERIM REPORT

DRAFT REGIONAL DEVELOPMENT PLAN

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ABBREVIATIONS

AEZ	Agro-Ecological Zone
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BCAL	Bangladesh Census of Agricultural Livestock
BCEOM	French Engineering Consultants
BIDS	Bangladesh Institute of Development Studies
BIWTA	Bangladesh Inland Water Transport Authority
BJRI	Bangladesh Jute Research Institute
BKB	Bangladesh Krishi Bank
BNPP	Bangladesh National Physical Planning Board
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engineering Technology
BWDB	Bangladesh Water Development Board
CA	Catchment Area
CAT	Coordination Advisory Team
CCC	Caisse Centrale de Coopération (France)
CEC	Commission of European Communities
CNR	Compagnie Nationale du Rhone
CPM	Coarse Pilot Model
CS	Consultants Studies
DAE	Department of Agricultural Extension
DANIDA	Danish International Development Agency
DHI	Danish Hydraulics Institute
DOE	Department of Environment
DOF	Department of Fisheries
DOS	Disk Operating System
DSSTW	Deep Set Shallow Tube Well
DTW	Deep Tube Well
DUL	Desh Upodesh Ltd.
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIP	Early Implementation Programme
FAO	Food and Agricultural Organisation of the United Nations
FAP	Flood Action Plan
FCDI	Flood Control, Drainage and Irrigation Project
FFYP	Fourth Five Year Plan
FHS	Flood Hydrology Study
FMM	Flood Management Modelling
FPCO	Flood Plan Co-ordination Organisation
FSR	Farming Research System
FWP	Food for Work Programme
FY	Financial Year
GW	Groundwater
HTW	Hand Tube Well
HYV	High Yielding Variety
IDA	International Development Agency
IRRI	International Rice Research Institute
JICA	Japanese International Cooperation Agency
JPPS	Jamalpur Priority Project Study
LAD	Least Available Depth

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LGEB	Local Government Engineering Bureau
MIWDFC	Ministry of Irrigation, Water Development & Flood Control
MOA	Ministry of Agriculture
MOEF	Ministry of Environment and Forestry
MOSTI	Manually Operated Shallow Tubewell for Irrigation
MPO	Master Plan Organisation
NARS	National Agricultural Research System in Bangladesh
NCA	Net Cultivable Area
NCR	North Central Region
NCRM	North Central Regional Model
NCRMG	North Central Regional Model Group
NCRS	North Central Regional Study
NGO	Non Government Organisation
NGR	Natural Growth rate
NWP	National Water Plan
O&M	Operation and Maintenance
ODA	Overseas Development Agency
PA	Planning Area
PFDS	Public Foodgrain Distribution System
POE	Panel of Experts
PWD	Public Works Datum
RARS	Regional Agricultural Research Station
RHD	Roads and Highways Department
SATEC	French Engineering Consultant Firm Member of the Study Consortium
SOB	Survey of Bangladesh
SRDI	Soil Resources Development Institute
SRP	Systems Rehabilitation Project
SRTI	Sugarcane Research and Training Institute
STW	Shallow Tube Well
SWMC	Surface Water Modelling Centre
SWSMP	Surface Water Simulation Modelling Programme
TOR	Terms of Reference



CHAPTER 1

INTRODUCTION

1.1 Introduction

The overall objective of North Central Regional Study (NCRS) is "to prepare a regional water development plan with emphasis on the flood control and drainage measures that would be needed to achieve a sustained development of the regional economy, taking into account social and environmental factors. The regional study will focus on areas where flooding and improved drainage hamper economic activity and will identify a series of measures to alleviate these adverse effects and to develop the land and water resources" (sect 3.1. TOR, FAPCO 1990).

The NCRS forms component three (FAP-3) of the Flood Action Plan. The Flood Action Plan comprises twenty-six components and supporting activities and is being co-ordinated by the Government of Bangladesh through the Flood Plan Co-ordination Organisation (FPCO) and the World Bank.

The Flood Action Plan aims to identify, plan, design and construct high priority projects which are technically, economically, environmentally and socially feasible. The plan follows a staged approach which focusses initially on:-

- measures to control flooding and improve drainage in areas bordering the main rivers, their main rivers and distributaries.
- regional studies of flood control and drainage, together with supporting activities to provide inputs into the planning and design of the main components of the Action Plan.

1.2 Phases of the Study

1.2.1 Phase 1

Phase I of the NCRS was a reconnaissance study (BCEOM 1990) and took place in April to June 1990. It encompassed the following activities:

- collection and review of data
- overall description of the region
- initiate data collection for regional computer model
- work with SWMC in construction of a hydraulic model
- initial assessment of cause/consequences of flooding with region
- inventory of existing projects, schemes, infrastructure
- assess broad development potential and constraints
- define the broad objectives of the regional water resources development plan
- identify the broad planning scenarios
- confirm priority projects identified in the Action Plan and prepare TOR for the preparation of the priority projects
- review and revise TOR for Phase 2 of the NCRS

1.2.2 Bridging Period

A bridging period took place between May 1990 and April 1991, which ensured continuity between the end of Phase 1 (June 1990) and the start of Phase 2 (March 1991) of the NCRS. The bridging activities comprised the following:

- River Survey - A longitudinal and cross-section survey of some 780 km. of watercourses within the North Central Region; carried out by Desh Upodesh Ltd. with a supervisory mission in Nov-Dec 1990 to check field work, computations and drawings.
- Groundwater Measurement - a programme of installation and monitoring of piezometers on 2 transects adjacent to the Jamuna River by Desh Upodesh Ltd. in July 1990. The purpose of the investigation was to study the relationship between river levels and adjacent groundwater levels.
- Geotechnical Investigations - an addendum to Phase 1 study aimed at determining the general characteristics of the likely embankment construction material. Mainly concerning the Jamalpur area. Contract executed by Desh Upodesh Ltd. from May 1990 to June 1990.

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- Surface Water Measurements - a programme of work carried out by Desh Upodesh Ltd., under the supervision of the Bridging Hydromodeller, during the monsoon season of 1990. A total of 15 water level stations were surveyed and monitored from June 1990 to November 1990 with discharge measurements taken in August and September 1990.
 - Hydromodelling - modelling activities carried out by the Bridging Hydromodeller, (BCEOM), from October 1990 to April 1991. The activities were directed towards the development of a coarse pilot model of the North Central Region using the hydrologic and hydrodynamic software Mike 11 from the SWMC.

1.2.3 Phase 2

Phase 2 of the North Central Regional Study commenced on March 8th, 1991. The study is being undertaken by a consortium of the following expatriate firms:

- o BCEOM
- o CNR
- o SATEC DEVELOPMENT
- o MOTT MACDONALD INTERNATIONAL
- o EUROCONSULT

in collaboration with the following Bangladeshi firms:-

- o DESH UPODESH LTD.
- o BETS LTD.

The study is being jointly financed by the Commission of the European Communities and the Government of France.

The basic purpose of the Phase 2 study is the preparation and evaluation of alternative water development strategies and the preparation of a regional water development plan, including the identification of priority projects and detailed project planning. The detailed activities of the Phase 2 study are clearly set out in the Terms of Reference, (BCEOM 1991), but a brief resumé of these are given below:-

a) Preliminary Activities

During this period the Consultant reviewed the previous and on-going activities in the region, including previous reports of relevant studies, bridging period activities, other activities under the Flood Action Plan. Formulated plans for additional surveys, as required, and continued on-going ones. The coarse pilot hydraulic simulation model has been refined. A review of the

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Terms of Reference for the Jamalpur Priority Project was carried out and refinements made as necessary. An Inception report was prepared and submitted in May 1991. This was revised, at the request of the FPCO and re-submitted in July.

The Revised Inception Report set out a detailed work plan and included a change of emphasis to include more analysis on social and environmental issues as well as concentrating on impact and benefit assessment.

b) **Comparison of Alternative Development Strategies and Preparation of a Draft Regional Water Development Plan**

This is the current phase being reported on and comprises the identification of the basic regional water development options in terms of the types of flood control options along the main rivers together with the sub-regional drainage options. The planning sub-regions identified in Phase 1 of the study have been reviewed and refined based on water resource development constraints and opportunities, and Planning Units (PUs) have been delineated.

Based on the regional development options identified, the alternative development strategies for the defined sub-regions have been developed. Each strategy comprises a phased investment programme of flood control, drainage and water management projects and takes into account necessary complementary agricultural and rural development activities.

The identified strategies are compared in terms of their technical, financial, economic and environmental soundness in order to maximise the water resource linked development opportunities for the region. The draft plan provides an overview of the alternative strategies and justifies the preferred strategies and identification of the priority projects for which pre-feasibility studies will be undertaken in the final phase of the Study.

c) **Preparation of Regional Water Development Plan**

This final phase of the study will elaborate and finalise the Regional Development Plan and carry out pre-feasibility studies of the projects included in the draft plan. Terms of Reference for these projects will be prepared.

The Jamalpur Priority Project Study will be carried out concurrently with the latter half of the North Central Regional Study, Phase 2. It is clear that the interaction between the two projects will be important. Development strategies for the Jamalpur area must accord with the overall development strategies for the Region as a whole and must be seen to form an integral part of the Development Plan. Options examined for the Jamalpur area will impact on the PUs which lie "downstream" from it. Close liaison must be maintained between the two studies to ensure a coordinated approach to the work.

1.3 Scope of the Report

This Interim Report presents a Draft Regional Water Development Plan (DRWDP) which is based on the preliminary analysis carried out in the first 8 months of Phase 2 of the Study.

The Interim Report includes an overview of the Region's resources and delineates the region into thirteen planning units (PUs) which form the basis for planning decisions, (see Figure 1.1.1 and Chapter 5).

The methodology of planning and the development option is described in chapter 4.

The main objective of the Interim Report is to identify priorities for further study. All the analysis is at a preliminary level and is intended to enable a rational decision to be made as to which possible schemes should be studied further at pre-feasibility level.

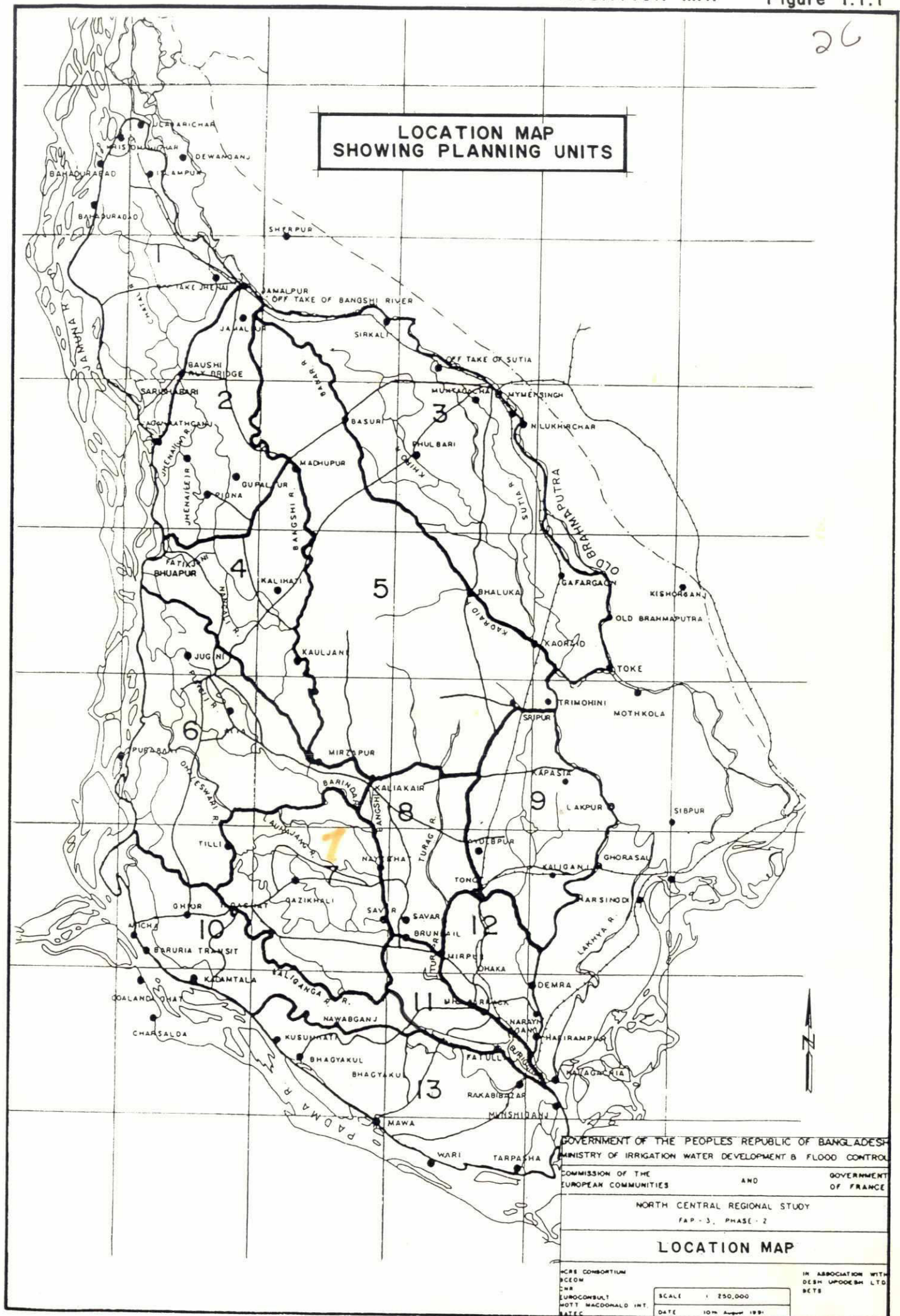
In addition to the Interim Report a series of preliminary supporting Reports (PSRs) are being produced. These contain the background data and detailed analysis on which the Interim Report is based. The list of PSRs is given in Table 1.1.

?

TIME

These are being prepared as the study progress and will eventually be presented as supporting documentation to the Final Regional Water Development Plan (FRWDP) due in May 1992.

Relevant PSRs will be circulated to the appropriate parties as and when they are drafted.



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TABLE 1.1
Preliminary Supporting Reports (currently being prepared for eventual submission along with the Final Regional Water Development Plan)

PSR I	LAND RESOURCES AND AGRICULTURE I.1 Land Resources I.2 Cropping and Yields I.3 Livestock
PSR II	WATER RESOURCES II.1 Hydrometeorology II.2 River and Drainage System II.3 River Morphology II.4 Groundwater II.5 Hydraulic Model
PSR III	FISHERIES III.1 Fishery Resources III.2 Fishery Initiatives
PSR IV	HUMAN RESOURCES AND SOCIO-ECONOMICS IV.1 Population, Households, & Employment IV.2 Survey Result IV.3 Awareness and Project Interest
PSR V	ENVIRONMENT V.1 Natural Environment V.2 Human Environment V.3 Impact Assessment
PSR VI	INFRASTRUCTURE AND EXISTING SCHEMES V.1 Communication V.1.1 Roads V.1.2 Navigation V.2 Facilities V.3 Embankments V.4 Flood Control, Drainage & Irrigation V.5 Other Structural Schemes V.6 Non-Structural Schemes
PSR VII	ENGINEERING VII.1 Earthworks and Embankments VII.2 Flood Control Structures VII.3 Topographic Survey VII.4 Engineering Costs
PSR VIII	DEVELOPMENT OPTIONS VIII.1 Compartments/Embankments/Structures VIII.2 Flood Proofing VIII.3 Improved Drainage VIII.4 Fishery Initiatives VIII.5 Other Initiatives
PSR IX	PLANNING UNITS IX.1 Derivation of Planning Units IX.2 PU Characteristics and Options
PSR X	ECONOMICS AND BENEFIT ASSESSMENT X.1 Agro-economics X.2 Benefit Assessment X.3 Multi-Criteria Analysis X.4 Macro-Economics
PSR XI	INSTITUTIONS XI.1 General XI.2 Requirements

CHAPTER 2

STUDY AREA - OVERVIEW

2.1 General

2.1.1 Location

The North Central Region covers an area of 12,000 sq.km., bounded by the Jamuna River in the west, the Padma and Meghna rivers in the south and the Old Brahmaputra and Lakhya rivers in the north and east. Figure 1.1.1 shows the Project Area of the North Central Regional Study and its location within Bangladesh.

2.1.2 Physical Features

The area is a low-lying one with elevations varying from +4m in the south to +18m in the north (Public Works Datum). The single notable physical feature of relief is the Madhupur Tract, an area of uplifted old alluvium, some 30 km. wide, which divides the North Central region in a north-south direction, approximately in the centre, with elevations from 7 to 10 metres above the adjacent flood plain.

While the Region is one of generally low relief, the micro-topography shows considerable variation through such man-made features as embanked roadways, railway embankments, raised house lot plots. These modifications to the natural topography influence the natural flooding and drainage characteristics of the region.

2.2 Land Resources

2.2.1 Agro-ecological Zones

The **agro-ecological Zones** (see Figure 2.2.1), in which the North Central Region (NCR) is located can be divided in two distinct areas.

- i). The Madhupur Tract (AEZ 28), an old alluvium outcrop situated in the centre of the NCR, raised about 1-5 meter above the floodplain. The Madhupur Tract is closely dissected by valleys with some level upland areas.
- ii). The floodplain areas consisting of a pattern of recent alluvium river plains of the main rivers surrounding the NCR:
 - the Jamuna Floodplain, both active (AEZ.7) and Young (AEZ.8), which are occur in the Northern Western and Southern areas.

NORTH CENTRAL REGIONAL STUDY (FAP-3) AGRO - ECOLOGICAL ZONES

A. Stable Flood Plain

1. Ridges

A1 Predominantly High / Medium Highlands
Inundation land type: F0 to F1
Predominantly Texture family: loamy
Agroecological regions and sub regions:
Ridges in 8a, 8b, 8c, 8d, 9a, 9b, 9c, 9d, 9e, 12b, 16, 19f

2. Basins Predominantly Medium Highlands to Medium Lowlands

A2a Medium High and Medium Lowlands
Predominantly Inundation land types: F1 to F2
Predominantly Texture family: loamy to clayey
Agroecological regions and sub regions:
Basins in 8a, 8b, 8c, 9b, 19g

A2b Medium High to Lowlands
Predominantly inundation land types F2 to F3
Predominantly Texture family: clayey and loamy
Agroecological regions and sub regions:
Basins in 8d, 9c, 9d, 9e, 12b, 16, 19f

A2c Predominantly low lands
Predominantly Inundation land types F2 to F4
Predominantly Texture family: clayey
Agroecological regions and sub regions:
15

3. Basins Depressions

A3 Predominantly Medium and low lands
Predominantly Inundation land types F2 to F4
Predominantly Texture family: clayey
Agroecological regions and sub regions:
Basins Depressions in 8a, 8b, 8c, 8d, 9a, 9b, 9c, 9d, 9e, 12b, 15, 16, 19f, 19c

B. Active Flood Plain

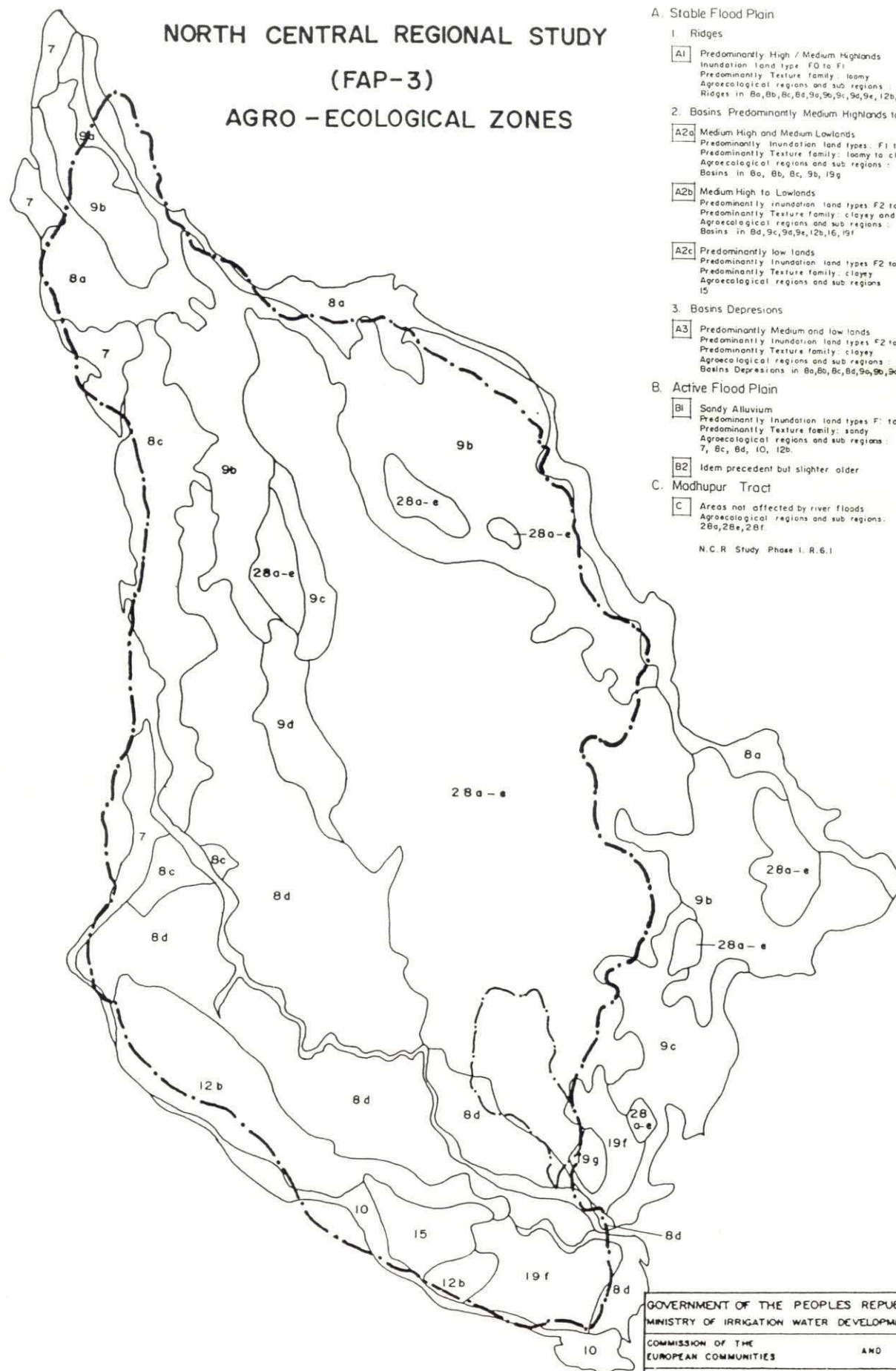
B1 Sandy Alluvium
Predominantly Inundation land types F1 to F3
Predominantly Texture family: sandy
Agroecological regions and sub regions:
7, 8c, 8d, 10, 12b

B2 Idem precedent but slighter older

C. Madhupur Tract

C Areas not affected by river floods
Agroecological regions and sub regions:
28a, 28e, 28f

N.C.R. Study Phase I. R.6.1



GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL

COMMISSION OF THE EUROPEAN COMMUNITIES AND GOVERNMENT OF FRANCE

NORTH CENTRAL REGIONAL STUDY
FAP - 3, PHASE - 2

AGRO-ECOLOGICAL ZONES

ICRISAT CONSORTIUM
SCEM
CNR
EUROCONSULT
MOTT MACDONALD INT.
BATEC

IN ASSOCIATION WITH
DESH UPDESH LTD.
BETS

SCALE 1:250,000

DATE 10th August 1991

A

- the Old Brahmaputra Floodplain, (AEZ.9) which occur in the Northern and Eastern areas with a small area bordering the Western side of the Madhupur Tract.

- the Old Ganges River Floodplain, the Old Meghna testuarine Floodplain and the Padma Floodplain covering small areas in the South.

The Floodplains have a very gently undulating relief comprising broad and narrow ridges and depressions. Differences in elevation between adjoining sides and depressions range from 1-3 metres.

2.2.2 Soils

The Region's soils often occur in complex patterns, most valleys probably have at least 5 different soil series within their boundaries. Further more, most soil series are divided into two or more soil phases, different soil depth phases and different depth of flooding phases, and a considerable variability in soil fertility.

Floodplain Soils comprise a pattern of sandy to loamy soils in the higher parts of the floodplain ridges grading into clay in adjoining basins. Southern floodplain are more clayey. (Table 2.1). With the exception of the higher ridges most of the floodplains are inundated by accumulated rainwater in June, July and by additional silty river water near the rivers in August, September. Permeability is good in the sandy and loamy ridge soils, not puddled for transplanted rice crops. Basin soils have a low permeability (see Table 2.2).

The moisture retention capacity is moderate in most loamy soils, low in sandy and clayey soils and in most soils is puddled for transplanted rice. Some basin and deep silty soils are kept wet during all or most of the dry season by capillary rise of moisture. Iron toxicity may occur in these soils. Organic matter content is generally low. Most soils are slightly acid to neutral in reaction with a moderate acidity in the Old Brahmaputra Floodplain.

Floodplain are generally classified as good agricultural land.

The **Madhupur Tract Soils** are underlain by Madhupur clay with differences in depth, drainage and degrees of weathering. Most soils, both deep and shallow, are well to moderately well drained. They are strongly acid, low in organic matter and have a low moisture retention capacity. Fertility is variable, most moderate to low. Iron toxicity may occur in valleys which stay wet during all or most of the dry season.

The Madhupur Tract can be classified as moderate agricultural land, except the shallow red and brown soils which have a low potential for both agriculture as well as forestry.

Zinc and sulphur deficiencies are reported to be increasing in both floodplain and Madhupur Tract soils. Active Floodplains are prone to river bank erosion along the main rivers and their distributaries.

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TABLE 2.1
Proportions (%) of depth-of-flooding land types and soil textural families in
Agroecological zones

Region/ Subregion	Depth-of-Flooding land type				Settlement +Water	Soil Textural family		
	F0	F1	F2	F3		Sandy	Loamy	Clayey
7	13	29	20	8	30	19	51	1
8a	27	37	26	1	9	10	77	4
8b	35	32	14	2	16	4	72	8
8c	34	44	9	2	11	1	82	6
8d	19	28	22	19	12	5	61	21
9a	76	11	3	0	10	6	81	3
9b	33	38	16	3	10	1	46	42
9c	25	35	25	5	10	0	42	48
9d	26	25	31	9	9	0	37	54
9e	10	15	31	34	10	1	31	58
10	20	25	18	4	33	5	54	8
12b	16	17	36	18	11	1	37	53
15	0	0	13	73	14	0	7	79
19f	11	21	29	22	17	5	49	29
28a-c	62	11	8	9	10	0	12	78
28f	43	29	3	5	20	0	14	66

The settlement + water column is common to both the depth-of-flooding land type table and the soil textural family table.

F0 includes Highland (above normal flood level) and Medium Highland flooded up to 30cm.

F1 includes Medium Highland flooded up to 30-90 cm.

F2 includes Medium Lowland flooded up to 90-180 cm.

F3 includes Lowland flooded up to >180 cm.

Texture is that of the subsoil, approximately the layer between 20-50 cm.

Sandy includes sands and loamy sands.

Loamy includes textures between sandy loam and silty clay loam.

Clayey includes sandy clays, silty clays and clays.

Source : NCRS 1990

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TABLE 2.2
Proportions (%) of inundation categories and permeability of soils in the NCR

District	F0		F1		F2		F3	Settlement + Water	Total	
	P	I	P	I	P	I	I		P	I
Dhaka	14.0	4.0	7.2	12.9	1.9	10.9	25.7	23.4	23.1	53.5
Gazipur	43.1	8.4	12.9	4.7	0.3	8.3	12.7	9.6	56.3	34.1
Manikganj	8.8	3.4	9.0	15.7	2.3	26.6	19.4	14.8	20.1	65.1
Munshiganj	8.0	0.8	10.0	5.6	7.0	12.4	39.6	16.6	25.1	58.4
Narayanganj	16.9	0.8	11.6	10.5	3.4	11.8	31.2	13.8	31.9	54.3
Jamalpur	19.2	3.5	27.0	22.6	8.9	8.9	0.3	9.6	55.1	35.3
Mymensingh	32.4	5.8	22.5	18.5	1.0	11.3	3.6	4.9	55.9	39.2
Tangail	23.0	2.7	21.6	15.5	2.8	14.9	6.8	12.9	47.4	39.7
Total NCR	23.0	4.1	17.1	14.2	3.1	13.2	12.8	12.5	43.2	44.3

FO-F3 Depth of flooding land type see Table 2.1

P Permeable

I Impermeable

Source : MPO, 1990

2 Authenticity

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2.2.3 Flood Categories

Following the Soil Resources Development Institute and Soil Data Processing System the net cultivated area (NCA) is classified according to depth of flood in a normal year as follows :

- F0 = Highland with no inundation or inundation less the 30 cm.
- F1 = Medium highland, shallowly inundated from 30-90 cm.
- F2 = Medium low-land, inundated from 90-180 cm.
- F3 = Low land, flooded from 180-270 cm.

For the NCA of the North Central Region 31% is estimated as F0, 36% as F1 19% as F2 and 14% as F3 (settlements and water bodies are not included in these percentages) These classifications are according to crop suitability and not based on actual measured flood depths.

2.3 Water Resources

2.3.1 Climate

The climate of the area is tropical monsoon, with average annual rainfall varying from 1400 mm in the Tangail, (south-west), region to 2200 mm in the Mymensingh, (north-east), region. The northeast monsoon defines a generally dry and cool period from November to February, with temperatures ranging between 12°C and 28°C and rainfall amounts only 2-3% of the annual total.

The sub-seasonal period from March to May is characterised by convective rainfall which yields some 20-25% of the annual total, temperatures rising to a maximum of 40°C and a significant increase in humidity results.

The south-west monsoon winds usually begin in June and last through to October. It is this period which is characterised by the heavy, persistent rains of the year.

2.3.2 Surface Water

The river system of the region is complex and has been the subject of particular study. The detailed analysis is to be presented in PSR II, and a summary is given in Chapter 3 below.

Although there is an extensive river network in the Region the base flows in the interior rivers are small in the dry season and thus the availability of surface water for irrigation is limited, see numbers of UP's in Table 2.3.

There is the possibility of large scale surface irrigation water being supplied from the major rivers. However, the benefit:cost of such schemes is generally low compared with irrigation from groundwater, where there is adequate groundwater supplies (see below).

2.3.3 Groundwater

The NCR area is covered by weakly consolidated alluvial sediments of the Meghna, Ganges and Brahmaputra river system. The main physiographic units consist of flood plains of the Old Brahmaputra, Jamuna and Meghna rivers surrounding the central elevated Madhupur Tract. Over most of the area, a four layer multi-aquifer system is recognized which consists broadly of:

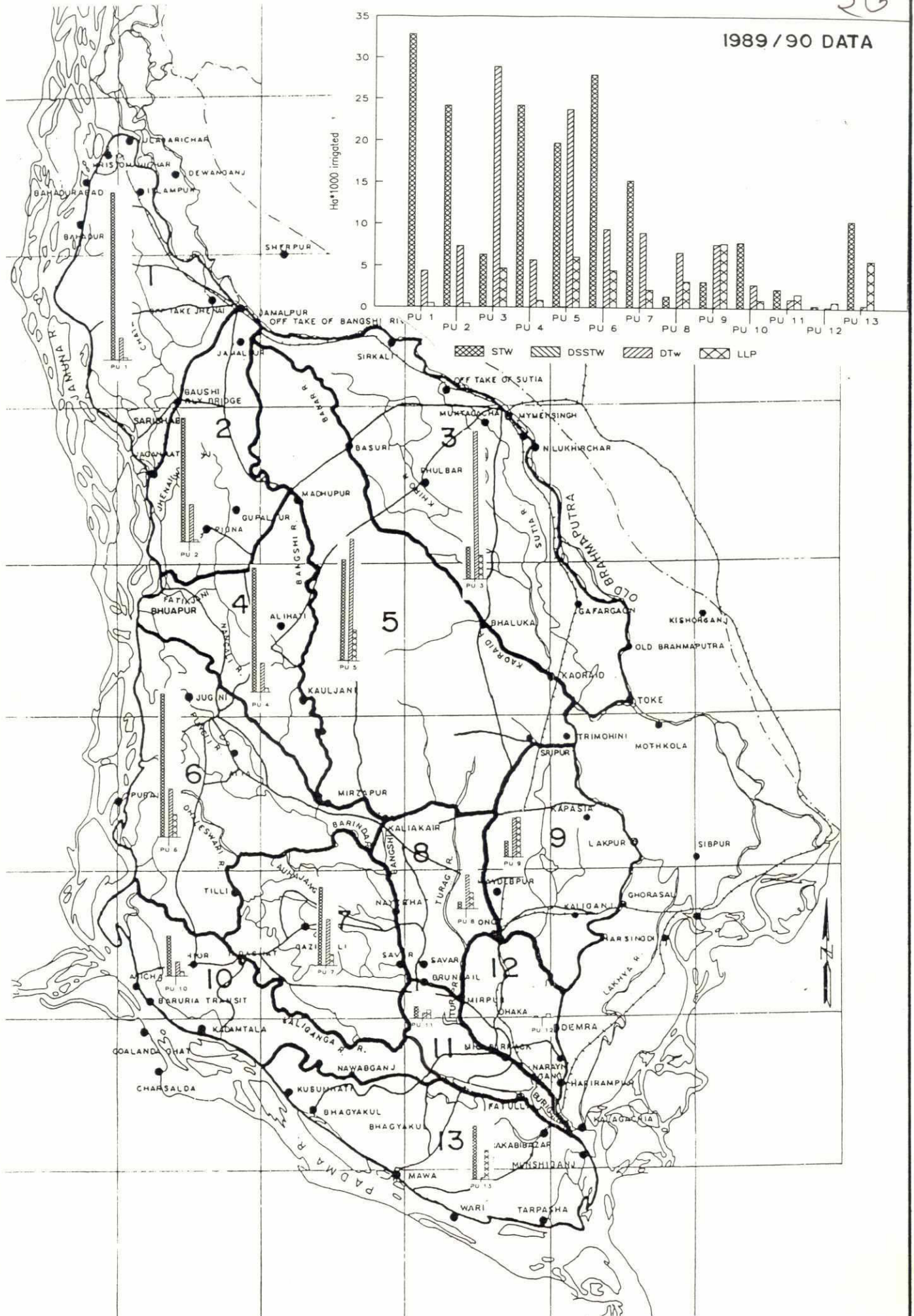
- Layer 1 : Upper clay or silty clay layer
- Layer 2 : Intermediate fine sand aquifer
- Layer 3 : Lower semiconfining clay layer
- Layer 4 : Main medium to coarse grained aquifer

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TABLE 2.3
Irrigated Areas by Planning Units & Equipment Type

	Unit	PLANNING UNITS												
		PU 1	PU 2	PU 3	PU 4	PU 5	PU 6	PU 7	PU 8	PU 9	PU 10	PU 11	PU 12	PU 13
LAND AREAS														
Gross	km2	894	740	1724	762	2125	1144	901	420	770	672	250	80	1015
F0-F3 Land	%	91.7	91.1	89.8	91.4	93.8	89.7	92.1	92.1	89.0	83.8	78.6	67.0	82.2
WATER DEMAND														
Irrigation (80% F0-F3)	mm	459	456	449	457	469	448	460	461	445	419	393	335	411
Potable Reserve	mm	25	27	27	19	18	28	31	25	27	25	62	68	34
AVERAGE AQUIFER CONDITIONS														
Storage Coefficient	%	12.4	9.1	1.8	10.4	3.5	9.4	7.1	3.2	1.2	6.2	4.9	2.4	3.9
DTW Specific Capacity	l/s/m	17.4	14.1	6.5	11.2	7.1	12.8	10.4	6.0	5.6	12.5	7.9	9.1	10.5
Maximum SWL	m	6.5	6.9	11.8	7.1	10.4	7.5	7.6	11.3	11.9	7.4	6.0	3.7	5.8
Seasonal Fluctuation	m	1.9	2.6	7.9	2.4	5.4	2.4	2.4	4.7	6.1	1.6	1.2	1.4	1.6
GROUNDWATER RESOURCES														
Useable Recharge NFP	mm	663	563	496	587	486	650	690	558	583	921	915	880	1282
Useable Recharge PFP	mm	628	535	485	543	476	597	641	542	557	839	871	813	1224
Groundwater Potential NFP														
STW	mm	597	458	134	452	159	410	274	141	75	202	166	166	182
DSSTW	mm	661	524	180	556	226	578	449	221	106	348	288	226	280
DTW	mm	663	563	281	587	328	647	682	433	187	680	634	500	549
Groundwater Potential PFP														
STW	mm	574	442	134	447	159	410	274	141	75	202	166	166	182
DSSTW	mm	628	504	180	522	225	549	449	221	106	348	288	226	280
DTW	mm	628	535	281	543	322	594	633	420	187	641	631	500	546
PRESENT MINOR IRRIGATION														
STW	Ha*1000	32.9	24.2	6.3	24.2	19.7	28.0	15.2	1.4	3.2	7.9	2.3	0.3	10.5
DSSTW	Ha*1000	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
DTW	Ha*1000	4.4	7.4	28.9	5.7	23.7	9.4	9.0	6.7	7.6	2.9	1.1	0.2	0.4
LLP	Ha*1000	0.5	0.4	4.7	0.9	6.1	4.5	2.2	3.2	7.8	1.0	1.7	0.8	5.8
Total Groundwater	Ha*1000	37.3	31.6	35.3	30.0	43.6	37.4	24.3	8.1	10.9	10.7	3.4	0.5	10.9
Total All	Ha*1000	37.7	32.0	40.0	30.8	49.7	41.9	26.5	11.3	18.7	11.7	5.2	1.3	16.6
STW	mm	247	229	21	204	57	152	102	21	22	72	59	29	61
DSSTW	mm	0	0	0	0	0	0	0	1	0	0	0	0	0
DTW	mm	28	58	113	46	72	52	59	100	62	29	20	8	2
LLP	mm	3	3	17	9	19	21	13	48	69	8	43	57	35
Total Groundwater	mm	275	287	134	250	129	204	161	122	84	101	79	37	63
Total All Types	mm	278	290	151	259	148	225	174	170	153	109	122	94	98

1989/90 DATA



The clay layers may be thin or absent in the Jamuna and Brahmaputra flood plain areas, and are particularly thick on the Madhupur Tract.

Table 2.4

Growth of STW Numbers for North Central Region 1988/1989

District	1988	1989	Percentage Growth
Manikganj	2,175	3,755	38%
Dhaka	2,118	2,798	32%
Munshiganj	832	1,431	72%
Gazipur	598	790	32%
Tangail	14,695	17,994	22%
Jamalpur	8,086	9,475	17%
Mymensingh	3,785	4,438	17%
Total	32,829	40,681	24%

The aquifers of the study area have been extensively developed for irrigation by shallow tubewells (STW) and deep tubewells (DTW) over a period of some 20 years. Deep tubewells are concentrated in the Madhupur Tract, while shallow tubewells predominate elsewhere. Most of the deep tubewells have been installed by BADC; The IDA Deep Tubewell Project has recently completed the sinking of 4000, two cusec deep tubewells in the Mymensingh, Dhaka, Gazipur and Manikganj districts.

The groundwater related study has assessed the impact of flood control on groundwater resources and prepared a groundwater development plan which integrates possible flood control and drainage measures proposed for the North Central Region.

The groundwater investigations are to be presented in PSR II.4, a summary of some of the findings is given below:-

It should be noted that special conditions apply to the urbanised areas of Dhaka and Tongi where groundwater recharge is reduced and intensive abstractions for public and industrial water supplies are occurring. Detailed studies and groundwater modelling have been conducted in this region for Dhaka WASA.

Patterns of Groundwater Development

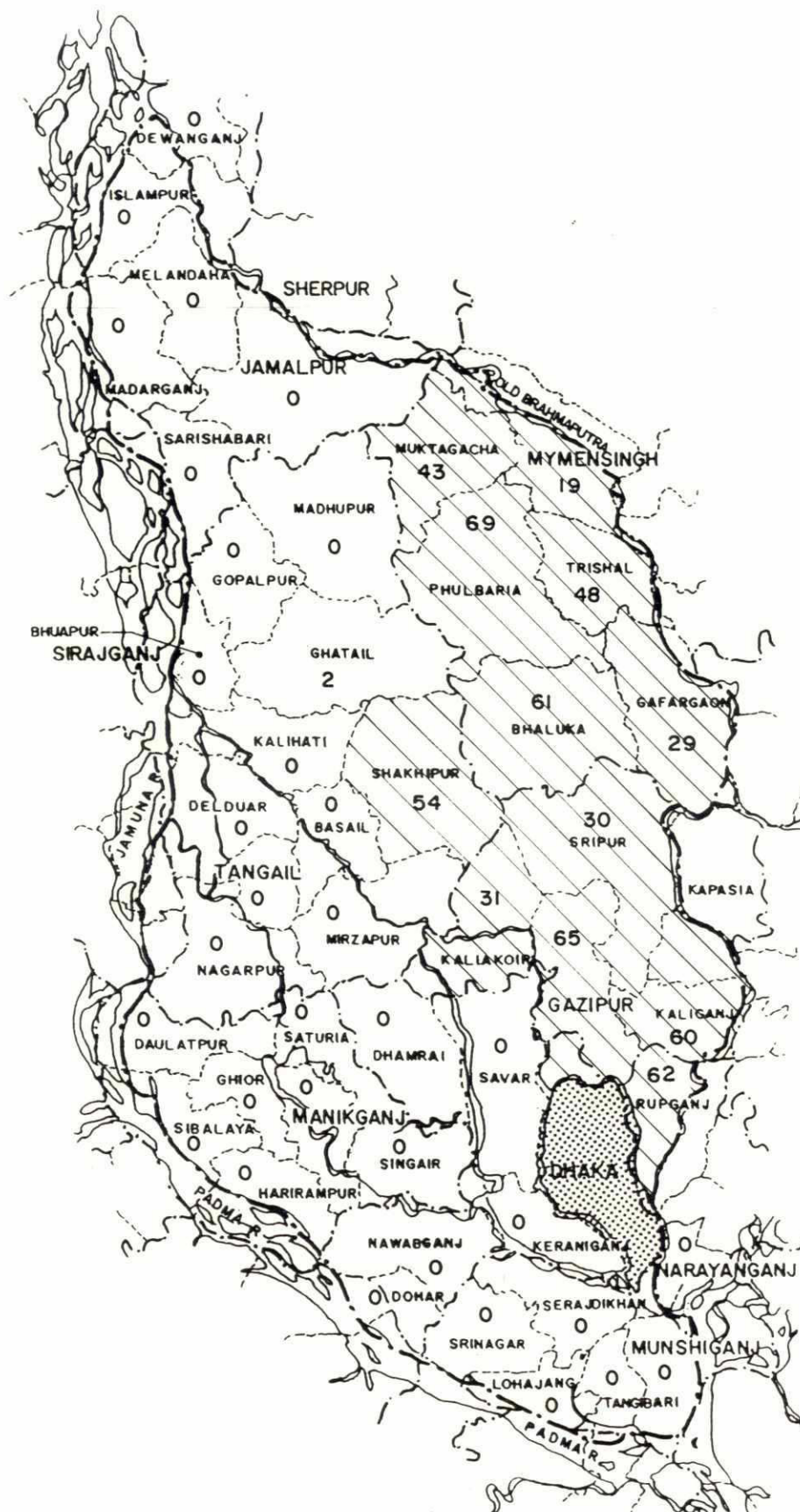
Details of estimated irrigated areas and abstractions for the 1991 irrigation season for the 13 PUs in the study area are summarized in Table 2.3. The area irrigated by equipment type per PU is given in Figure 2.3.1. The growth of STW numbers in 1988 and 1989 is given in Table 7.4. Further details relating to MPO statistics and planning constraint are detailed in PSR II.4

The highest concentrations of STWs occur in Tangail, Jamalpur, Dhaka and Manikganj districts where groundwater levels are shallow and aquifer conditions are favourable. Numbers are limited in the Madhupur Tract. Unlike northwest Bangladesh, deep setting of shallow tubewells (DSSTWs), has never been significant in the North Central Region.

GROUND WATER CONSTRAINTS



AREAS OF POTENTIAL FUTURE
GROUNDWATER DEFICIT.



LEGEND

30 - % OF IRRIGATION DEMAND
NOT IRRIGABLE BY GROUND WATER.

IRRIGATION DEMAND FOR 80%
FO - F3 LAND WITH USEABLE
UNCHANGE LIMITS

PROJECT BOUNDARY

DISTRICT BOUNDARY

UPAZILA BOUNDARY

NOTE :

FULL FLOOD PROTECTION ONLY HAS
A NEGLIGIBLE AFFECT ON THE
FUTURE GROUND WATER DEFICIT
SHOWN IN FIGURES.

DTWs are most concentrated in the Madhupur Tract and peripheral areas where conditions are not generally suitable for shallow tubewells due to deep water levels and poorer aquifers.

Deep and shallow tubewells are very much the dominant mode of irrigation everywhere in the study area except Munshiganj, where low lift pumps are the primary method.

Computer simulation of groundwater recharge based on software developed for the MPO has been used to assess the effects of flood control measures on groundwater recharge.

For the reassessment of groundwater recharge after flood protection, the simulation model was run with a modified MPO synthesized flood hydrograph. The results of the recharge modelling for each of three flood protection cases calculated (full, partial and no flood protection) show that there are adequate groundwater resources to cater for the MPO's anticipated future growth in irrigation demand even in the full flood protection case.

The only area that shows potential future groundwater deficit is the eastern part of the region (see Figure 2.3.2). This area receives little flood waters at present from external river sources and is predominantly on Madhupur tract.

Potential recharge with no flood protection ranges from a minimum of 500-600mm per annum in the Madhupur Tract to over 2000mm in areas south and west of Dhaka which are subject to prolonged deep flooding.

For the full flood protection case, groundwater recharge becomes dependent on infiltration from rainfall and areas of permanent open water. Recharge is substantially reduced in most areas. Large reductions exceeding 50% appear likely in areas which are presently subject to prolonged flooding such as Munshiganj. In Madhupur Tract areas where flooding is not normally widespread (except temporary and localised) reductions of typically 10 to 15% are indicated.

For the partial flood protection case, only small reductions in potential recharge are indicated, ranging up to 10% in areas where flooding is currently widespread, and less than 5% in the Madhupur Tract.

2.4 Human Resources

2.4.1 General

The full socio-economic statistics will be presented in Preliminary Supporting Report IV and will include the following analyses:-

- population study (characteristics and forecasts)
- labour force description
- land ownership and land tenancy system
- peoples' response to floods
- social impact of potential project schemes
- social constraints
- social economic indicators

These analyses will utilise:-

- published data
- secondary data
- studies conducted by International and local organisations
- field enquiries and survey

At this stage only some preliminary data are presented. These are based on Planning Unit boundaries, see Chapter 5, and help to give a general picture of the socio-economic characteristics of the Region, see Tables 2.5 to 2.8 and description below

2.4.2 Population and household data

The population of the region has been shown by PUs and estimated for 1991 (Table 2.4.1). The data is based on the 1981 census and updated using alternative annual growth rates of 1.86% and 2.17%.

The number of households has been calculated, again using alternative assumptions of 5.7 average household size (1981 census figure for NCR) or 5.2 average household size (preliminary 1991 census figure for NCR), see Table 2.5,

Densities of population are also shown in Table 2.5 for each PU. However average density of population per PU does not reflect the distribution of population and thus Union information has been presented in Table 2.6 and on the PU Figures given in Chapter 5.

Mauzas with a population of more than 10 000 inhabitants are significant in that they form potential growth centres. These have been identified in the PU population maps (See Chapter 5) and the number of such mauzas per PU is listed in Table 2.7

Table 2.8 gives the distribution of different types of households by Planning Unit. This table has been derived from official statistics and converts to PU basis (the methodology is to be explained in PSR IV).

TABLE 2.5

Estimated Population of Planning Unit in 1991.

(Ratio calculated in percentage of percentage of upazila included in Planning Unit)

Planning Unit Number	Area [1985]		Estimated Population 1981 (Census '81)				Estimated Population 1991 [AGR=1.86%] [Average size of H/H = 5.2]				Estimated Population 1991 [AGR=2.17%] [Average size of H/H = 5.2]			
	(in km ²)	%	No.	%	Density persons/km ²	Number	Density persons/km ²	No. of Household	Number	Density persons/km ²	No. of Household	Number	Density persons/km ²	No. of Household
1	2	3	4	5	6	7	8	9	10	11	12			
1	893.52	7.54	737,706	5.80	826	886,993	993	170,576	914,360	1,023	175,838			
2	739.63	6.24	604,558	4.75	817	726,900	983	139,788	749,328	1,013	144,102			
3	1723.91	14.55	1,486,749	11.68	862	1,787,617	1,037	343,772	1,842,772	1,069	354,379			
4	761.71	6.43	589,207	4.63	774	708,443	930	136,239	730,301	959	140,442			
5	2124.66	17.94	1,139,598	8.96	536	1,370,214	645	263,503	1,412,491	665	271,633			
6	1143.93	9.66	1,006,383	7.91	880	1,210,041	1,058	232,700	1,247,376	1,090	239,880			
7	900.91	7.61	831,126	6.53	923	999,318	1,109	192,176	1,030,151	1,143	198,106			
8	460.66	3.89	391,729	3.08	850	471,002	1,022	90,577	485,534	1,054	93,372			
9	789.36	6.66	661,348	5.20	838	795,182	1,007	152,920	819,717	1,038	157,638			
10	671.88	5.67	514,328	4.04	766	618,411	920	118,925	637,491	949	122,594			
11	249.86	2.11	437,568	3.44	1,751	526,117	2,106	101,176	542,350	2,171	104,298			
12	369.71	3.12	3,195,129	25.11	8,642	3,841,715	10,391	738,791	3,960,248	10,712	761,586			
13	1014.86	8.57	1,129,512	8.88	1,113	1,358,087	1,338	261,171	1,399,990	1,379	269,229			
N.C.R	11844.60	100.00	12,724,941	100.00	1,074	15,300,038	1,292	2,942,315	15,772,107	1,332	3,033,097			

Note :

Percentage in column 3 is calculated on the basis of total area of NCR (bottom of column 2).

Percentage in column 5 is calculated on the basis of total area of NCR (bottom of column 4).

Source : Bangladesh Population Census 1981, BBS(GOB).

Source file : C:\JUNTER\MITAB-2-3.WK1

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TABLE 2.6
Density of Population in Planning Unit per Upazila.
(per km² population 1981)

Planning Unit	District	Upazila	Density of Population		
			Average	Lowest	Highest
1	Jamalpur	Dewanganj	730.3	457.8	1230.8
		Islampur	734.7	411.0	1148.2
		Jamalpur	931.9	835.3	1028.5
		Madarganj	765.4	521.8	954.0
		Melandah	906.8	748.4	1235.1
		Sarishabari	900.0	740.7	1215.4
			828.2	411.0	1235.1
2	Jamalpur	Sarishabari	900.6	740.7	1013.8
		Jamalpur	828.3	740.1	1009.5
	Tangail	Bhuapur	629.8	339.3	929.1
		Ghatail	1016.9	988.7	1043.1
		Gopalpur	1006.0	847.7	1565.1
		Madhupur	892.0	728.2	1134.6
		878.9	339.3	1565.1	
3	Jamalpur Mymensingh	Jamalpur	899.1	779.6	1117.8
		Bhaluka	602.4	574.1	644.9
		Fulbaria	702.3	395.9	1000.7
		Gaffargaon	878.6	644.5	1347.4
		Muktagacha	797.5	535.0	1015.0
		Mymensingh	857.6	643.2	1628.5
		Trishal	860.8	682.8	964.0
		799.8	395.9	1628.5	
4	Tangail	Basail	888.2	738.8	1056.0
		Bhuapur	900.3	441.1	1201.8
		Ghatail	788.8	378.3	993.4
		Kalihati	974.6	611.7	1492.2
		Mirzapur	781.6		
		866.7	378.3	1492.2	
5	Gazipur	Joydevpur	453.4	302.8	506.9
		Kaliakair	418.3	330.7	720.7
		Sripur	495.2	668.4	779.1
	Jamalpur Mymensingh	Jamalpur	735.9	385.0	574.1
		Bhaluka	456.1	395.9	572.8
		Fulbaria	483.7	535.0	763.8
		Muktagacha	632.8	372.4	401.7
	Tangail	Ghatail	387.1	306.6	931.6
		Madhupur	639.0	480.4	601.9
		Mirzapur	1082.3	327.1	502.7
		Sakhipur	420.7		
			564.0	302.8	931.6
6	Gazipur	Kaliakair	907.3	901.8	912.8
		Daulatpur	827.9	771.0	875.5
		Ghior	832.9	759.6	902.0
	Tangail	Saturia	939.6	815.7	1063.4
		Basail	1006.8	924.3	1087.0
		Delduar	881.1	765.2	1075.5
		Kalihati	944.2	611.7	1141.4
		Mirzapur	980.9	839.7	1301.1
		Nagarpur	880.6	667.0	1038.2
		Tangail	960.3	604.0	1533.3
		916.2	604.0	1533.3	

Planning Unit	District	Upazila	Density of Population		
			Average	Lowest	Highest
7	Dhaka	Dhamrai	918.4	706.7	2101.6
		Savar	874.8		
		Kaliakair	863.1	813.5	912.8
		Ghior	973.4		
		Manikganj	971.2	826.9	1219.2
		Saturia	995.9	775.1	1286.3
8	Gazipur	Singair	1095.4	632.5	1693.3
			956.0	632.5	2101.6
	Dhaka	Savar	978.6	528.4	1752.5
		Joydevpur	623.9	453.4	932.5
		Kaliakair	674.8	408.8	1147.4
		Tongi	Urban area + Cantonment (SMA)		
9	Gazipur		759.1	408.8	1752.5
		Joydevpur	782.8	453.4	1314.1
		Tongi	Urban area + Cantonment (SMA)		
		Kaliganj	1023.5	638.8	2113.2
		Rupganj	925.5	701.0	1010.0
		Kapasia	659.0	559.8	720.5
10	Dhaka	Sripur	440.0	354.4	482.1
			766.2	354.4	2113.2
	Manikganj	Nawabganj	998.0	673.3	1442.5
		Daulatpur	673.0	531.1	875.5
		Ghior	844.8	749.0	973.4
		Harirampur	963.6	802.9	1245.9
		Shibalaya	687.1	491.9	946.4
11	Dhaka	Manikganj	858.3	765.1	971.0
			837.5	491.9	1442.5
	Keraniganj		1456.8	1074.7	2892.5
		Savar	1267.7	922.5	1547.0
			1362.3	922.5	2892.5
	Dhaka SMA				
12	Dhaka				
		Dohar	1286.4	320.3	2170.0
		Nawabganj	1312.0	859.9	2350.0
		Harirampur	846.8		
		Lohaganj	1305.2	873.1	1946.5
		Munshiganj	2393.4	702.4	7961.3
		Sirajdikhan	1158.2	803.1	2002.9
		Sreenagar	1176.6	653.3	1549.6
		Tongibari	1305.8	303.1	1775.0
			1348.1	303.1	7961.3

Source: CS 1991

TABLE 2.7

Mauzas with more than 10 000 per Planning Unit and District HQs.

Planning Unit	Nr. mauzas with population more than 10 000	District Headquarters		
		Name	Population	Nr. households
1	6	Jamulpur (adjacent)	91815	14456
2	1		91815	14456
3	11		98726	
4	1			
5	8			
6	1		84942	13659
7	1		37035	6611
8	1			
9	2			
10	2			
11	4	Narayaganj (adjacent)	246515	42218
12	1	Narayaganj	246515	42218
13	2			
	45			

Source: CS 1991

2.5 Agriculture

2.5.1 Cropping Systems

The agricultural situation in the North Central Region (NCR) has been described in the Reconnaissance Survey Phase-I (NCRS 1990) covering the period from 1985-86 to 1989-90 and in the Inception Report of the ongoing FAP-3 North Central Regional Study (NCRS 1991). In this Interim Report attention will be paid to the results of collection and assessment of data on the present agricultural situation and on new developments and expected changes in cropping patterns and farming systems in the study area.

In the floodplain of the NCR cropping patterns are to a great extent determined by the seasonal floods, i.e., the date when inundations start and end, the depths of inundation at peak levels and the risk of damage to crops due to early and late (flash) floods. Cropping systems and management practices are adapted to the local flood regimes and to the availability of irrigation water.

In most of the Madhupur Tract with permeable soils and limitations of droughtiness crop production is concentrated in the Kharif-I and Kharif-II season, except in areas where crops are irrigated.

With the introduction and rapid expansion of tubewell irrigation in the NCR, especially in the floodplain areas, and to a less extent in the Madhupur Tract, cropping patterns have changed, the use of HYV's increased and the rice production risen considerably.

In 1990-91 an estimated 829078 Ha of the study area has been cultivated, the so-called net cultivated area (NCA). This is 73% of the gross area. Out of this NCA 323835 Ha (39% of the NCA) has been irrigated. The total area planted to crops amounts to 1576347 Ha which is equivalent to a cropping intensity of 190%, ranging from 109% in planning unit No.1 to 218% in planning unit No.2. See Table 2.8. The main crop in the study area is rice. An estimated 1,070,625 Ha have been harvested, being 129% of the NCA or 68% of all crops planted. The total rice production is 2919617 tons of paddy (\pm 1,950,000 tons of rice).

TABLE 2.8

Distribution of Different Types of Households in the Different Planning Units of NCR 1983-84.

Planning Unit Number	Total Household No.	Landless			FARM HOUSEHOLDS										Non farm Household		Household with Cottage industry		Agricultural labour household	
		No.	%	4	Total		Small		Medium		Large		No.	%	No.	%	No.	%	No.	%
					No.	%	No.	%	No.	%	No.	%								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18			
1	124,997	65,254	52.20	87,274	69.82	63,362	72.60	20,477	23.46	3,435	3.94	37,723	30.18	5,211	4.17	53,475	42.78			
2	97,390	47,728	49.01	71,401	73.31	53,305	74.66	15,929	22.31	2,167	3.03	25,989	26.69	4,334	4.45	39,426	40.48			
3	251,593	123,015	48.89	179,555	71.37	129,587	72.17	45,057	25.09	4,910	2.73	72,040	28.63	10,705	4.25	97,113	38.60			
4	96,069	44,019	45.82	73,184	76.18	53,813	73.53	17,005	23.24	2,366	3.23	22,884	23.82	10,986	11.44	35,384	36.83			
5	204,344	84,153	41.18	161,529	79.05	107,856	66.77	46,164	28.58	7,509	4.65	42,815	20.95	9,578	4.69	77,516	37.93			
6	152,352	72,647	47.68	116,769	76.64	84,586	72.44	28,488	24.40	3,696	3.16	35,583	23.36	14,259	9.36	55,193	36.23			
7	136,803	73,094	53.43	90,692	66.29	65,942	72.71	22,261	24.55	2,490	2.75	46,111	33.71	9,564	6.99	53,018	38.75			
8	50,805	26,317	51.80	33,940	66.80	24,034	70.81	8,480	24.98	1,427	4.20	16,865	33.20	2,486	4.89	16,873	33.21			
9	102,960	50,910	49.45	79,014	76.74	59,301	75.05	17,514	22.17	2,199	2.78	23,945	23.26	8,954	8.70	32,746	31.81			
10	85,291	48,901	57.33	56,616	66.38	40,226	71.05	14,119	24.94	2,271	4.01	28,675	33.62	6,756	7.92	33,516	39.30			
11	69,363	51,696	74.53	27,689	39.92	22,772	82.24	4,445	16.05	472	1.71	41,674	60.08	4,927	7.10	15,270	22.01			
12	26,171	18,071	69.05	10,827	41.37	9,455	87.33	1,247	11.51	125	1.15	15,344	58.63	2,170	8.29	5,085	19.43			
13	182,660	118,973	65.13	114,132	62.48	94,079	82.43	17,705	15.51	2,349	2.06	68,527	37.52	15,113	8.27	61,266	33.54			
N.C.R.	1,580,796	824,776	52.17	1,102,622	69.75	808,317	73.31	258,889	23.48	35,415	3.21	478,176	30.25	105,044	6.64	575,880	36.43			

Note : Percentages in columns 4, 6, 14, 16 and 18 are calculated on the basis of column 2.

Percentages in columns 8, 10 and 12 are calculated on the basis of column 5.

Source : Bangladesh Census of Agriculture and Livestock 1983-84, vol.1, Table 4.1 and 4.2, BBS(GOB).



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Table 2.9 gives the areas and production of the different local and HYV's of rice in the three growing seasons :

- a) Kharif-I, the transition period between
- b) The Rainy Season Kharif-II, and
- c) The Winter Season, the so-called Rabi Season.

The table shows that 47% of the total rice production is produced during the rabi season, occupying an area of 41% of the NCA, that 58% of the NCA is planted to rice during the rainy season (flood season) of which 21% is planted to Deep Water Aman (D.W.Aman) and 37% in areas which are flood free or only shallowly flooded. The most productive crop, the HYV Boro planted to 30% of the total rice area has been producing 46% of the total rice production, 51% of the total area has been planted to HYV's producing 72% of the total production.

In the 1990-91 season the area planted to boro rice decreased after a steady rise of $\pm 35\%$ since 1987. The area planted to aus rice on the contrary showed some increase after a downward trend since 1987:-

Year	Boro	Aus
1986-87	100%	100%
1987-88	111%	92%
1988-89	127%	87%
1989-90	135%	73%
1990-91	125%	83%

A possible reason for this development might be the increase of fuel prices at the end of 1990 and the fear for scarcity of fuel during the Gulf crises. Farmers in the 1990-91 season might have decided to shift to the so-called braus, planted as late HYV boro or early aus at the beginning of March. By doing so they saved on fuel costs for irrigation before the onset of the rains. The fallow period after boro rice in the mid-Kharif I season, which has only a few crop options is then shifted to the rabi season, offering possibilities to grow a third crop as pulses, oil seeds or vegetables after the aman crop. If this new development in cropping pattern gives a better economic result it is likely that the decrease in the total area planted to boro will continue, especially in the highland (F0) and medium highland (F1) areas.

Another new development is the practice of transplanting deepwater aman, mainly in Tangail district (planning units 2,4 and 6). Usually deepwater aman is broadcast in March/April in deepflooded areas (F2 and F3). By transplanting seedlings of 45-60 days old in May/June farmers can grow a deepwater aman crop after harvesting of boro. No ploughing is practiced, due to the soft soil after irrigated Boro. Seedlings raised in seedbed or splits from established plants are used for this purpose. Tillering will be less compared with broadcasted aman, so farmers are planting closely with 2-3 transplants per hill. Only less deeply flooded areas are used for this practice. Deepwater aman varieties are photosensitive, so flowering of the broadcasted and the transplanted deepwater aman will be at the same period in the first weeks of November. There is no difference in yield between broadcasted and transplanted deepwater aman.

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TABLE 2.9
Estimated Land Utilization in the NCR According to Planning Units

Planning Unit	Gross Area	NCA	% of NCA	Irrigated Area	% NCA	Cropped Area	Cropping Intensity
1	89352	70009	78	39197	56	147524	211
2	73963	59850	83	36150	60	130715	218
3	172391	127979	75	40472	32	241622	189
4	76171	58420	76	29082	51	121066	207
5	212466	121318	57	42600	35	203803	168
6	114393	95880	86	40640	42	200550	209
7	90091	67238	73	23243	35	130690	194
8	46066	27192	59	12719	46	46620	171
9	78936	57757	73	22528	39	102304	177
10	67188	48255	72	13094	27	90540	188
11	24986	18564	67	5683	30	20480	109
13	101486	76616	76	18427	24	140433	183
Total	1147489	829078	73	323835	39	1576347	188

Note : Area in Hectare; Cropping Intensity in percentage

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TABLE 2.10
Crop area and production per Planning Unit (Hectares and Tons)

Planning Unit	B. Aman		Local T. Aman		HYV T. Aman		Local Aus		HYV Aus		Local Boro		HYV Boro		Total Rice	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
1	1015	1460	18775	37331	23118	74872	8249	11157	1129	2802	2329	6506	38689	220008	93305	354136
2	9309	15457	12605	24360	20994	66709	8294	11076	1346	3476	1124	2364	35689	125882	89362	249325
3	200	371	50005	102004	50453	174165	35148	53270	29612	96329	4349	9726	40508	167790	210276	603654
4	24194	25538	7256	15681	7823	29879	10698	13641	1320	3651	934	1340	29218	88009	81442	177740
5	2669	3363	30473	66206	40377	147706	33338	47801	11936	35771	3062	6260	39399	149572	161254	456679
6	40733	47794	6012	14323	2804	9940	26967	33301	3175	7565	774	1235	40787	136449	121253	250607
7	27471	34167	2170	4249	1714	6117	26906	24446	619	1242	621	1278	22801	107354	82302	178854
8	529	733	1611	2998	6093	20657	2515	3676	1583	5486	1371	2955	11583	53199	25285	89705
9	6492	13152	4052	7366	16512	54813	8886	17893	5830	20179	1575	3429	24458	103116	67804	219948
10	24784	29844	147	237	63	186	13482	12063	53	127	1111	2196	12268	61105	51907	105757
11	3438	5533	318	573	758	2496	1603	2909	282	806	373	713	5570	26284	12342	39314
12	2454	5176	261	419	930	3492	793	1099	468	1348	208	409	3050	12641	8164	24584
13	27422	33932	174	274	341	1185	15881	29542	836	2989	1844	3720	19431	97675	65929	169316
Total NCR	170710	216520	133859	276021	171980	592217	192760	261874	58189	181771	19675	42131	323451	1349084	1070625	2919619

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TABLE 2.11

Proportional Area and Production per Rice Crop in 1990-91

Rice Crop	% of NCA	% of total rice area		Total	% of total rice prod.		Total
		Loc. Var.	HYV		Loc. Var.	HYV	
Kharif-II							
B. Aman	21	16	0	16	8	0	8
Local T. Aman	16	13	0	13	10	0	10
HYV T. Aman	21	0	16	16	0	20	20
Sub-Total Kharif-II	58	29	16	45	18	20	38
Kharif-I							
Local Aus	23	18	0	18	9	0	9
HYV Aus	7	0	5	5	0	6	6
Sub-Total Kharif-I	30	18	5	23	9	6	15
Rabi							
Local Boro	2	2	0	2	1	0	1
HYV Boro	39	0	30	30	0	46	46
Sub-Total Rabi	41	2	30	32	1	46	47
Total NCR 1990-91	129	49	51	100	28	72	100

TABLE 2.12

Rice Crops Average Yield (tons/ha) in 1990/91

Planning Units	D. W. Aman	Local T. Aman	HYV T. Aman	Local Aus	HYV Aus	Local Boro	HYV Boro
1	1.44	1.99	3.24	1.35	2.48	2.79	4.96
2	1.14	1.93	3.24	1.34	2.58	2.10	3.44
3	1.85	2.04	3.45	1.52	3.25	2.24	4.14
4	1.04	2.16	3.75	1.28	2.77	1.43	3.01
5	1.17	2.17	3.65	1.43	3.00	2.04	3.53
6	1.17	2.38	3.54	1.23	2.38	1.59	3.23
7	1.24	1.96	3.57	0.91	2.01	2.06	4.71
8	1.39	1.86	3.39	1.46	3.47	2.15	4.59
9	2.03	1.82	3.32	2.01	3.46	2.18	4.22
10	1.20	1.61	2.96	0.89	2.38	1.98	4.98
11	1.61	1.80	3.29	1.81	2.85	1.91	4.72
12	2.11	1.61	3.76	1.39	2.88	1.96	4.14
13	1.24	1.58	3.48	1.86	3.58	2.02	5.03
Total NCR	1.24	2.06	3.45	1.36	3.12	2.14	4.01

TABLE 2.13

Other Crops Average Yield (Tons/Ha) in 1990/91

Planning Unit	Wheat	Jute	Potato	Sugar Cane	Pulses	Oil Seeds	Onion
1	2.20	1.60	14.90	76.50	0.90	0.50	6.00
2	1.90	1.70	13.50	51.30	0.80	0.80	7.80
3	1.80	1.60	10.30	45.20	0.60	0.70	6.20
4	1.90	1.70	12.90	59.40	0.80	0.70	8.10
5	1.90	1.50	11.60	50.10	0.80	0.80	7.20
6	1.90	1.40	11.60	54.60	0.80	0.80	7.50
7	1.80	1.40	12.70	55.60	0.90	0.50	3.90
8	2.10	1.60	14.00	49.90	0.80	0.70	6.50
9	1.50	1.80	12.40	48.20	0.70	0.70	11.40
10	1.70	1.40	16.20	33.50	0.90	0.60	3.90
11	1.90	1.60	25.40	41.00	0.80	0.70	6.50
12	1.40	1.60	23.80	44.10	0.70	0.90	10.90
13	1.50	1.50	29.90	44.30	0.90	0.80	5.10
Total NCR	1.90	1.60	24.10	55.40	0.80	0.70	5.40

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According to BRRI sources this transplanting practise started about 5 years ago. The rice-farming systems research section of BRRI started trials in 1990 in the vicinity of Mirzapur with transplanting deep water aman in areas flooded not deeper than 210 cm. Some of the trial plots have net enclosures and are stocked with fingerlings of carps. Last year 440 kg of fish has been harvested per Ha. Other results are not yet known.

Crops other than rice cover 61 % of the NCA, mostly planted during Kharif-I and Rabi seasons. The main crops are jute, wheat, oilseeds, vegetables, pulses, spices and sugarcane. The areas around Dhaka are known for the production of vegetables, potatoes and sugarcane for chewing purposes. Production of pineapples, bananas, papaya and jackfruit is locally important in areas of the Madhupur Tract (planning units 5,8 and 9) and in some parts of planning unit 3.

In the present cropping pattern as shown in Table 2.14 only some major crops are included and should not be regarded as a guideline or even an average of the existing cropping system. The number of crops which are cultivated in the NCR is more than 50. However, the predominance of the rice crops in all the existing cropping patterns is uniform. T.Aman crops are cultivated in the F0 and F1 flood categories where there is less risk of flooding in normal years, while deep water aman is only planted in F2 and F3 areas, Aus in the F0-F2 flood categories, and some mixed with D.W.Aman in F3 areas. Boro is only planted, when irrigation is available or in depressions following receding water.

Future cropping patterns (Table 2.15) with improved drainage and controlled floods can be expected to offer the following possibilities.

TABLE 2.14
PRESENT CROPPING PATTERNS

	F0 = Highland <30cm	F1 Medium Highland <30-90 cm	F2 = Medium Low land <90-180 cm	F3 = Low Land <180-270 cm
Single Cropped	Rainfed: T. Aman Aus Fruits Sugarcane Groundnut Irrigated: Boro-HYV	Rainfed : T. Aman Aus Jute Sugarcane Irrigated: Boro-HYV	Rainfed : D. W. Aman Aus B. Aman+Aus Millet Jute Irrigated: Boro-HYV	Rainfed : D. W. Aman Jute Millet Groundnut Rabi Crops Irrigated: Boro-HYV Boro-Local
Double Cropped	Rainfed: Aus/Jute-T. Aman Aus/Jute-Rabi Crops T. Aman-Rabi Crops Irrigated: Boro-T. Aman (HYV) (HYV)	Rainfed : Aus/Jute-T. Aman Jute/Aus-Rabi Crops T. Aman-Rabi Crops Irrigated: Boro-T. Aman (HYV) (HYV)	Rainfed : Aus/Jute-Rabi Crops D. W. Aman-Rabi Crops Irrigated: Aus/Jute-Boro (HYV) Aus+ Aman-Boro(Local) Mustard-Boro (HYV)	Rainfed : Jute/Aus & Aman-Rabi Crops Boro (Local)-Vegetables Irrigated: Mustard-Boro (Local) (HYV)
Triple Cropped	Rainfed: T. Aman-Rabi-Summer Vegetables Irrigated: T. Aman-Pulses/Mustard-Boro (HYV) (HYV) T. Aman-Vegetables-Boro (HYV) (HYV)	Rainfed : Aus/T. Aman-Rabi Crops (Local/HYV) T. Aman-Rabi crops-Jute Irrigated: T. Aman-Pulses/Mustard-Boro (HYV) T. Aman-Vegetables-Boro (HYV)	Rainfed : Aus/Jute-Rabi Crops Irrigated: Boro-Mustard-Summer Vegetables	Rainfed : Jute/Aus& Aman-Rabi Crops Irrigated: Mustard-Boro (Local) (HYV)

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TABLE 2.15
FUTURE CROPPING PATTERNS

	F0 = Highland <30cm	F1 Medium Highland <30-90 cm	F2 = Medium Low land <90-180 cm	F3 = Low Land <180-270 cm
Single Cropped	Rainfed: T. Aman (HYV) HYV Aus Vegetables Rabi Crops Fruit trees/Annual Crops Irrigated: Boro (HYV)	Rainfed : T. Aman (HYV) Aus (HYV) Jute Vegetables Irrigated: Boro (HYV)	Rainfed : T. Aman (HYV+Local) D. W. Aman (TR) Jute etc. Irrigated: Boro (HYV)	Rainfed : D. W. Aman (TR+B) Aus (Local) Jute etc. Irrigated: Boro (HYV+Local)
	Rainfed: T. Aman HYV-Rabi HYV Aus-HYV T. Aman Irrigated: Boro (HYV)-T. Aman (HYV)	Rainfed : Jute/Aus (HYV)-T. Aman (HYV) T. Aman (HYV)-Rabi Crops Irrigated: Boro (HYV)-T. Aman (HYV)	Rainfed : Aus (HYV) - T. Aman (HYV) T. Aman (HYV+Local)-Rabi Crops D. W. Aman (TR)-Rabi Crops Irrigated: Boro (HYV)-T. Aman (HYV+Local)	Rainfed : Aus (HYV) - Rabi Crops D. W. Aman (TR+B)-Rabi Crops Irrigated: Boro (HYV+Local)-Rabi Crops
Double Cropped	Rainfed: T. Aman (HYV) - Rabi Crops-Summer Vegetables Irrigated: Boro HYV-T. Aman (HYV)-Rabi Crops	Rainfed : Aus (HYV)-T. Aman (HYV)-Rabi Crops T. Aman (HYV)-Rabi Crops-Vegetables Irrigated: Boro (HYV)-T. Aman (HYV)-Rabi Crops	Rainfed : Aus (HYV)-T. Aman (HYV+Local)-Rabi Crops T. Aman (HYV+Local)-Rabi Crops-Vegetables Irrigated: Boro (HYV)-T. Aman (HYV)-Rabi Crops Boro-Summer Vegetables-Rabi Crops	Rainfed : D. W. Aman (TR)- Mustard-Vegetables Irrigated: Boro (HYV)- D. W. Aman (TR)- Rabi Crops

Rainfed: Land which becomes highland (F0) or medium highland (F1) will be planted to Aus or Jute followed by T.Aman sometimes succeeded by rabi crops.

- On F2 land mixed aus and broadcasted aman will be grown or jute followed by rabi crops.
- In F3 areas broadcasted aman will remain the only crop to be grown, in some areas to be followed by rabi crops.

Irrigated: Land under irrigation which becomes highland (F0) or medium highland (F1) will be planted to boro HYV, "braus" HYV or aus HYV followed by T.Aman.

- On Medium low land (F2) the crop to be grown are boro HYV followed by transplanted deepwater aman.
- In the deeper flooded areas only boro HYV or local will be grown.

With a lower level of floods a reduced risk of flash floods and a shorter duration of inundation farmers will face a lower risk for crop failure and are likely to invest more in their crops by shifting from local to high yielding varieties.

2.5.2 Livestock

Livestock in the NCR are virtually all kept on small farms. It is an integral part of the farming system. Cattle is providing milk, meat, manure, hides and power for land preparation and threshing. Fodder is mainly supplied as byproducts of the farm, like weeds, straw, bran and oilcakes, while water hyacinth and some grass from roadsides and embankments are supplementary fed. Quality and stamina of the cattle is poor.

In the NCR the number of draft animals is not adequate and is meeting only $\pm 75\%$ of the requirements. As a result landpreparation is not optimal and often delayed, sometimes interrupting, the planned cropping pattern. Dairy cattle is concentrated in areas around Dhaka, as Munshiganj and Narayanganj. Tangail has the largest number of cattle per Ha (2.6 per Ha) and Jamalpur the lowest (1.6 per Ha). Goats and sheep are mainly kept in highland areas, chickens in areas around Dhaka and ducks more in deepflooded areas.

The Directorate of Livestock Services started programmes on cattle and livestock vaccination, artificial insemination, cultivation of fodder crops and the development of non-government dairy and poultry farms. In some of these programmes NGOs like CARE, BRAC etc. are involved.

It has not been possible to obtain reliable quantitative data on forest areas, forest production and ongoing activities. Collected data from the Ministry of Forest at Central District and upazila level and the data published by BBS are so conflicting that any attempt to get even a vague impression of the existing situation would not produce any useful result.

Ongoing developments are mainly concentrated on the Madhupur Tract areas and consist of plantation programmes for wood lots and some agroforestry activities as inter planting of young plantation with rice, pineapples and vegetables. Furthermore seedlings are raised in forest nurseries located in most upazilas for sale to the public and for roadside and woodlot plantations.

2.6 Fisheries

2.6.1 Overview of Fisheries

Flooding in the North Central Region, whilst being disruptive and at exceptional times highly damaging, also provides benefits one of which is a very important, self-sustaining floodplain fishery. A large number of fish species migrate from rivers to reproduce feed and grow on the floodplains and further add to a significant resource.

Inland freshwater fisheries in Bangladesh are usually categorised as those of the open water capture fisheries and those comprising closed water culture fisheries. Exploitation of the open water fisheries goes on throughout the year but intensifies considerably during the monsoon when seasonal river and rainfall flooding connects the various components of the aquatic system: main rivers, tributaries, canals, beels ditches and floodlands to provide an integrated biological production system when fish and prawns breed and in increase in number and biomass. Closed water culture fisheries relate mainly to numerous small ponds scattered throughout the region which are stocked with various species of carp whose fry are obtained either from natural sources such as traditional fry collection centres on the Jamuna, Old Brahmaputra and Dhaleswari rivers or, increasingly in recent years, from private and government hatcheries.

Most of the fish production in the NCR (75-85% by weight) is derived from open water capture fisheries. Of this, the greatest proportion is provided by floodplains (Table 2.16). These areas typically support open-access, part-time subsistence fishing carried out by a large majority of rural households. In contrast, rivers and beels tend to be exploited by full-time professional fishermen who must pay a charge fixed by lease or license.

Table 2.16
Fish production (tonnes) in the North Central Region 1983-89

Habitats	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
Rivers	10107	11598	9279	11702	9842	7222
Beels	5221	4522	4435	4321	4160	4501
Floodplain	14876	14390	12036	12520	13453	14866
Total Capture	30204	30510	25750	28543	27455	26589
Fish Ponds	7562	5330	5578	8240	8854	8825
Total	37766	35840	31328	36783	36309	35414

Source : Derived from Department of Fisheries Catch Statistics, 1983-89

The most recent estimate of just over 26,000 tonnes of fish from the capture fisheries of the NCR provides sufficient animal protein to feed, at current estimated levels of per capita availability (7.5 kg per annum), about 3.5 million people. When the contribution from pond culture in the region is added, then the total is sufficient to feed about 4.7 million. This number is well below the total population of region, provisionally estimated at about 15 million for 1991, which means that a substantial quantity of fish must be imported from other regions of Bangladesh, principally Hilsa from the south and various other species from the haor area of the northeast.

Although the time series of available information is relatively short, the data in Table 2.17 reveal a number of general trends. Total catch of the capture fisheries has decreased from 1983 to 1989 by about 12% while that from pond culture increased by 17% resulting in an overall decrease in fish production of 6%. The greatest reduction in catch (39%) was recorded in the Jamuna and Padma rivers whilst the pattern in other rivers was not clear. The catch from beels decreased by 14% during the same period but, surprisingly, floodplain catches increased in 1988/1989 to previous levels of 1983/84. Broadly similar trends in changes in annual fish production were reported recently from the North West Regional Study (FAP-2).

The decline in fish yields have generally been attributed to the widespread development of flood control and drainage (FCD) schemes in the NCR and other areas of Bangladesh. It is well established that FCD projects have reduced floodplain fish stocks by lowering the amount of floodplain habitat available to fish and by disrupting or preventing the migration of fish, prawn and fish fry on to the floodplain. Lack of effective fisheries regulations and management has also adversely affected fish stocks by allowing the widespread use of harmful fishing methods and possibly by overfishing.

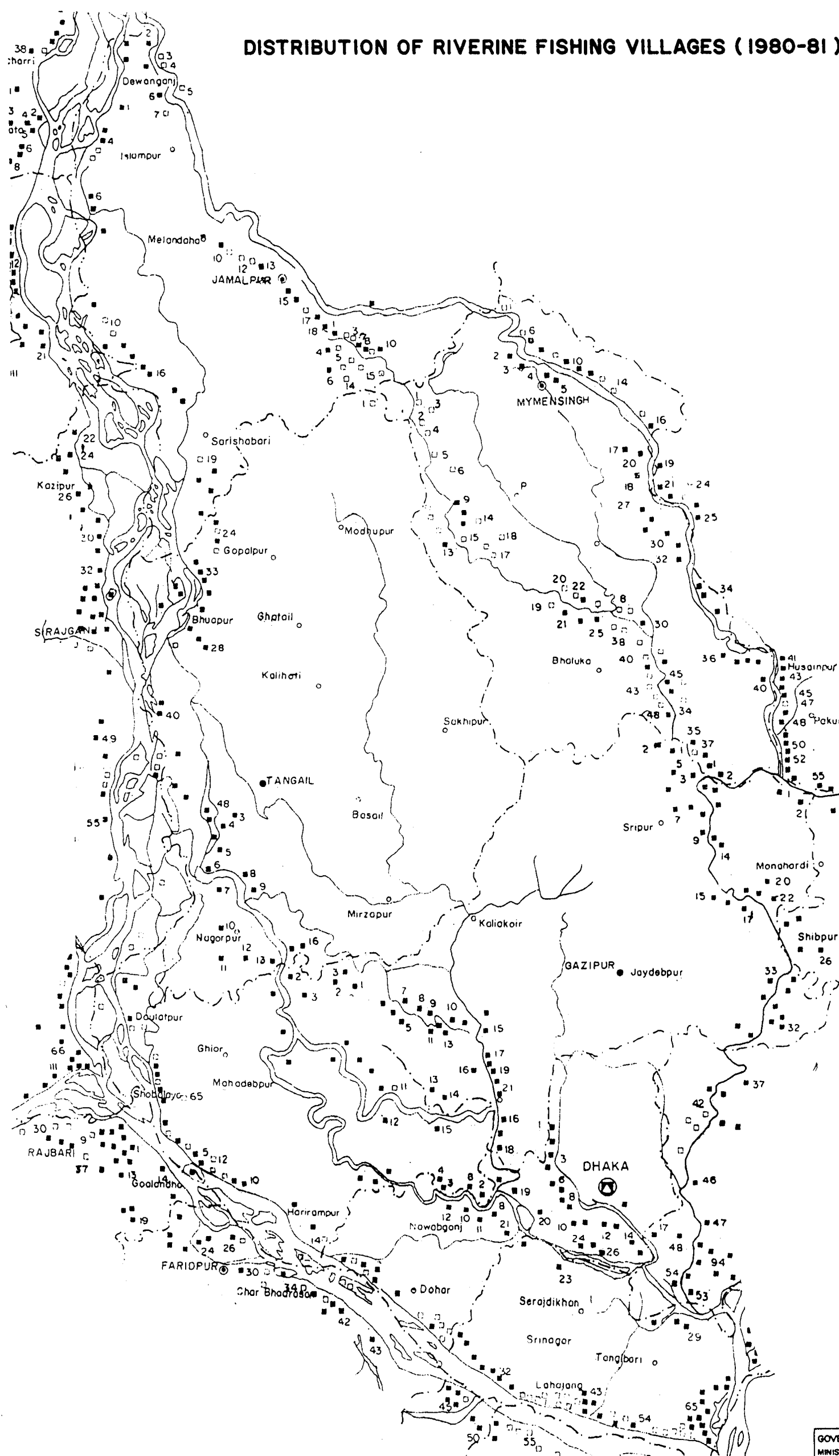
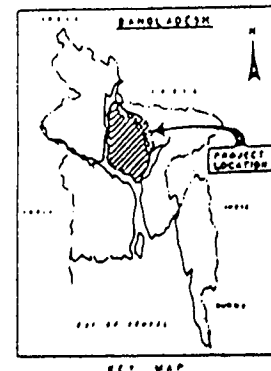
2.6.2 Methodology

Assessment of Existing fish Resources

Attempts have been made in this study to provide a quantitative assessment of the impact of various FCD schemes on the fish resources of the North Central Region. To achieve this, it was necessary to analyse published fisheries statistics which have been collected since 1983 by the Fisheries Resources Survey System (FRSS) of the Department of Fisheries (DOF). Even though the quality of the FRSS statistics remains uncertain, they represent the only source of national fisheries information and as such have been used widely by national and international organizations as a basis for fisheries assessment and planning.

In this study, the FRSS statistics were used to provide a quantitative assessment of the existing fish resources in the NCR and to identify major trends during the period for which data were available (1983-1989). The FRSS provides data on capture and culture fisheries and sub-divides the former on the basis of different types of water bodies. Those which are relevant to the NCR comprise rivers, beels and floodlands (floodplain). Catch statistics relating to both capture and culture fisheries are published for each of four former districts covering the NCR: Dhaka, Jamalpur, Mymensingh and Tangail.

DISTRIBUTION OF RIVERINE FISHING VILLAGES (1980-81)



- PERMANENT VILLAGES
- SEASONAL VILLAGES

SOURCE : DEPARTMENT OF FISHERIES, FRAME SURVEY (1980-81)

GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH	
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL	
COMMISSION OF THE EUROPEAN COMMUNITIES	AND GOVERNMENT OF FRANCE
NORTH CENTRAL REGIONAL STUDY	
FAP - 3, PHASE - 2	
RIVERINE FISHING VILLAGES	
ICRIS CONSORTIUM BCEOM CNR EUROCONSULT MOTT MACDONALD INT. BATEC	IN ASSOCIATION WITH DASH UPDATES LTD. BETS
SCALE 1:250,000	DATE 10th August 1991

FIGURE 2.6.1

Unfortunately, all districts except Tangail, contained areas outside the NCR, which in the case of old Mymensingh, were substantial. Therefore to utilise published data in the assessment of the fisheries of the NCR, information relating to areas outside the NCR was excluded and the remaining data were adjusted to individual Planning Units (PU).

The manner in which such adjustments were made varied according to the type of water body (fishery) to which the published data referred. For riverine catches, the distribution of fishing villages (Fig.2.6.1) and the number of fishing boats that each contained were taken into account for each PU in the same way as that used by FRSS and Catch Assessment Survey (CAS) to derive annual estimates of catch from each PU. Fish production from beels was estimated by applying productivity rates from each district to the total area of beels within each PU. This in turn was based on the area of beels within respective upazilas making up each PU. For several upazilas data were incomplete or absent and therefore values of annual fish yield from beels should be regarded as minimum estimates.

FRSS estimates of floodplain catch are based on the product of the average catch of subsistence households and the total number of households (urban and rural) in each district. In this study, urban households were omitted from the analysis since it seemed more logical to base catches on rural households alone as indicated by the Bangladesh Bureau of Statistics (BBS, 1990). The population of fishing households was estimated from the ratio of numbers of fishing households (given in DOF statistics) to the total number of households in each district. The proportion of fishing households was then multiplied by the number of rural households (in 1981) in each upazila to obtain the total fishing households per upazila. The latter was then multiplied by the average annual catch per household (from DOF statistics) to obtain the total catch per upazila which was then converted to catch per PU by taking into account proportional area of upazilas in each PU. This analysis did not take into account population growth over the last decade, therefore values of floodplain catch are probably underestimates.

Fish production from ponds was estimated by using values of average productivity (kg/ha) for each district and the total pond area in each upazila estimated by SPARRSO in 1983/84 by satellite imagery, infra-red aerial photography and ground surveys. Upazila data were then converted to each PU, as before, by taking into account proportional areas. Estimated pond productivity rates appear highly suspect since in most cases they are unrealistically high and should be treated with caution.

Assessment of Impact of FCD Schemes

The methodology outlined by MPO (Technical Report No.17, 1985) was followed in making an assessment of the potential impact of FCD projects on floodplain fisheries due to the loss of usable fish habitat. The method is fairly approximate, but in the absence of more detailed information on fish productivity or biomass in different water depths and habitats on the floodplain, then it offers the best available method to date. The method has been applied recently in an analysis of the effects of FCD and FCDI projects on the fish resources of the South East Region of Bangladesh (Interim Report, 1991).

The method is based on an estimate of yield per unit area of floodplain - dependent fish i.e., all fish excluding *Hilsa* from all three types of open water fishery: rivers, beels and floodplain. For the NCR, the analysis results in an overall catch of 40 Kg/ha (Table 2.17) this is somewhat lower than that for Bangladesh as a whole (50 kg/ha) for the same period. This catch was valued at Tk. 30/kg based on average current prices in the NCR, ranging from Tk. 25/kg for small miscellaneous species to Tk. 40/kg for larger species such as catfish, carp etc. This value was applied directly to catch rate to derive the total value of fish loss due to FCD schemes.

Table 2.17
Estimated Yields from Capture Fisheries of the NCR, 1988-1989

Habit	Area (000 ha)	Catch (tonnes)	Catch Rate (kg/ha)
Rivers	49.2	6637	147
Beels	11.6	4501	388
Floodplain	592.7	14866	25
Total	653.5	26004	40

- Source: 1. Area of principal rivers obtained from BBS 1990
 2. Area of beels derived from LGEB data (pre 1983)
 3. Area of floodplain derived from MPO estimates of land in categories $F_1 - F_3$
 4. Catch estimates (excluding *Hilsa*) derived from Department of fisheries catch statistics 1988-89

One of the positive impacts on fisheries which might be expected from the implementation of FCD schemes is the increased development of aquaculture under conditions of improved control over flooding. However, because of the serious lack of information on long-term trends in aquaculture and the dubious nature of current estimates of pond production in the NCR (and elsewhere in Bangladesh), it was considered unrealistic to attempt a quantitative assessment of the impact of FCD schemes on culture fisheries. Indeed, current estimates of pond production appear to be gross overestimates and thus to increase still further these estimates by assuming a beneficial impact of FCD projects is unreasonable. Instead, estimated pond production was included in the overall assessment of the effects of FCD on fish resources but was assumed in all cases to remain unchanged.

2.6.3 Impact of FCD schemes on fisheries

Quantitative assessment of the impact on capture fisheries of FCD schemes RS 1 to 7 were based on estimates of the reduction in floodplain habitat ($F_1 - F_3$) derived from computer modelling of changes in flow regimes in each PU (Table 2.18). Under this range of options, the planning units where major reductions in flooded area occur, comprised PUs 1,2,4,6,7,8 and 10. Greatest estimated reductions in flooded area resulted from the major embankment schemes relating either to the Jamuna river alone, from Bhuapur to Aricha, or from the embankment proposed along Jamuna, Dhaleswari and Kaliganga rivers. Serious reductions in floodplain habitat were also recorded in PU 1 resulting from embankment of the Jamuna and a restricted inflow of the Jhenai river from the Old Brahmaputra river. The potential reduction in floodplain capture fisheries in terms of yield and economic value are appreciable in all PUs mentioned above, but especially so in PU 6. In fact, in this area the estimated losses, were much higher following the method of MPO, to such a degree that in some cases the loss was actually greater than the estimated size of the existing fishery. This resulted principally from the underestimation of the latter using the FRSS system based on the number and average catch of fishing households. An alternative approach was therefore used to assess the impact of FCD projects on the fisheries of this PU which was based simply on applying the percentage reduction in flooded area to the estimated yield of the capture fishery in 1988/89. This approach provided a more realistic assessment of the various FCD schemes. In view of the serious potential loss to floodplain fisheries in these areas, it is clear that consideration must be given to include, as part of the future regional plan, fishery development programmes which are designed to avoid, reduce or compensate for the adverse effects of FCD projects. Details of proposed fisheries initiatives are described further in the Fisheries Supporting Document.

TABLE 2.18

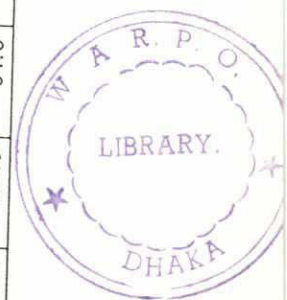
Effects of FCD options on fish production (tonnes) and catch value (million Tk.) in the NCR

PU	Scheme	Reduction in area of F1 - F3 (%)	Without Project						With Project						Change (%)							
			CAPT			CULT			TOTAL			CAPT					CULT			TOTAL		
			Wt.	Tk.		Wt.	Tk.		Wt.	Tk.		Wt.	Tk.		Wt.	Tk.		Wt.	Tk.		Wt.	Tk.
1	RS1	21	3373	108.9		428	15.6		3801	124.5		2926	95.5		428	15.6		3354	111.1		-12	-11
2	RS2	20	1584	45.4		330	11.6		1914	57.0		1249	35.3		330	11.6		1579	46.9		-18	-18
4	RS2	23	1101	28.8		316	10.6		1417	39.4		698	16.7		316	10.6		1014	27.3		-28	-31
5	RS2	8	3060	87.6		1437	51.2		4497	138.8		2893	82.6		1437	51.2		4330	133.8		-4	-4
6	RS6	54	2020	58.4		570	18.7		2590	77.1		942	26.9		570	18.7		1512	45.6		-42	-41
	RS7	56	2020	58.4		570	18.7		2590	77.1		902	25.7		570	18.7		1472	44.4		-43	-42
7	RS5	59	2020	58.4		570	18.7		2590	77.1		842	23.9		570	18.7		1412	42.6		-45	-45
	RS4	9	1680	50.1		712	25.6		2392	75.7		1467	43.7		712	25.6		2179	69.3		-9	-9
	RS6	26	1680	50.1		712	25.6		2392	75.7		1065	31.6		712	25.6		1777	57.2		-26	-24
	RS7	25	1680	50.1		712	25.6		2392	75.7		1088	32.3		712	25.6		1800	57.9		-25	-24
	RS5	51	1680	50.1		712	25.6		2392	75.7		473	13.9		712	25.6		1185	39.5		-50	-48
8	RS6	13	664	19.4		394	13.9		1058	33.3		599	17.4		394	13.9		993	31.3		-6	-6
	RS7	12	664	19.4		394	13.9		1058	33.3		604	17.6		394	13.9		998	31.5		-6	-5
	RS5	23	664	19.4		394	13.9		1058	33.3		549	15.9		394	13.9		943	29.8		-11	-11
10	RS4	9	1083	31.8		589	20.6		1672	52.4		925	27.1		589	20.6		1514	47.7		-9	-9
	RS6	18	1083	31.8		589	20.6		1672	52.4		767	22.3		589	20.6		1356	42.9		-19	-18
	RS7	16	1083	31.8		589	20.6		1672	52.4		802	23.4		589	20.6		1391	44.0		-17	-16
11	RS7	6	1308	46.7		223	8.0		1531	54.7		1269	45.5		223	8.0		1492	53.5		-3	-2
13	RS7	7	2931	90.3		977	34.2		3908	124.5		2740	84.6		977	34.2		3717	118.8		-5	-5

Note 1 : For details of schemes, see Table 6.2

Source : CS 1991

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2.7 Existing Schemes and Infrastructure

2.7.1 Existing Schemes

An inventory of existing schemes in the NCR is given as Table 2.19 and shown as Figure 2.7.1. These schemes are in different stages of implementation/operation/planning and their status is to be reported on more fully in PSR VI.

Other significant activities presently being undertaken in the Region include:-

- Jamuna Multipurpose Bridge (a decision on its implementation status is due at end 1991)
- Jamuna Bridge - Sector Studies
- BWDB System Rehabilitation
- Rural Development Project-13 (Infrastructures Old Dinajpur and Jamalpur Districts)
- Rural Development Project-6 (Infrastructure in Manikganj District)
- Tangail Agricultural Development Project
- Road Master Plan Project

Also, the projects listed below are future actions which are due to start in the near future:-

- National Minor Irrigation Development
- Shallow Tubewells and Low-Lift Pump Irrigation
- Agricultural Support Sector Project
- Food for Work Programme

Many past studies and feasibility studies are also still of relevance. Two in particular are worthy of mention:-

- the Dhaka South West Project
- the Old Brahmaputra Development Project

2.7.2 Infrastructure

The infrastructure of the Region is shown In Figure 2.7.2 and a list of roads with their classification given in Table 2.20. The length of RHD road in each PU is given in Table 2.21.

The distribution of other infrastructural facilities such as schools, hospitals, and markets is given in Table 2.22, based on Upazila data converted to PU basis by aerial proportion.

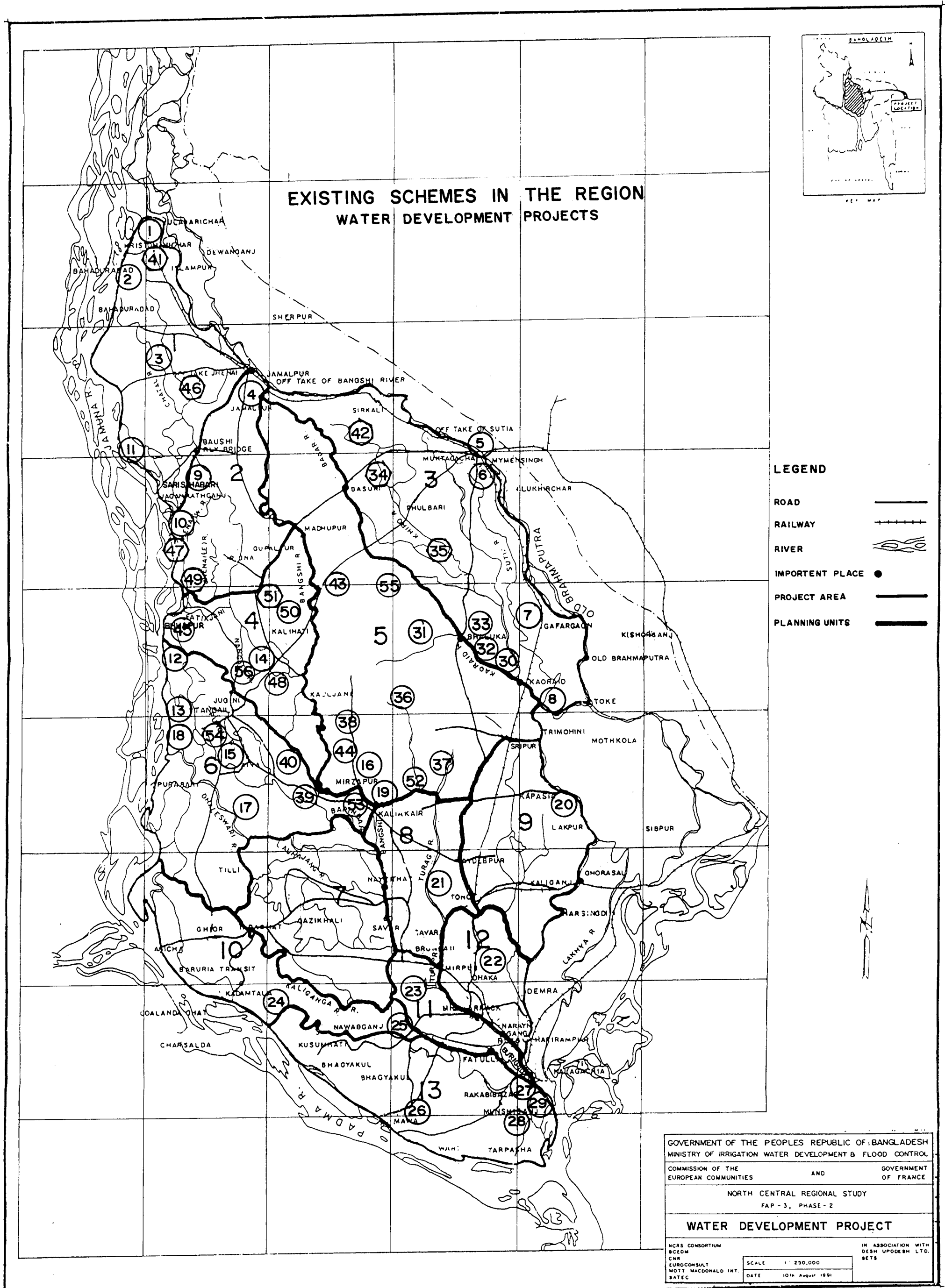


Figure No. 2.7.1

TABLE 2.19
LIST OF WATER DEVELOPMENT PROJECTS IN NORTH CENTRAL REGION AREA FAP-3

Sl. No.	Name of Project	Type	PU No.	District	Upazila	Status	Area Benefitted (sq. km)	Length (Km)	Crest Level (m PWD) Av	Height Av (m)	Top width (m)	Remarks
01.	Dewanganj Town Project	T. P.	1	Jamalpur	Dewanganj	C		13.50		3.50		Remaining parts Partly washed away by Jamuna River
02.	Bahadurabad Sub-Project	Flood Embk.	1	Jamalpur	Islampur	C		7.50		3.50		
03.	Mohammadpur Delalerpara Sub-Project	Embankment	1	Jamalpur	Melandaha	C		14.30	19.50	4.50	4.30	
04.	Gabakhali Sub-Project	Embankment	1&2	Jamalpur	Jamalpur							
05.	Dublaikurkhal & Katakhal Scheme	FCDI	3	Mymensingh	Muktachacha	C	40.50					Completed 1984-1985
06.	Garamara sluice	D	3	Mymensingh	Mymensingh	C	6.50					Completed 1958-1959
07.	Shila River Sub-Project	FCDI	3	Mymensingh	Gaffargaon	OG	50.00					
08.	Upper Shila Sub-Project	FCDI	3	Mymensingh	Gaffargaon	OG	26.30					
09.	Kabariabari Khal	D	2	Jamalpur	Shariaabari							Completed 1989-1990
10.	Pigna-Jokerchar	Flood Embk.	2	Tangail		C	84.00	37.00	15.30	3.25	4.25	
11.	Shariaabari-Jagannathganj	Embankment	2	Jamalpur		P						Postponed
12.	Mogragala Sub-Project	FCD	6	Tangail	Tangail	P		25.00				SSFCDI 1983-1984
13.	Karatia-Silimpur	Flood Embk.	6	Tangail		P						
14.	Charan Beel Sub-Project	FCD	4	Tangail	Kalihati	C	40.00	40.00	14.85	3.00	4.30	
15.	Kamarnagaon Sub-Project	Flood Embk.	6	Tangail		C	65.00	42.00	13.10	2.70	4.30	
16.	Pathakhali Konai Beel Sub-Project	Embankment	5	Tangail	Mirzapur	C	25.00	23.00	10.20	2.00	4.30	
17.	Babupur-Lauhati Flood Embk.	Flood Embk.	6	Tangail	Delduar	C	41.00	15.00	11.40	2.50	4.30	
18.	Kakua-Bhanna-Mirkutia F. Embk Sub-Project	Flood Embk.		Tangail		P		20.00	13.50	3.20	4.30	
19.	Alirbeel Sub-Project	D	5	Gazipur	Kaliakair	OG	41.20					Under P. S.
20.	Re-Excavation of Dardarkhal	D	9	Gazipur	Kapasia		57.35					Year of completion 1990
21.	Tayebpurbazar to Kashimpur & Sluice	FCD	8	Dhaka	Savar	P		10.00				Year of completion 1979
22.	Greater Dhaka City Flood Prot. Project	FCD	12	Dhaka		OG						
23.	Keraniganj Irrigation Project	FCDI	11	Dhaka	Keraniganj			3.38		2.00	2.45	
24.	Dhaka South West Project	FCD	10&13	Dhaka	Manikganj	OG	971.66	178.00				Completed embankment 72 km Reg. 2 Nos.
25.	Aglarchalk Irrigation Project	PCI	13	Dhaka	Nowabganj	P						Pipe sluice 9, completed upto June 30, 1991
26.	Sreenagar-Mawa & Bhaggayakul Project	SSFCDI	13	Munshiganj	Sreenagar	C	22.95	30.00	7.30	3.50	4.28	55% complete
27.	Erosion of R. Bank of Dhaleswari	Embankment	13	Munshiganj		P						
28.	Munshiganj-Tangibari Project	FCDI	13	Munshiganj		P						Proposed for 1991-1992
29.	Munshiganj Town Protection	T. P.	13	Munshiganj	Munshiganj	P						PP submitted work could not be started due to financial constraint

C = Completed, OG = on going, P = Proposed

Continued :

TABLE 2.19
LIST OF WATER DEVELOPMENT PROJECTS IN NORTH CENTRAL REGION AREA FAP-3

Sl. No.	Name of Project	Type	PU No.	District	Upazila	Status	Area Benefited (sq. km)	Length (Km)	Crest Level (m PWD) Av	Height Av (m)	Top width (m)	Remarks
30.	Sluice Over Laithi khal	D	3	Mymensingh	Bhaluka	C	16.19					
31.	2 Vent Regulator Over Bahatara khal	D	5	Mymensingh	Bhaluka	C						
32.	5 Vent Regulator on Chullar khal	D	3	Mymensingh	Bhaluka	C						
33.	2 Vent Regulator Over Dijori khal	D	3	Mymensingh	Bhaluka	C						
34.	Bannar khal scheme	PCD	3	Mymensingh	Mukttagacha	OG						
35.	Khiri river scheme	PCD	3	Mymensingh	Bhaluka	OG						
36.	Laithi river scheme	PCD	5	Mymensingh	Bhaluka	OG						
37.	Suktajuri khal scheme	PCD	5	Mymensingh	Bhaluka	OG						
38.	Excavation of Tankir khal	D	5	Tangail	Kalihati	C	4.08					
39.	Mashajan Louhajang scheme	PCD	6	Tangail	Mirzapur	C	20.23					
40.	Barkati Beel sub-project	PCD	6	Tangail	Basail/Mirzapur	C	3.73					
41.	Katakhali khal sub-project	PCD	1	Jamalpur	Islampur	C	2.83					
42.	Banar khal sub-project	PCD	3	Jamalpur	Islampur	C	4.86					
43.	Regulator Over Bailjani khal	PCD	5	Tangail	Ghatail	C	10.12					
44.	Regulator Over Konai Nadi	PCD	5	Tangail	Mirzapur	C	8.09					
45.	Flood Embankment Nikrail to Bhuapur	Embk.	4	Tangail	Bhaluka	C	35.62					
46.	Regulator Over Rouh khal	PCD	1	Jamalpur	Melandah	C	8.09					
47.	2 Vent Regulator Over Shakharia khal	PCD	2	Tangail	Gopalpur	C	28.32					
48.	2 Vent Regulator Over Satbeha khal	PCD	4	Tangail	Kalihati	C	19.42					
49.	Regulator Over Old Louhajang River	PCD	2	Tangail	Bhuapur	C						
50.	Sluice Over Sanki Bhanga khal	PCD	4	Tangail	Ghatail	C	10.52					
51.	Sluice Over Puta Nadi	PCD	4	Tangail	Ghatail	C	4.86					
52.	Sluice Over Pabdakhal khal	PCD	5	Tangail	Mirzapur	C	4.86					
53.	Sluice Over Bhulua khal	PCD	6	Tangail	Mirzapur	C	6.07					
54.	Kamar-Naogaon sub-project	PCD	6	Tangail	Delduar	OG						
55.	Bailjana khal sub-project	PCD	5	Tangail	Ghatail	OG						
56.	Pungli River Embankment	Embk.	4	Tangail	Kalihati	P						

C = Completed, OG = on going, P = Proposed

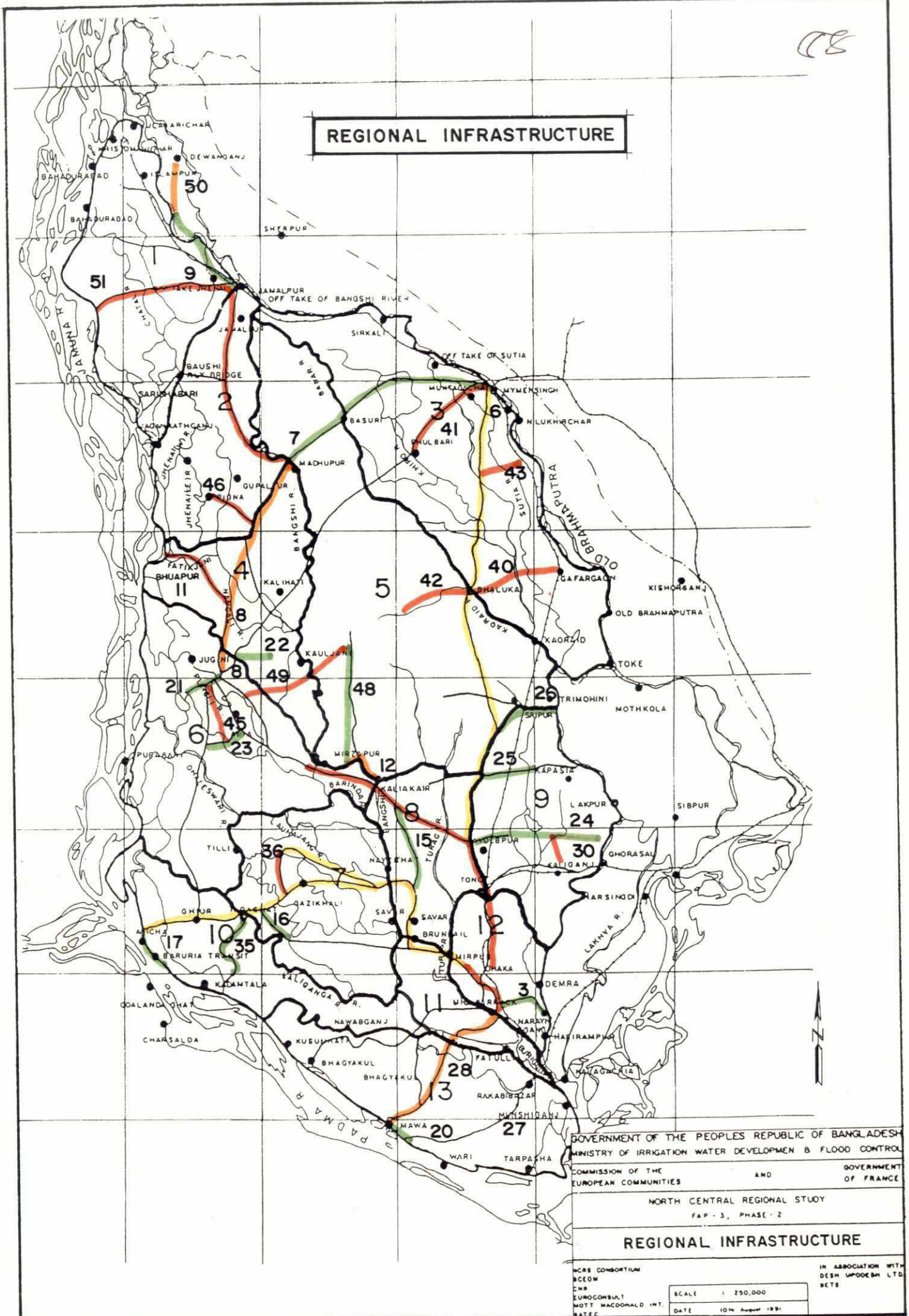


TABLE 2.20
Roads in the NCR

Sl. No.	Name of Road	Length Km	Location in Planning unit Nrs.
National Highway			
01.	Dhaka-Mirzapur	84.15	6, 8, 12, 8/9
02.	Dhaka-Aricha	75.02	7, 10, 11, 12
03.	Dhaka-Demra	6.84	12
04.	Polder Road	8.32	12
05.	Dhaka-Mawa	35.40	11, 12, 13
06.	Mymensingh-Joydebpur	56.72	3, 5, 5/9, 8/9
07.	Mymensingh-Madhupur	32.18	3, 5
08.	Joydebpur-Tangail-Madhupur	99.75	4, 6, 8, 2/4
09.	Madhupur-Jamalpur	18.70	2, 5
	Sub-Total :	417.08	
Regional Highway			
10.	Dhaka-Narayanganj	14.00	12
11.	Tangail-Bhuapur	23.00	4
	Sub-Total :	37.00	
Feeder Road			
12.	Masterbari-Mirzapur	5.00	8
13.	Joydebpur Rly. Station	5.50	9
14.	Tongi Rly. Station	1.29	9
15.	Nayarhat-Kaliakoir	16.10	8
16.	Manikganj-Shingair	19.32	7
17.	Aricha-Daskandi	7.65	10
18.	Aricha-Ghior-Nagarpur-Tangail	58.50	6, 10
19.	Demra-Narayanganj	8.66	12
20.	Mawa-Louhajang	8.05	13
21.	Tangail-Charabari	7.35	6
22.	Kalihati-Ratanganj/Balla	10.84	4
23.	Pakullah-Delduar-Elasin	14.27	6
	Sub-Total :	162.53	
Upazila Connecting Road			
24.	Tongi-Ghorasal	26.00	9
25.	Salna-Kapasias	18.50	9
26.	Sreepur-Mawna	8.00	5
27.	Fatullah-Munshiganj-Louhajang	37.80	13
28.	Tongibari-Sirajdikhan	14.00	13
29.	Rampal-Digirpar	17.00	13
30.	Kaliganj-Ajmatpur	9.66	9
31.	Sreepur-Bairagirchala	5.64	5
32.	Munshiganj-Sreenagar	13.36	13
33.	Zinzira-Keraniganj-Dohar	41.00	10, 11, 13
34.	Hemayetpur-Shingair	16.85	7, 11
35.	Manikganj-Jitka-Harirampur	27.50	10
36.	Kalampur-Saturia	23.00	7
37.	Dhamrai Connecting Road	1.40	7
38.	Golora-Saturia	10.10	7
39.	Sreenagar-Dohar	27.00	13
40.	Goffargaon-Bhaluka	21.00	3
41.	Mymensingh-Fulbaria	20.93	3
42.	Bhaluka-Shakhipur	21.00	5
43.	Churkhali-Sutiakhali	6.50	3
44.	Muktagacha-Chuchua	10.00	3
45.	Tangail-Delduar	12.88	6
46.	Porabari-Shalogani-Gopalpur	8.00	2
47.	Tangail-Omarpur	8.00	6
48.	Gorai-Shakhipur	28.64	5
49.	Tangail-Shakhipur-Basail	28.35	4, 5, 6
50.	Digpait-Islampur-Dewanganj	42.00	1, 2
51.	Jamalpur-Madarganj	22.54	1
	Sub-Total :	526.65	
	Grand Total	1143.26	

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TABLE 2.21

Length of RHD Road of Different Categories in Each Planning Unit

Unit No	National Highway (Km)	Regional Highway (Km)	Feeder Road (Km)	Upazila Connecting Road (Km)	Total (Km)	Remarks
1	-	-	-	50.87	50.87	Boundary of unit Nos.2&4
2	16.84	-	-	21.67	38.51	
3	46.38	-	-	58.43	104.81	
4	22.56	23.00	10.84	12.60	69.00	
2/4	14.25	-	-	-	14.25	
5	31.42	-	-	75.88	107.30	
6	58.57	-	77.81	24.03	160.41	
7	34.83	-	19.32	47.61	101.76	
8	50.10	-	21.10	-	71.20	
9	-	-	6.79	54.16	60.95	
5/9	4.86	-	-	-	4.86	Boundary of unit Nos.5&9
8/9	22.73	-	-	-	22.73	Boundary of unit Nos.8&9
10	20.09	-	9.96	30.33	60.38	
11	20.16	-	-	17.88	38.04	
12	55.41	14.00	8.66	-	78.07	
13	18.88	-	8.05	133.19	160.12	
Total	417.08	37.00	162.53	526.65	1143.26	

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TABLE 2.22
Distribution of Infrastructural Facilities in the
Different Planning Units of NCR.

Planning Unit Number	Area (ha) [1985]	Total Population [1981]	Educational Institution		Hospitals & Clinics		Hat & Bazar		Roads in [1985 data used]		
			No. [*]	per 1000 persons	No. [*]	per 10,000 persons	No. [*]	per 10,000 persons	Metal		Kutcha
									km.	km. per ha.	km. per ha.
1	89,352	737,706	389	0.53	17	0.23	61	0.83	24.5	0.0003	2250.6
2	73,963	604,558	289	0.48	17	0.28	64	1.06	54.3	0.0007	588.6
3	172,391	1,486,749	887	0.60	48	0.32	27	0.18	170.1	0.0010	3322.8
4	76,171	589,207	313	0.53	13	0.22	68	1.15	52.8	0.0007	849.4
5	212,466	1,139,598	619	0.54	32	0.28	109	0.96	170.4	0.0008	1875.7
6	114,393	1,006,383	573	0.57	21	0.21	116	1.15	99.4	0.0009	999.0
7	90,091	831,126	718	0.86	30	0.36	88	1.06	117.8	0.0013	713.9
8	46,066	391,729	207	0.53	19	0.49	39	1.00	64.9	0.0014	876.4
9	78,936	661,348	340	0.51	20	0.30	110	1.66	93.0	0.0012	1016.2
10	67,188	514,328	432	0.84	22	0.43	88	1.71	55.8	0.0008	604.9
11	24,986	437,568	327	0.75	10	0.23	21	0.48	63.3	0.0025	312.5
12	36,971	3,195,129	369	0.12	18	0.06	45	0.14	273.9	0.0074	126.8
13	101,486	1,129,512	785	0.69	37	0.33	111	0.98	72.9	0.0007	1121.3
N.C.R	1,184,460	12,724,941	6,248	0.49	304	0.24	947	0.74	1,313	0.0011	14,658
											0.0124

Note : [*] Calculated on the basis of Population data of 1981.

[□] Calculated on the basis of Area data of 1985.

Source : Computed from data obtained from the Bangladesh Population Census 1981, BBS(GOB).

2.8 Environment

2.8.1 General

The NCRS has taken two approaches to assessing the environmental aspects of the DRWDP:-

- a systems approach
- a qualitative classification of impacts (using guidelines from FPCO and other FAP studies)

The systems approach is described briefly below and is to be developed further in PSR V. The qualitative classification of impacts is used in the preliminary ranking of projects, see Chapter 6.

2.8.2 Elements of a Systems Approach to Water Management Aspects of Environmental Quality

Overview

Hindsight repeatedly instructs us that one-dimensional "fixes" for highly complex problems in resources management and development invariably prove suboptimal. Indeed, in Bangladesh, the stream of "dis-benefits" which flowed from certain previous FCDI investments can be seen, in retrospect, to have rendered whole projects uneconomic.

In planning theory, the term "systemic effects" refers to the intersectoral linkages inherent to almost any large-scale manipulation of the biophysical and/or social landscapes. Yes, we may devise a scheme intended to alter existing condition "A", but by necessity, changing "A" entails changing "B", with possible ramifications, as well, to "C", and so on. Complicating things greatly, of course, is that some of the most critical connections may not be sequential, linear, and predictable; but might instead arise "synergistically", as when the combined effects of two (or more) components prove much greater than would be expected from merely adding them together arithmetically.

There now exist a number of formal methodologies to conduct rigorous, comprehensive, and holistic assessments of the environmental impacts of proposed development schemes. There also exist proven mechanisms to inject "environmental sensitivity" into the conceptual and operational planning of large-scale water projects; but conventional assessment and mitigation technologies are generally employable only after specific project proposals have been drafted for implementation at specific geographic sites - even if still in the sketchiest and most preliminary terms.

Moreover, environmental planning is a field considerably broader than project assessment and impact amelioration. It -like other modes of planning- attempts to explicitly address higher "normative questions" about how a society perceives itself in the present; where it intends to be in the future, and what mechanisms should be applied toward getting there.

(2)

While almost everybody agrees that Environment now belongs in development planning for Bangladesh, the applicable "normative" issues have generally not yet been laid out on the table. Here are some exemplary questions:

- Should we assume from the outset that in Bangladesh, no development scheme can be obstructed or abandoned on environmental grounds alone —and if not, why not?
- Should procedures for environmental review be much less stringent than ordinarily applied in the North?
- Should "essential" projects ever be evaluated on grounds other than economic efficiency; and should limited program resources be diverted into "uneconomic" environmental improvements?
- Are recommendations for post-project environmental mitigation, and monitoring practicable within the existing institutional context?
- Can "quality of life" issues even be taken seriously in the face of irresistible demographic pressures?

Approach to the Study

The first two phases of "environmental input" to the NCR regional plan have occurred prior to any preliminary outlining of "prospective projects and sites". Accordingly, ordinary impact assessment techniques and mitigation procedures have been largely inapplicable until now.

Furthermore, the larger Flood Action Plan has evolved away from its initial "one-problem one solution" mode, and towards a more sophisticated reformulation —still very much underway— of the overall prospects for water management in Bangladesh: the actual task now requires delineating the boundaries of the "problems", technical and social; discovering the intersectoral linkages; unraveling the causal chains; and defining the parameters of environmental quality.

But there exist no pre-packaged environmental methodologies for identifying causal chains and intersectoral linkages; for enumerating elements of the quality of life and lists of the normative questions; or for drawing the conceptual boundaries of problems and solutions. This has provided both the opportunity and rationale to develop an alternate investigative framework.

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The goal has been to collect examples of the systemic effects, causal linkages, and normative questions that characterize water-related resource management issues in the North Central Region. We also hoped to assess elements of environmental quality, and of the overall "quality of life".

Our objective remains to gain a good-enough sense of the regional ecology —and of the human interactions with the natural environment— to be able to write compelling, but short narratives on the way things really work in the NCR: "who gains, who loses; what, when, where, and how." The subsequent formal and quantitative environmental studies of the projects —if any— to be recommended under the NCRWP for serious further consideration could thus be predicated on *actual local knowledge*.

Our methodology —which will be described in more detail in the Supporting Reports was intended to be "inventive and eclectic", rather than comprehensive, systematic, and quantitative.

All of our interpretations and judgements are based entirely upon first-hand field observations, and also on informal —but sometimes quite lengthy and intensive— interviews. (Ordinarily, the field team consisted of two ecologist-planners; one expatriate and one local. Travel was usually on foot or by local transport, with maximum possible use of mechanized country boats plying secondary waterways, and under normal passenger service.)

We personally conducted every such interview, mostly with fishermen or fish merchants, boatmen, small farmers, and low-ranking officials; often in relatively remote areas inaccessible by vehicle. Thus while our analyses may not necessarily be correct, the fault is at least our own —and cannot be laid upon pre-existing, but dubious databases.

Some preliminary observations of our Phase 1&2 field studies —also to appear in much more depth in the upcoming Supporting Reports— include the following:

- There is an extreme discrepancy between the GoB's statistics —which suggest a recent general decline of 15%, or less, in production from the inland, open-water capture fishery— and the claims of virtually all of our non-governmental interviewees; who insist that landings are *actually down by two-thirds*, compared to a decade ago. (Fishermen, of course, may have many reasons to exaggerate their difficulties.) As the fisheries deteriorate, "Jhele" —the traditional caste of professional Hindu fishermen— tend increasingly to emigrate illegally to India, and not necessarily to West Bengal.
- The mechanization of country boats, and their widespread use in the narrow, secondary rivers of the NCR, is in itself, a probable major factor in the recent deterioration of navigability of such waterways. (The wakes from engine-driven vessels undermine streambanks, and cause a general widening of the channels, with a marked reduction in depth, and a visible increase in turbidity —effects which might also further degrade local fisheries.)

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- The recent total deforestation of the large tracts within the Madhupur National Park—in the context of an abortive, donor-assisted "social forestry" scheme—may have contributed markedly to the recent severe flashfloods in the Banar River, and in other NCR waterways draining the Madhupur. This flooding was indeed, "devastating", and the wooded riparian corridor along many km of both banks of the Banar was completely washed away. Vast amounts of sediment and debris were thereby released into a heretofore-navigable channel, and it will possibly take decades for fisheries and navigation to recover.
 - Due, in large part, to institutional weaknesses and communication failures, a wave of "red-hot" investment and speculation in residential real-estate is now underway in a low-lying area outside of Dhaka, in a zone astonishingly inappropriate for urbanization and development. (Accelerated land-filling has already begun.) The entire area lies fully athwart one of the NCR's principal floodways—carrying monsoon discharges not only from the NCR itself, but from North Bengal, Assam, and Tibet, as well. Under peak flood conditions, this site is the floor of a world-class waterway, larger than any river in Europe!

There is no question that considerable responsibility for the generalized—and probably accelerating—degradation of Bangladesh's environment lies with an array of phenomenal human pressures that can appear altogether irresistible: the present density of rural populations; the galloping pauperization; the frightful demographics; the awesome wave of urbanization visible on the near-term horizon.

The challenge now is to identify those subsectors of Environment where the dominant social forces are not necessarily uncontrollable, and where ecological stabilization and improvement may well be feasible— and then to devise implementable strategies to do so.

CHAPTER 3

HYDRAULIC STUDIES

3.1 River and Drainage System

A detailed description of the hydrology and morphology of the region's river system is presently being prepared for inclusion in the Preliminary Supporting Report II. A brief description is given below.

3.1.1 Major Rivers

The Jamuna River, which forms the western boundary of the region, was once a much smaller watercourse, but owing to the change in the course of the Brahmaputra River, the majority of the flow of this great river now passes down the old Jamuna alignment. The name of the original watercourse has been retained.

The Jamuna river has a broad braided bed with large sand shoals and islands (chars). It is very unstable morphologically, with severe bank erosion, resulting in recorded shifts in bank alignment of over one kilometre in a single year.

The mean annual flood discharge of the Jamuna at Bahadurabad is estimated to be 65,000 cumecs, with the 1 in 100 year flood discharge estimated at 104,000 cumecs, (NCRS Phase I Report, Hydrology Annex).

The old course of the Brahmaputra River forms a part of the eastern boundary of the study area. The mouth of this river has been silting up steadily over the years since the river changed its course and now the flows down this branch are a fraction of the original, this has significant impacts on dry season flows. The mean annual flood, calculated at Mymensingh, is 3,120 cumecs, 4.8% of the mean annual flood of the Jamuna. The remainder of the eastern boundary of the study area is delineated by the Lahkya River, a right bank distributary of the Old Brahmaputra. Due to heavy silting of the Old Brahmaputra downstream of this bifurcation, the majority of the flow passes down the Lahkya River.

The southern boundary of the study area is formed by the Padma River, the river which takes the combined flow of the Ganges and Jamuna. Relatively little morphological movement of this river takes place, its flow being confined to a single bed with a few sandy shoals. Estimates of flood discharge have been made which give the 1 in 100 year flood flow as 151,000 cumecs at Baruria, (NCRS 1990, Hydrology Annex).

The Dhaleswari River is a left bank distributary of the Jamuna River. The Dhaleswari offtakes from the Jamuna in three separate locations, the northern offtake, is near Bhuapur. Just south, the Pungli river offtakes, and flows approximately parallel the River Jamuna to join the southern limb about 20 kms downstream of its offtake from the Jamuna. The southernmost offtake, called the Old Dhaleswari, joins the Kaliganga which then joins with the northern branch to become the main Dhaleswari. This then joins

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the river Buriganga flowing into the confluence of the Padma and Meghna rivers.

The Dhaleswari is a typical meandering river, its monsoonal sediment load determining its processes of erosion and deposition. The mean annual flood of the Dhaleswari at Sagir is estimated to be 688 cumecs.

3.1.2 Region's Interior Rivers

The interior rivers can be categorized as falling into three systems (see Figure 3.1.1) :

- the Dhaleswari-Kaliganga system in the South-western part
- the Pungli-Bangshi-Turag system in the Central part
- the Banar-Lakhya system in the eastern part.

The Dhaleswari-Kaliganga system is made up with distributaries, offtaking in the southern half of the Jamuna's left bank.

The Pungli-Bangshi-Turag system is a mixed system, supplied by local rainfall (Madhupur Tracts) and overspilling, along the northern half of the Jamuna's left bank and along the right bank of the Old-Brahmaputra.

The Banar-Lakhya system is mainly supplied by local rainfall and by water coming from the Old-Brahmaputra : downstream of Toke, the Lakhya river is the main branch of the Old-Brahmaputra.

In practice, the two former systems are largely connected by secondary branches and spill channels during flood flows. Under medium and low water-stages, no flow is able to get into most of the distributaries.

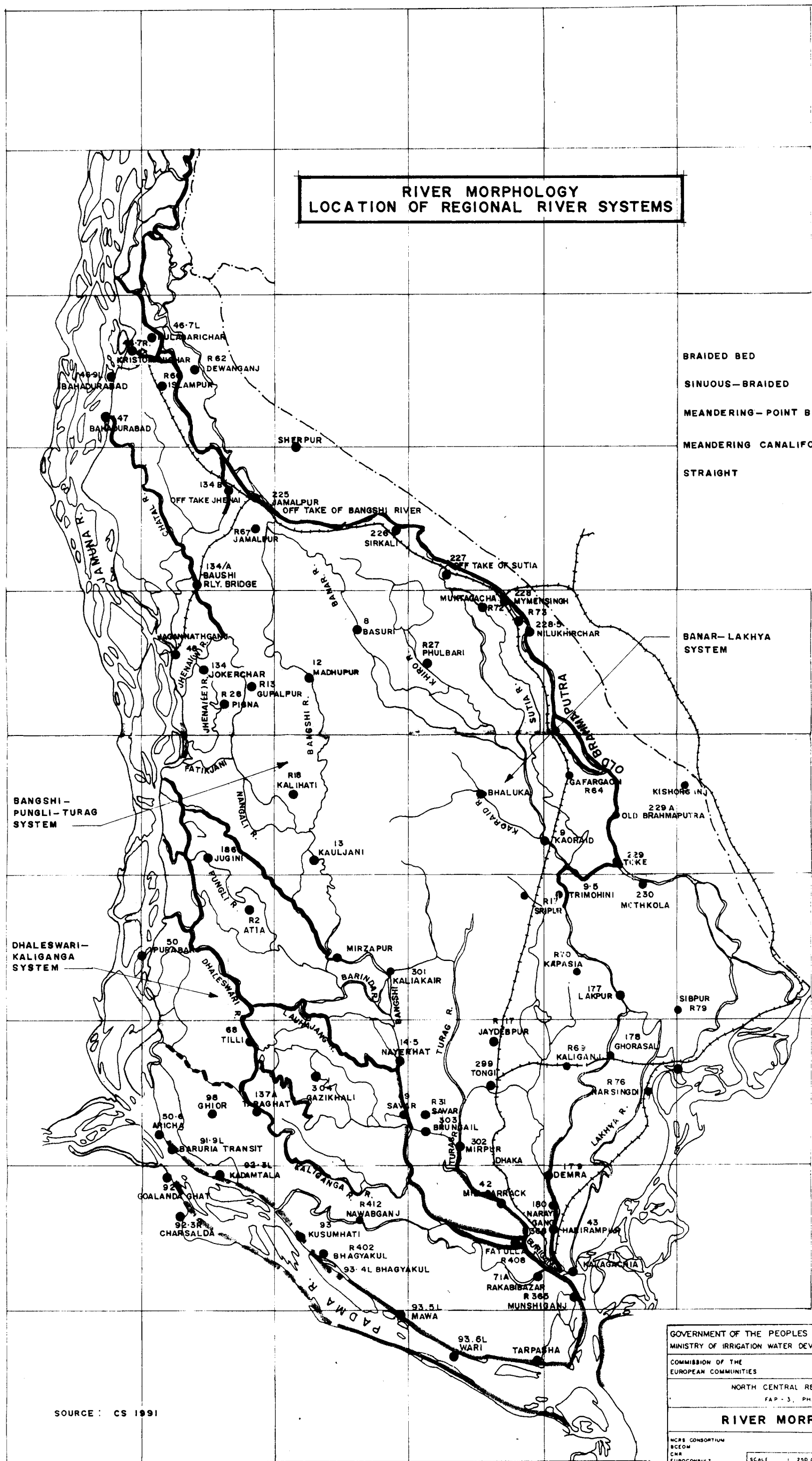


FIGURE 3.1.1

3.1.3 River Morphology

The qualitative classification of the regional rivers is based on four major planform properties observed on aerial photographs and satellite imageries: sinuosity, point-bars, braiding and anabranches.

A brief description is given below on the Region's river characteristics. This will be described in more detail in PSR II.3

Jamuna

The Jamuna is a broad braided river with large sand shoals and islands (chars), side-channels and anabranches. High rates of lateral migrations take place : average rates of approximately 300 m/yr and maximum values of 800 to 1000 m/yr are reported.

Its main features are the following:

- Dominant discharge	:	38,000 m ³ /s
- Slope (at dominant discharge)	:	6 to 8 cm/km
- Median size (d ₅₀) of bed material	:	0.17 to 0.26 mm
- Mean water surface width (bankfull)	:	4.5 km
- Mean surface width of a branch(bankfull)	:	$16.1 * Q_b^{0.53}$
- Mean depth at bankfull stage	:	$0.23 * Q_b^{0.32}$
- Mean annual sediment load	:	$0.5 * 10^9$ tons
- Mean total sediment concentration (at dominant discharge)	:	500 ppm

According to FAP-1 studies (Halcrow 1991), the Jamuna is in the braiding-meandering transition, as it shows, at macro-scale, characters of both patterns.

Padma

The Padma is a stable braided channel, which also shows a meandering character at macro-scale. Its banks are reported as consisting of more cohesive soil than the Jamuna's.

Though some significant rates of bank-line migration are reported, the erosion process seems less unpredictable than along the Jamuna, as the braiding character is far less developed than in the Jamuna river.

Its main features are the following:

- Bankfull discharge	:	55,000 m ³ /s(approx.)
- Slope (at dominant discharge)	:	2 to 4 cm/km
- Median size (d ₅₀) of bed material	:	0.13 mm
- Mean water surface width (bankfull)	:	4.3 km
- Mean annual sediment load	:	$0.6 * 10^9$ tons

Regional rivers

Table 3.1 indicates some observed characteristics pertaining to the geomorphology of the main regional rivers. Figure 3.1 delineates the three river systems, locates the main regional rivers and indicates the river patterns.

i) Dhaleswari-Kaliganga system

The Dhaleswari is the main left bank distributary of the Jamuna river and the main channel of a complex river system. It offtakes in two major locations - the first offtake, near Bhuapur, is decaying while the second one, just upstream of Porabari is presently the most active and is showing signs of rapid development.

Recently, the upper intake has shown little shifting of location while, in contrast, the southern one has shown significant movement. At present, these two offtakes only flow during the higher discharge levels of the Jamuna: from late May to early November for the upper one and from early April to early January for the lower one.

In addition to the major intakes, there are several minor spill-channels which can become significant at higher discharge levels, particularly when differences in levels develop between the Jamuna and Dhaleswari channels. In the long term, the relative importance of each offtake is a transient feature, owing to the character of the Jamuna river.

Old maps of 1956 show that much of the area between the Jamuna and the present channel of the Upper Dhaleswari was predominantly char land and the 1830 bank line seems to indicate that the present left bank of the Dhaleswari was the boundary of the Jamuna. As the left bank retreat has started again south of Bhuapur since 1989, the reactivation of one of the minor offtakes cannot be excluded.

The downstream channels of the Dhaleswari system are relatively old and appear to have reached a mature regime whilst the upstream ones are unstable and still in course of development.

The upper courses of the Dhaleswari, from the upper and lower offtakes to the offtake of the Barinda river, shows a meandering point-bar pattern. The process of meander bend migration is very active. Lateral migration of 2 km with simultaneous downvalley translation are observed on aerial photographs, from 1983 to 1989. Old meander loops can be seen at a large distance from the present course.

The middle course, from the Barinda offtake to the Kaliganga, displays also a meandering point-bar pattern, but the meander migration is less active.

Downstream of the confluence with the Old Dhaleswari, which comes from the southernmost offtake, the Dhaleswari becomes the Kaliganga, a meandering point-bar then meandering canaliform river where the process of erosion is less and less active.

TABLE 3.1
Regional Rivers - Main Morphological Characteristics

RIVER	Qbank m ³ /s	slope cm/km	depth m	width m	length channel	length valley	sinuosity	river pattern
Upp. Dhaleswari	2100	6.0	7.0	300	40 km	25 km	1.60	sinuous point-bar
Mid. Dhaleswari	1700	4.5	7.0	250	20 km	12 km	1.66	sinuous point-bar
Kaliganga	1700	3.7	9.5	200	49 km	34 km	1.44	sinuous point-bar
Low. Dhaleswari	3000	2.7	10/11	250/300	26 km	21 km	1.25	straight
Old Dhaleswari	200	3.3	3.0	60	62 km	30 km	1.90	meandering
Barinda	400	5.8	2.0	100	52 km	33 km	1.57	meandering
Bangshi South	1300	3.1	10/15	150	25 km	21 km	1.20	sinuous canaliform
Upp. Jhenai	300	3.7	5.0	120	37 km	30 km	1.23	sinuous point-bar
Low. Jhenai	?	5.6	3/4	40/50	85 km	61 km	1.40	meandering
Upp. Bangshi	?	4.2	4.0	50	32 km	18 km	1.80	meandering
Pungli	350	6.7	4/5	80	53 km	38 km	1.40	sinuous point-bar
Bangshi-Pungli	1300	3.9	7.0	100	78 km	60 km	1.30	meandering
Turag								
Buriganga	1300	1.5	10/14	150/200	39 km	38 km	1.0	straight
Lakhya	1700	3.0	10.0	200/250	65 km	53 km	1.20	sinuous canaliform
Old Brahmaputra								
--> Jamalpur	2800	8.4	6.0	500	48 km	40 km	1.20	sinuous point-bar
--> Mymensingh	2800	7.4	6.0	200/300	62 km	49 km	1.24	sinuous point-bar
--> Toke	2800	5.8	8.0	200/300	80 km	61 km	1.30	sinuous point-bar

The lower course of the main Dhaleswari, after the confluence with the Bangshi-South river, is a straight stable and deep channel which flows into the confluence of the Padma and the Meghna rivers.

The Minor Dhaleswari, the Barinda, the Elanganj and the Louhaganj rivers which offtake from the main channel upstream of the Kaliganga confluence, are stable highly meandering channels which flow into the South-Bangshi river, a stable sinuous canaliform stream.

Table 3.1 shows that, as usual in a river system, the slope gradually decrease (from 6 cm/km to 2.7 cm/km) in the downstream direction, as the width decreases and the water depth increases.

It is assumed that the mean diameter of the bed material decreases probably from the offtakes to the confluence with the Meghna. It should not, however, be very different from that of the Jamuna and the Padma.

The sediment load, controlled by the relatively high bed level at offtake, is lower than the Jamuna's. Sediment concentration seems still rather high in the Lower Dhaleswari : this is in line with visual observations of the Dhaleswari-Meghna confluence on satellite imagery, at the end of the wet season.

The upper and middle course of the Dhaleswari are near the threshold between wide-bend point-bar streams, very sensitive to slight changes, and equiwidth meandering and stable streams (see Figure 2). The other rivers are in the stable region of the diagram.

ii) Pungli-Bangshi-Turag system

The Jhenai and the Bangshi rivers are rather stable old meandering channels. The Pungli, a distributary of the Upper Dhaleswari, is a meandering point-bar river with some evidences of erosive activity. These three streams flow into the Turag river, a sinuous canaliform then straight channel which becomes the Buriganga.

The slope gradually decreases from 6.7 cm/km to 1.5 cm/km in the downstream direction, as the width decreases and the water depth increases (see Table 3.1).

iii) Banar-Lakhya system

All this system is composed of stable meandering canaliform rivers.

At its downstream end, the Lakhya becomes less and less sinuous, which gives evidence that the water and sediment discharges are in balance with the channel's capacity for transport (like the downstream ends of the Turag, the Dhaleswari and the South-Bangshi).

iv) Old-Brahmaputra

The Old-Brahmaputra, which follows the old course of the Brahmaputra river, offtakes at the northern end of the North Central Region.

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Its mouth is presently heavily silted up and practically no water flows into the river from the Jamuna at medium and low stages.

In the wet-season, the Jamuna river overflows into the Old-Brahmaputra.

The estimation of the bankfull discharge is 2800 m³/s. The slope is gradually decreasing in the downstream direction, from 8.4 cm/km to 5.8 cm/km at the offtake of the Lakhya river. The channel pattern is sinuous point-bar. The process of meander bend migration is active in the upper course but decreases with the slope, downstream of Jamalpur.

Like the Dhaleswari, the sediment load, controlled by the relatively high bed level at offtake, is probably lower than the Jamuna's. The river is liable to experience significant adjustments if any variation of the dominant discharge or the sediment load occurs.

The Old-Brahmaputra offtake has been studied during the course of this Study and is to be reported on in PSR II. Proposals are made in Annex 2 for further studies required to establish the feasibility of resuscitating the Old Brahmaputra.

3.2 Hydromodelling

3.2.1 Model set-up and calibration

The response of the river systems of the North Central Region to rainfall input and effects of cross-boundary rivers were modelled using the Danish Hydraulic Institute Mike 11 computer software. This model comprises two components: one, called the "NAM" model, calculates the time variation of runoff from excess rainfall on the catchments and the second, the hydrodynamic component, routes this resultant runoff through a simulated representation of the physical river system of the region.

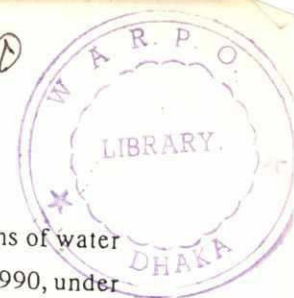
The "NAM" model was calibrated against time variations in groundwater level, rather than the most desirable parameter of resultant measured catchment runoff, owing to the lack of observed surface water monitoring stations from "closed" catchments, (that is, catchments draining through one monitored outlet and having no cross-boundary inputs). Nevertheless, the calibration achieved using the parameter of groundwater level are considered satisfactory for the purposes of this study.¹

The hydrodynamic component of the model was initiated during the Bridging Study, carried out between September, 1990 and April, 1991 and consisted of the preliminary hydrometric and topographic data collection, together with the set-up of the configuration of the river system. Data from 33 rain gauges and 45 water level measurement stations was collected, in addition to all discharge measurement data from 17 stations. Data related to the period 1986 to 1989 inclusive. Subsequently, this data was

¹Details of the model calibration are given in the Preliminary Supporting Report II.5

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augmented with data for the year 1990, as supplied by BWDB and further limited observations of water level and discharge measurement at selected stations during the period August to September, 1990, under the Bridging Study.



The calibration of the "NAM" model was extended during this study to incorporate the data from 1990.

The hydrodynamic model set-up was improved over the model developed during the Bridging Study, primarily in the refinement of the incorporation of the flood plains into the river cross sections, but some adjustment of the river set-up was necessary after further scrutiny of the satellite imagery and field survey.

Owing to limitations of the computer operating system, the Regional model was sub-divided into 3 sub-models. The sub-divisions were made at locations where a common water level was observed, these observations forming the fixed boundary conditions for each sub-model. The eastern sub-model included the rivers Banar, Lakhya, Khir, Khir South, Kaoraid and Sutia. The western sub-model included the rivers Bangshi, Jhenai, Jhenai east, Jhenai west, Chatal, Futikjani, Nanglai north, Nanglai south, Dhaleswari, Kaliganga, Dhantara Khal, Tongi Khal, Turag, Buriganga, Pungli, Elangjani, Louhajang, Old Dhaleswari, Ichamati, Bangsi, together with a number of artificial spill channels from the Jamuna. The Old Bramaputra was modelled using a separate model, since there are only 2 open distributaries, (the Jhenai and the Lakhya), both of which have observation water level stations at the separation points of the model.

The calibration of the Old Bramaputra sub-model relied heavily on the physical configuration of the offtake from the Jamuna, which had not, (up to the time of this report), been surveyed. However, by including an artificial cross section at this point, a satisfactory calibration was achieved.

The eastern sub-model was calibrated satisfactorily for the year 1989 and subsequently verified for 1988 and 1987, after incorporating some adjustments to the initial set-up performed during the Bridging Study.

The western sub-model proved to be the most complex sub-model, due, in part, to its size and also to the complex interaction with the major rivers bordering the region. The size restrictions on the model precluded the inclusion of all probable spill channels from the Jamuna and therefore the accuracy of the model in extreme flow conditions may be suspect. This problem should be overcome when the model is transferred to the UNIX operating system by the Surface Water Modelling Center at a later date. Calibration was made using data from 1989 and subsequently verified for 1987 and 1988.

3.2.2 Incorporation of Engineering Interventions

The basic purpose of the hydrodynamic model is to investigate the effects of the imposition of various engineering interventions, (embankments, drainage, compartmentalization), on the present flooding and drainage situation. To this end, the basic model, as set-up for the calibration runs, was modified accordingly, either in adjusting the physical linkages between rivers, "improving" the conveyance of selected reaches, or representing the construction of embankments along certain rivers.

Within the time frame allowed for this exercise, a degree of detail was sacrificed to permit sufficient model runs to be made in the time. For example, if a reach of river was to be tested for the effects of resectioning, (either by deepening or widening, or both), the cross section in the model was not adjusted but the conveyance was improved by the required percentage by changing the value adopted for the channel roughness along the reach in question.

Where an embankment was to be constructed, if the embankment would cut off any tributaries or distributaries, the boundary conditions on these rivers at the location of the embankment were adjusted such that the flow at the upper point was zero.

If a river discharge was to be restricted, (under normal conditions with a gated regulating structure), a time varying discharge boundary was imposed at the selected point, the discharges being adjusted to the desired magnitude).

The incorporation of diversion channels necessitated the addition of artificial channels of appropriate proportion to carry the required discharge.²

3.2.3 Post-processing of results

The output from the Mike 11 model is in the form of water level and discharge at selected nodal points on the included rivers of the model, (a nodal point being defined as the location of a cross-section as input, or a model generated point if the spacing of the cross-sections in the river exceeds the pre-defined limit). The investigation of the effects of the various engineering interventions required, in addition to the Mike 11 output, the variations of the consequent flooding characteristics of each intervention. A relationship was required, therefore, between the water level at a nodal point in the river system and the area of flooding, (if any), that would result from the water reaching this level.

The incorporation of the flood plains in the model provided the means by which the above information could be ascertained, albeit in a relatively coarse way. Each nodal point, (cross-section), represents the physical characteristics of the river cross-section, (from topographic survey), and a representation of its associated flood plain by means of an area-elevation curve derived from the MPO 1 kilometre square grid of levels which are attributed to the particular flood cell attached to the nodal point.

The area elevation curve cannot present a spacial picture of the distribution of land elevation in the flood cell, but can simply provide an average representation of the amount of the flood cell lying between certain elevations. These area elevation curves are included in the model cross-sections and thus the resulting water level and discharge at a nodal point takes into account the flow of water on the flood plain, albeit fairly simplistically.

²Further details of the methodology employed for incorporation of the engineering interventions are given in the Preliminary Supporting Report II.5

The North Central Region has, for the purposes of the study, been sub-divided into 13 Planning Units. For a meaningful economic analysis of the effects of the engineering interventions, the flooded areas were required to be calculated on a Planning Unit basis. By superimposing the Planning Unit areas on a map of the regional rivers and the associated river nodes and flood cells, each flood cell, (or proportion of a flood cell), could be assigned to a Planning Unit. If the assumption is made that the shape of the area-elevation curve holds good for either all or part of the flood cell, (a reasonable assumption, since the curve has little spacial meaning within the flood cell), a relationship could be derived between the resulting water level at a node, the area of flood plain inundated and the proportion of each Planning Unit containing that flooded area. Using this methodology ensures compatibility between the cross-section used in the model and the flood plain configuration used for flooded area calculations.

The calculation of flooded areas is performed using a purpose written software suite which considers each nodal point on each river in turn and then integrates the results over the entire region to give the flooded area within each Planning Unit for each engineering intervention considered.

A refinement to the above calculation considers the area flooded in each Planning Unit for a depth of flooding appropriate to the MPO flood phase limits. These limits are termed "notional", since they have no specific return period or duration context, but apply only to the actual year of the model run.

CHAPTER 4

DEVELOPMENT FRAMEWORK

4.1 Preparation of the Regional Plan

4.1.1 General

The preparation of the Regional Water Development Plan involves much field work, data collection, analysis, gathering of views and the coordination of many disciplines. The NCRS is being carried out within the overall framework of the Flood Action Plan (FAP) and both provides information to and depends on information from other FAP studies. Linkages are being maintained with most FAP studies but those of particular relevance to the NCRS are as shown in Table 4.1. Other activities of particular relevance are given as Table 4.2.

TABLE 4.2
Other Activities of Particular Relevance to FAP 3

No.	FAP Study Activity	Relevance to NCR Study
1	FINNMAP	National Programme of aerial Photography and Topographic Mapping includes FAP-3 and FAP 3.1 areas.
2	Jamuna Bridge	Left bank bridge approach works affect the NCRS embankment alignment option and may close the Northern Dhaleswari intake Channel.

C:\123\INTERIM\TABLE4.WK1

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The approach to planning and impact assessment also draws heavily on the guidelines prepared by the FPCO (FPCO 1991).

4.1.2 Methodology

The preparation of the Draft Regional Water Development Plan (DRWDP) has followed a planning process as summarised in Figure 4.1.1. Three main categories of activity are being carried out simultaneously:-

- planning unit analysis
- derivation of development options
- supporting analyses on the many disciplines and activities relating to the plan

4.2 Derivation of Planning Units

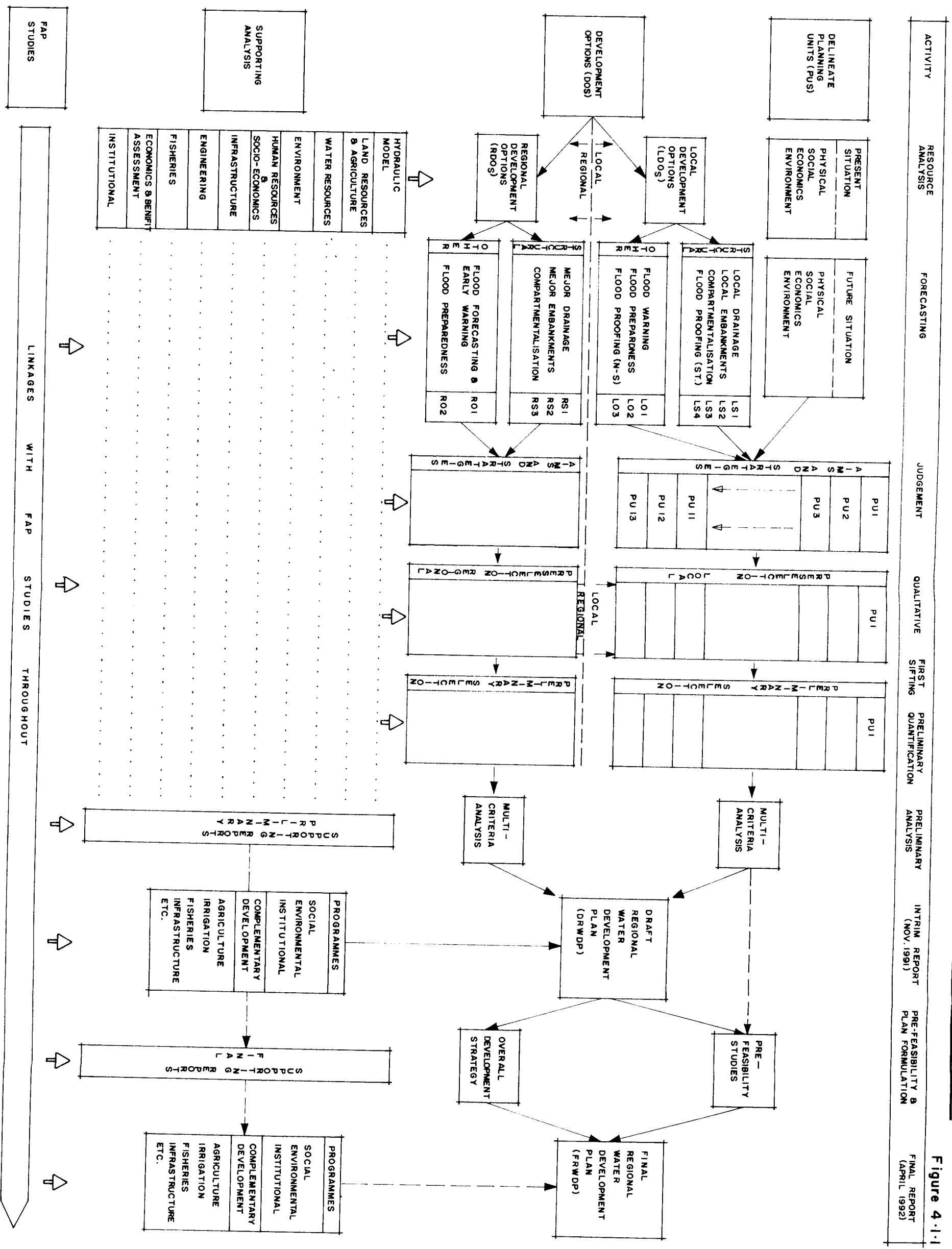
The Region has been divided into Planning Units (PUs) to assist in classifying the characteristics of the region, and to allow alternative development strategies to be prepared for different PUs.

These PUs have been delineated using hydrological characteristics, but also allowing for resource characteristics such as soils, land use, population intensities and considering administrative boundaries where significant. Thirteen PUs have been designated (see Figure 1.1.1). It should be stressed that the PUs are defined to assist in the planning process, they are not development units and it is likely that some development options may need to be implemented over more than one PU.

The PUs have been analysed using a multi-disciplinary approach. The results of the analysis are summarised in Chapter 5, further detail will be presented in PSR IX.

PLANNING PROCESS

Figure 4-1-1



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TABLE 4.1
FAP Studies of Particular Relevance to FAP 3

No.	FAP Study Activity	Relevance to NCR Study
1	Brahmaputra Right Embankment Strengthening	Flood design levels common to right and left banks RB alignment setback input for main river hydromodelling. [Boundary conditions]
10	Flood Forecasting and Early Warning	Proposals made by FAP-10 will need to be integrated with the formulation of developments in NC Region.
11	Disaster Preparedness	Proposals made by FAP-11 will need to be integrated with the formulation of developments in NC Region.
8A	Greater Dhaka Protection Project	Flood Protection works interface on NCRS system.
8B	Dhaka Integrated Town Protection Project	Flood Protection works on NCRS River System.
9A	Secondary Terms Flood Protection	Only 3rd priority towns are within North Central Study area. Therefore Mymensingh, Jamalpur and Manikganj.
13	Operation & Maintenance Study	To provide procedures for incorporation of disadvantaged groups for future O&M Programme.
14	Flood Response Study	To provide guidelines estimates to benefit & disbenefit FCD for flood action plan projects for population in flood plain area and flood protection option.
15	Land Acquisition and Settlement Report	To identify ways of improvement to present land acquisition process and resettlement of displaced people.
16	Environmental Study	To provide guidelines for environmental impact assessment and mitigation planning.
17	Fisheries Study and Pilot Project	Provision of data on FCD impact and fisheries resource development guidelines.
18	Topographic Mapping	To continue ongoing activity to provide appropriate aerial photographs Satellite imagery Topographic mapping for FAP activities.
19	Geographical Information System (GIS)	To develop a system for Geographical based data obtaining, storing manipulating and retrieving for FAP activities.
20	Compartmentalization Pilot Project	To develop and test compartmentalization FCD in protected areas on pilot NCR area should provide useful information.
21	Bank Protection	Pilot project to develop appropriate effect & economical method of river training and bank protection essential for NCR area works.
22	AFPM Pilot Project	Active flood plain protection reclamation applicable to Jamina AFPM.
23	Flood Proofing Pilot Project	To identify and test effective measures to mitigate flood effects especially in unprotected areas.
24	River Survey Programme	To collect hydrological & morphological data needed for FAP project inputs for hydromodelling.
25	Flood Modelling Management Project	Simulation modelling co-ordination assist in production of models for FAP studies including FAP-3 at SWMC (MPO). Principally provides reference boundary conditions to regional studies.
26	Institutional Development Programme	To establish institutional requirements for planning implementing and managing the FAP projects and to undertake the implementation of the recommendations.

C:\123\INTERIM\TABLE4.WK1

4.3 Development Options

The development options have been identified both from earlier work in the Study and from related activities being carried out in other FAP studies. The options apply both at a local and regional level (see Figure 4.1.1) and in some cases the local option is dependent on a regional scheme being already in place.

The options can be categorised as 'structural' or 'other'. Structural development options involve a physical intervention on the present flooding and drainage situation. 'Other' includes mainly non-structural development options although they may be some limited physical works included.

The degree of control which can be imposed on both flooding and drainage within an area will be totally dependent on the structural measures which are applied and the efficiency and effectiveness of the water management system. The degree of control of flooding and drainage which is required is a separate factor and will be dependent on the production and economic activities or potentials of the area in question.

The proposed approach is one of permitting sufficient flooding so as not to adversely impact on fisheries and navigation whilst taking into account the benefits to be gained from reduced flood damage to agriculture, infrastructure, housing and industry. It should be an approach which does not impact greatly on the natural systems.

The main imposed situations are :

- the existence or occurrence of major flood flows and hence levels around the entire region
- the occurrence of high rainfalls
- the existence of infrastructure which impedes natural drainage
- the downstream water level control at the confluence of the Meghna and Padma which impairs drainage.
- complex microrelief within each planning unit
- topography (e.g. Arial Beel)

The main development options being studied are as follows:

A. Structural

a) flood embankments

- fully controlled flooding (based on full flood control along the major rivers by embankments and fully gated structures)
- semi-controlled flooding (where flooding depends partly on embankments with fully gated structures, and partly on natural openings or semi-regulated ones).

b) drainage and river improvements

- controlled major drainage and river improvements;
- uncontrolled major drainage and river improvements;

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c) flood embankments and drainage

- combinations of the above options

d) compartmentalisation

- minor river flood embankments/drainage improvements and including water management systems comprising peripheral inlet/outlet structures, internal water control works, channel improvement, and infrastructure improvements.

These options are being refined by planning unit in order to obtain an optimum development situation according to technical, economical, financial, social and environmental criteria.

The basic components to achieve the structural development options are:

- major river flood embankments
- minor river flood embankments
- submersible embankments
- major river training, under FAP-21/22
- major inlet/outlet structures on the embankments
- main and minor river drainage improvements
- gravity drainage outlets
- pumped drainage
- compartmentalisation
- development of unprotected or partially protected areas in terms of flood proofing

B. Other Options

Other options for flood damage mitigation which are being considered include:

- flood preparedness
- early warning systems (linked to flood preparedness)
- flood proofing or adjustment
(introduction of crop varieties less susceptible to flood damage)

4.4 Prediction of Impacts and Selection of Criteria

4.4.1 General

The approach to impact assessment and multicriteria analysis is being evolved as the Study progresses. A summary of the approach is outlined below and will be reported on in more detail in PSR X.

It must be stressed that developments relating to changes to agriculture and hydraulics in the region should not be dissociated from the regional socio-economic development. Agricultural development resulting from intervention on the hydrological system may be either the spear head for rural development or simply an accompanying measure (small scale agricultural hydraulics) like many others (fisheries, crafts and small scale rural industries etc.)

A development analysis must be qualified by the fact that today's farms rarely obtain their income solely from agriculture; various complementary activities are for the most part associated with this activity. Depending on the socio-economic class of the producer these complementary activities include irrigated or rainfed cropping, fisheries, services (labour, tools), crafts, commerce, informal family-run business around population centres etc. Some farm units also obtain income from abroad (sent by emigrants working in foreign countries). All categories of peasants (whether or not they are landowners, proletarianised, suburbanised, displaced or benefiting from emergency aid) may be considerably effected by changes related to hydraulic development directly or indirectly.

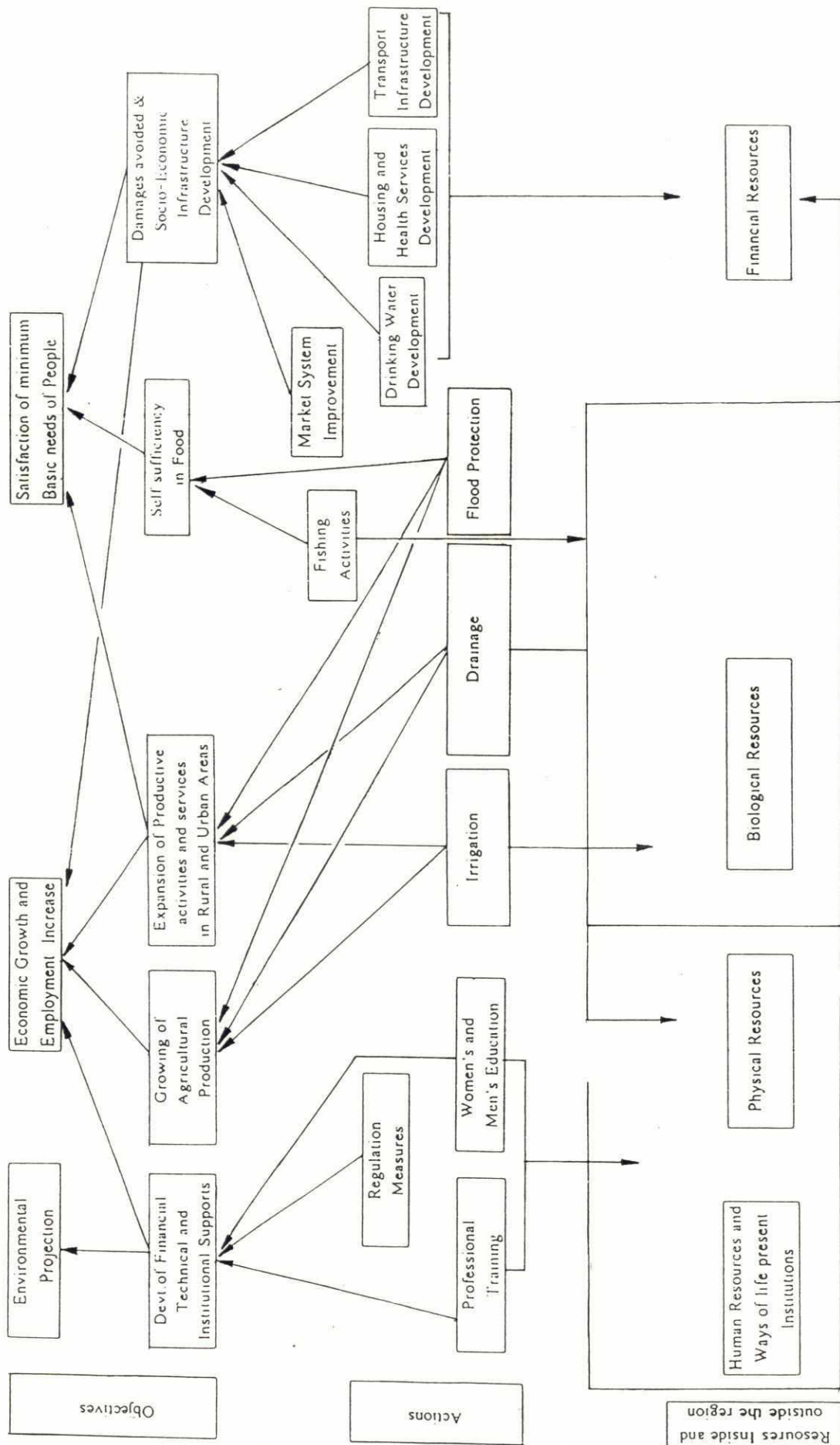
There are many reasons why the main rural development objectives of the Government must be taken into account to obtain water development options that are well suited to the human needs. The factors involved are summarised in Figure 4.4.1.

Considering these objectives an approach to a multicriteria analysis is outlined below. At this stage only preliminary consideration has been given to this analysis but the approach will be developed further as the Study progresses and as more substantive and quantitative data is obtained:-

Stages in the Multicriteria Analysis

- a. the identification of the regional development factors which can be grouped together under the following groups:
 - objectives
 - measures and actions
 - physical, biological, financial, and human resources
- b. the analysis of relations between actions and objectives on the one hand, between actions and resources on the other hands (in the first case the type of relation means "contributing to", in the second case the type of relation means "depending on").
- c. the definition of impacts squaring with these types of relation (see Table 4.3 which give an inventory of the regional development impacts which can occur).

REGIONAL DEVELOPMENT
OBJECTIVES - ACTIONS - RESOURCES



- 12
- c. the selection of the criteria which can assess quantitatively or estimate qualitatively each of the impacts previously identified. (see table 4.4)

4.4.2 Impact Assessment

The impact of possible schemes on the major outputs of agriculture and fisheries have been estimated following the assumptions outlined in Sections 2.5 and 2.6. The major contributory factor in these assessments has been the change in flood depths and durations calculated from runs of the coarse pilto model, see Section 3.2. The benefits or dis-benefits result from changes in cropping patterns due to the increased flood protection afforded, changes in the anticipated flood damage (to be described further in PSR X.1) and from changes in the fish yield relating to flood water volumes depths and patterns of flow.

TABLE 4.4

Criteria Selection

Checklist related to planning unit analysis

Quantitative Criteria	Comments
A. Economic Criteria <ul style="list-style-type: none"> - Contribution to National Income - EIRR % - NPV 12% Tk. Million - NPV (1) ratio - NPVR (2) ratio - Increase in value added/per year % - Investment and O&M costs % - Cost/Benefit ratio - Cost of land acquisition Tk. Million - Mitigation costs Tk. million - Increase in: <ul style="list-style-type: none"> - Value added/year/capital Tk. - net benefit/per year % 	<ul style="list-style-type: none"> - Economic Internal Rate of return - As defined in the FPCO "guidelines" (May 1991) - As defined in the FPCO "guidelines" (May 1991) - As defined in the FPCO "guidelines" (May 1991) - Increase % of value added from agriculture - Capital cost and operating and maintenance costs - Capital cost divided by total benefits - Average cost of land per acre x number of acres - Total additional costs for mitigation actions - Increase of incremental crop income per capita - Taking into account drainage reducing and fisheries losses
B. Agricultural Production Criteria <ul style="list-style-type: none"> - Area involved in the project % - Increase in Paddy production % - Cropping intensity % 	<ul style="list-style-type: none"> - Extension of the project impact inside the Planning unit - Percentage of increase due to the project - New cropping intensity due to the project
C. Fishing Production Criteria <ul style="list-style-type: none"> - Population to be resettled % - Changes in permanently flooded areas % - Changes in temporary flooded areas % - Changes in fishermen affected population % 	<ul style="list-style-type: none"> - Population to be resettled percent of total population - Reduction or extension of permanently flooded areas - Reduction or extension of temporary flooded areas - Reduction of the total flooded areas x population density

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TABLE 4.3
REGIONAL DEVELOPMENT DIRECT IMPACTS IDENTIFICATION

Actions	Contribution to objectives		Environmental Effects (Physical and Biological Aspects)
	Economic effects	Social and Institutional Effects	
Irrigation	- Increase of Agricultural Benefits	- Income improving population benefitting	- Ground water tapping increase
Drainage	- Expansion of productive activities and services	- Income distribution food contribution	- Ecological alternation
	- Increase of Agricultural Benefits	- Income improving employment increase	
Flood Protection	- Expansion of productive activities and services	- Income distribution food contribution	- Land acquisition for hydraulic infrastructure
	- Increase of Agricultural Benefits	- Income improving	- Ecological Alteration
Market system improvement	- Reducing of flooding damages	- Income distribution food contribution	- Land acquisition for hydraulic infrastructure
	- Improving of Inland Transport infrastructure system	- Security infrastructure system	- Fertility decrease - Erosion reducing - Ecological Alteration - Alteration of Fishing activities - Land acquisition for infrastructure - Navigability of river - Water need - Environmental protection
Domestic water supply	- Constraints for navigation Expansion of productive activities and services	- Employment increase	
	- Cost reducing	- Health improving	- Population benefitting - Population Benefitting - Employment increase - Employment increase
Navigation and Inland Transport	- Increase of Commercial Exchanges	- Strengthening of Technical institutional and financial support	
Housing and Health Services	- Expansion of productive activities and services	Food contribution	
Education and Training	- Development of Economic		
Regulation and Institutional Measures	- Management		
Fishing activity	- Fishing benefits		

CHAPTER 5

PLANNING UNITS

5. Planning Units

Appropriate information is outlined below for each Planning Unit on the following aspects:-

- rainfall
- hydrology
- land resources
- soils
- flood categories
- areas
- cropping
- groundwater
- fisheries
- population densities
- existing embankments
- possible water development options

Much of the data is presented on the figures. Other information can be found in Chapter 2 and will be presented in more detail in the Preliminary Supporting Reports.

5.1 PU 1

5.1.1 Characteristics

Land Resources: Active Jamuna Flood Plain $\pm 20\%$
Young Jamuna Flood Plain $\pm 45\%$
Old Brahmaputra Flood Plain $\pm 35\%$

Soils : Silt loam, silty clay loam, sandy loam, clay. Active Jamuna Flood Plain area near Jamuna Southern Chatal and the Northern Old Brahmaputra rivers are facing river erosion problems and problems with fresh deposits of sand and silt.

Floods : Most of the area is only shallowly flooded. Only the areas near the Jamuna and the Chatal rivers are moderately flooded. Risk of sudden flash floods on the active Jamuna Flood Plain. There are some small water bodies on the area N.W. of Melandaha on the Old Brahmaputra Flood Plain ($\pm 5\%$ of the area).

Flood Categories: Fo = 24%, F1 = 55%, F2 = 21%, F3 = negligible.

Groundwater : The aquifer conditions in PU 1 are among the best in the North Central region, with average storage coefficient exceeding 12% and tubewell specific capacities of 17 l/s/m. At present, maximum SWL averages 6.5m at the end of April, allowing STWs to operate in almost all areas.

Minor irrigation : Well developed and already meets some 60% of estimated irrigation demand. STWs are the dominant method in this area. The assesement indicates that under present conditions, groundwater could supply 100% of the estimated residual irrigation demand. The introduction of partial flood protection would reduce groundwater recharge by about 6%, but this would have no significant effect on resources which would still substantially exceed demand.

Agriculture : Agricultural area(cultivated) 70,009 HA = 78.4% of gross area
Irrigation area 39,197 HA = 56% of CTA
Cropped area 147,524 HA
Cropping intensity 211%

<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-Irrigated</u>
Single cropped	Boro	Sugarcane/Spices/Jute/Aus/ D.W.Aman/Fruit trees
Double cropped	Boro -T.Aman Aus/Jute-Boro D.W.Aman-Boro	Aus/Jute-T.Aman Sugarcane-Vegetables(mixed) T.Aman-Rabi crops
Triple cropped	Boro-Summer Veg.- T.Aman Boro-T.Aman-Mustard	Summer Vegetables-T.Aman- Winter Vegetables/Chilli Aus-T.Aman-Winter Vegetables Aus/Jute-T.Aman-Potato

Production	HYV	%	Area (Ha)		% of CTA	HYV	Production (Ton)		% of rice prod.
			Local	Total			Local	Total	
T.Aman	23118	55	18775	41893	59.8	74872	37331	112203	31.7
Boro	38689	92	2392	41081	58.7	220008	6506	226514	64.0
Aus	1129	12	8249	9378	13.4	2802	11157	13959	3.9
B.Aman			1015	1015	1.5		1460	1460	0.4
Total Rice	62936	65	30431	93367	133.4	271689	57467	354136	
jute				10922	15.6			17830	
Wheat				4949	7.1			11036	
Mustard				3053	4.4			1582	
Other Crops				35211	50.3				

Limitations: Some local drainage problems. Flash floods in early rainy season (June, July)
River erosion in Active Flood Plain areas. Sand deposits due to floods.

5.1.2 Aims and Strategy

Development Aims

- to reduce flood risk to agriculture in the area particularly in the pre-monsoon period and to reduce sand deposition
- reduce the loss of land and homestead through riverbank erosion
- to provide controlled flooding in the area to provide an environment for increased t.aman production which can benefit from the high level of irrigation facilities existing in the area;

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- to reduce the susceptibility to damage of the two railway lines (Jamalpur-Dewanganj and Jamalpur-Sarishabari) and the roads (main and feeder) in the area;
- to preserve or improve the fishery resources in the area

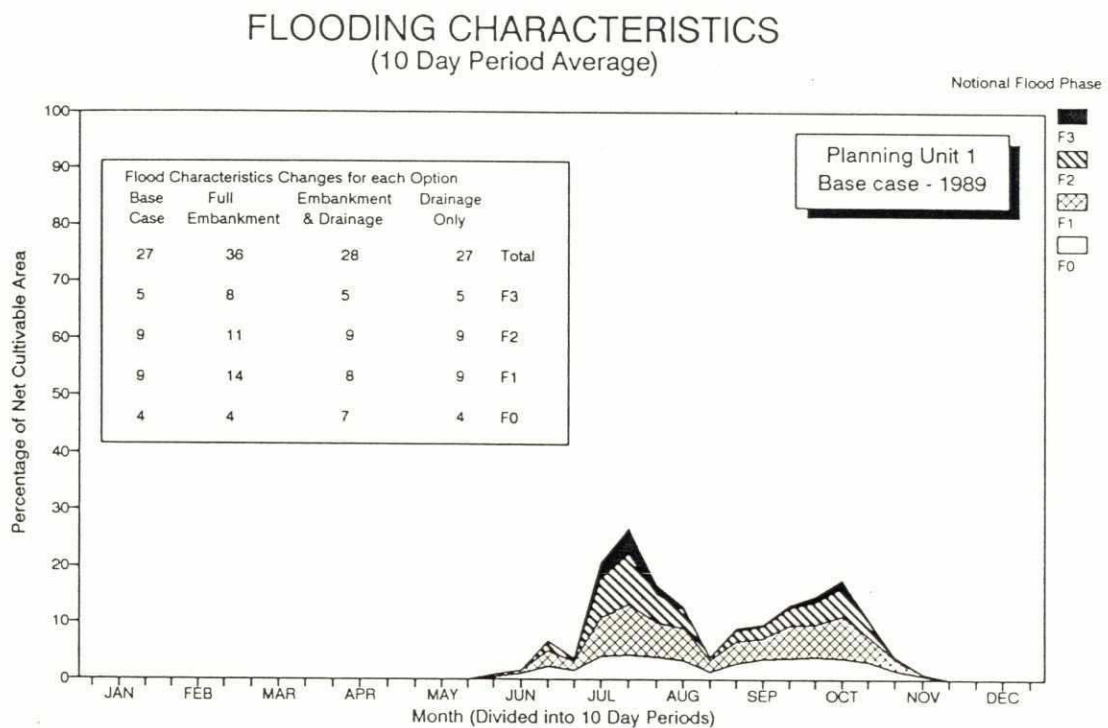
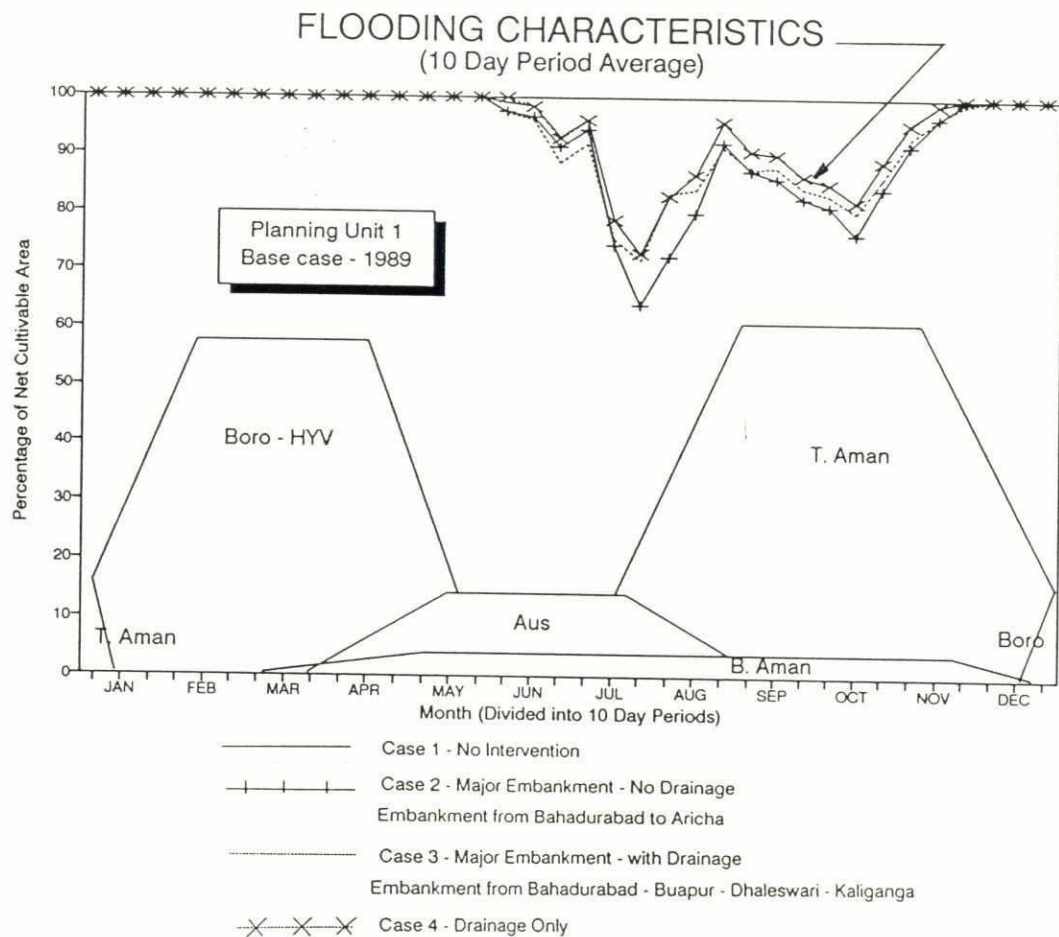
Development Strategy :

- upgrade and complete the embankment along the left bank of the Jamuna from Dewanganj to Sarishabari;
- to regulate inflow from the Jhenai River;
- consider regulation of flows through Baushi Bridge and at the junction of the River Chatal and Jamuna river
- study ways of protecting the railway line between Jamalpur and Dewanganj and the viability of a parallel new embankment closer to the Old Brahmaputra;
- provide temporary protection at key points on the rail line between Jamalpur and Sarishabari; thereafter assess the magnitude of potential damage when the main Jamuna embankment is in place and effective;
- provide for controlled flooding for the free movement of fish into the central part of the area where beel fisheries are important. The flood control management should also ensure adequate groundwater recharge potential is maintained;
- investigate the potential/viability for compartmentalisation in the area;



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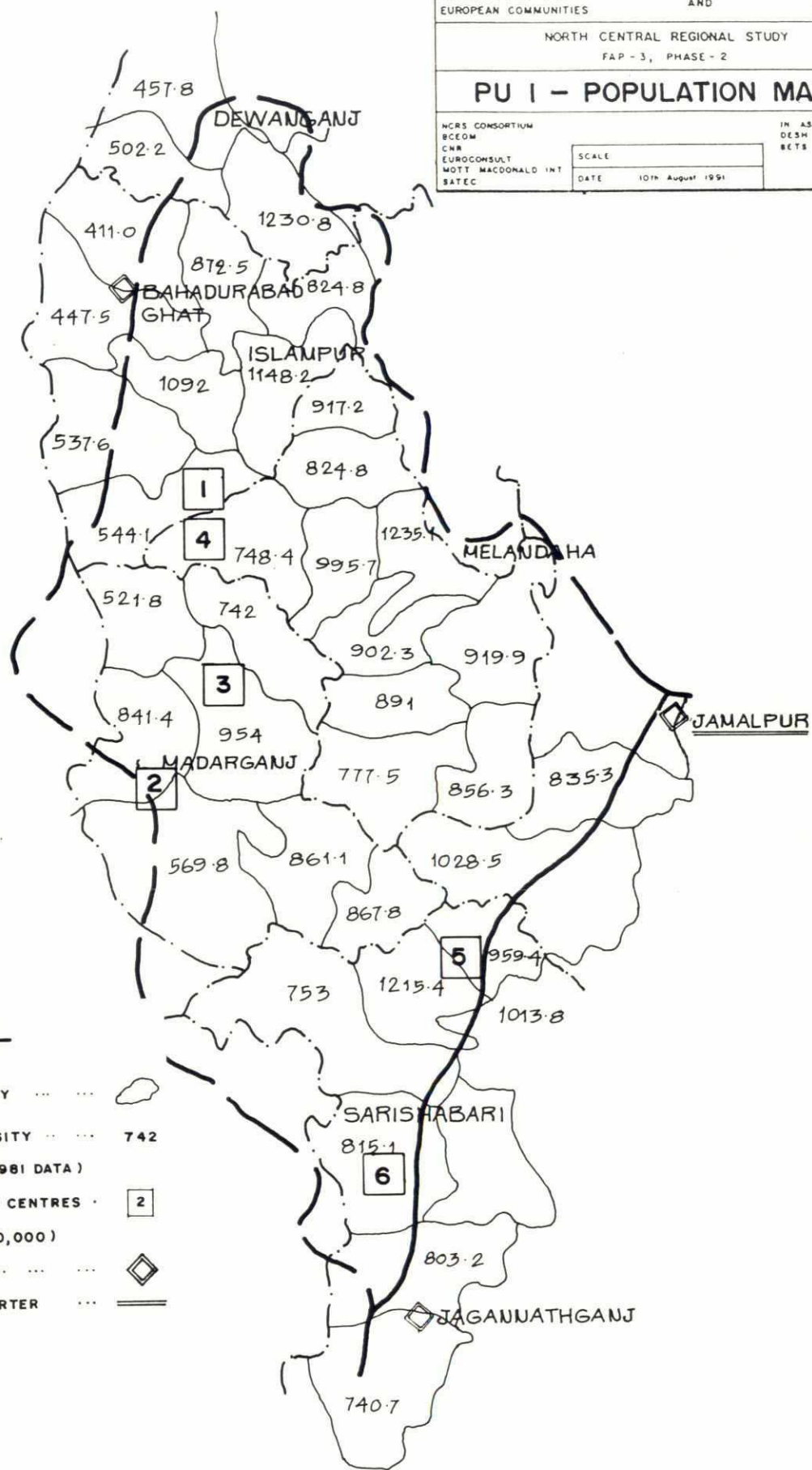
Figure 5.1.2
PU1 - Cropping Calendar and Flood Characteristics



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Figure 5.1.3

GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL	
COMMISSION OF THE EUROPEAN COMMUNITIES	AND GOVERNMENT OF FRANCE
NORTH CENTRAL REGIONAL STUDY FAP - 3, PHASE - 2	
PU I - POPULATION MAP	
<small>NCRS CONSORTIUM BCEOM CNR EUROCONSULT MOTT MACDONALD INT SATEC</small>	<small>IN ASSOCIATION WITH DESH UPODESH LTD. BETS</small>
SCALE	DATE 10TH August 1991



LEGEND :—

- MAUZA BOUNDARY
- POPULATION DENSITY 742
(PERSONS /Km², 1981 DATA)
- POSSIBLE GROWTH CENTRES 2
(POPULATION > 10,000)
- MAJOR TOWNS
- DISTRICT HEADQUARTER

5.2 PU 2

5.2.1 Characteristics

Land Resources: Young Jamuna Flood plain, Western part $\pm 60\%$
Old Brahmaputra Floodplain, Eastern part $\pm 35\%$
Older Jamuna Floodplain, Middle part South $\pm 5\%$

Soils : Silty clay loam, some areas with a firm subsoil (plastic) especially in the area South of Jamalpur and North of Ghatail.

Floods : Mainly rain water floods, in basins floods from 4-6 months at a depth of 6-12 feet, east of Gopalpur, 4-10 months. About 30-35% of the cultivated area is flooded every year.

Flood Categories Fo = 30,5% F₁ = 48,2%, F₂ = 16,7%, F₃, 4,6 %

Groundwater : The aquifer conditions are similar to PU 1 and are favourable, with average storage coefficient exceeding 9% and tubewell specific capacities of 14 l/s/m. At present, maximum SWL averages 6.9m at the end of April, allowing STWs to operate in almost all areas.

Minor irrigation : Very intensive and already meets some 64% of estimated irrigation demand. STWs are the dominant method in this area. The assesement indicates that under present conditions, groundwater could supply 100% of the estimated residual irrigation demand. The introduction of partial flood protection would reduce groundwater recharge by about 5%, but this would have no significant effect on resources which would still substantially exceed demand.

Agriculture : Agricultural area
(cultivated) = 59,850 HA = 83% of gross area
Irrigated area = 36,150 HA = 60%
Cropped area = 130,715 HA = 218%
Potential increase irrigation is limited (not more than 10%)

<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-Irrigated</u>
Single cropped	Boro	Aus/Aman
Double cropped	Aus/Jute-Boro	Aus/DW.Aman/Jute-Wheat/Potato/Rabi crops
Triple cropped	Aus/Jute-T.Aman-Boro, Mustard/Vegetables-T.Aman-Boro	Aus/Jute-T.Aman/Rabi crops

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Production	Area(HA)	% CTA	Production (Ton)	%
T.Aman	33,599	56.1	91,518	36.6 of rice crop
Boro	36,813	61.5	128,246	51.3 "
Aus	9,640	16.1	14,552	5.9 "
D.W.Aman	9,309	15.6	15,457	6.2 "
Total Rice	86,469	149.3	249,774	
Jute	7,961	13.0	13,271	
Wheat	3,513	6.0	6,523	
Mustard	3,434	6.0	2,765	
Other crops	17,655	44.7		

Limitation: Major limitation is drainage. This involves major system of rivers as well as local drainage impediments as river banks, roads etc.

5.2.2 Aims and Strategy

Development Aims

- reduce the amount of damage/loss of land/homestead through river bank erosion;
- reduce the amount of spillage from the River Jamuna during high floods and thereby reduce crop loss and infrastructure damage in the area;
- improve the hydraulic efficiency of the Jhenai River (although this might not be necessary if spillage into Sub-Region A1 is reduced);
- further increase agricultural development in the area, increase the security of the T. aman cultivation enabling farmers to increase HY aman cultivation and yields;
- reduce crop damage in the pre-monsoon period;

Development Strategy :

- investigate the viability of river training or bank protection on the River Jamuna; linking with the studies/requirements of the Jamuna Bridge Project and FAP-1;
- investigate and improve the quality of main embankment between Jagannathganj and Bhuapur. Review and revise the plans for improving the embankment for road construction in relation to the fertiliser factory.
- reduce the inflow through Baushi Bridge into the Jhenai at peak flood periods
- Ensure that flow/channel functioning should be maintained to a certain level for fisheries, navigation and dry season requirements;
- identify potential compartmentalisation configurations to improve the water management in different parts of the area;
- by modifying the flooding regime promote agricultural development both of monsoon crops (rainfed) and irrigated crops;
- improve the natural drainage system by improving cross drainage facilities.

PU 2/4 - PLANNING MAP

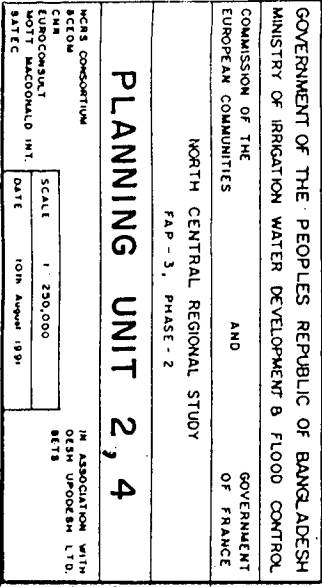
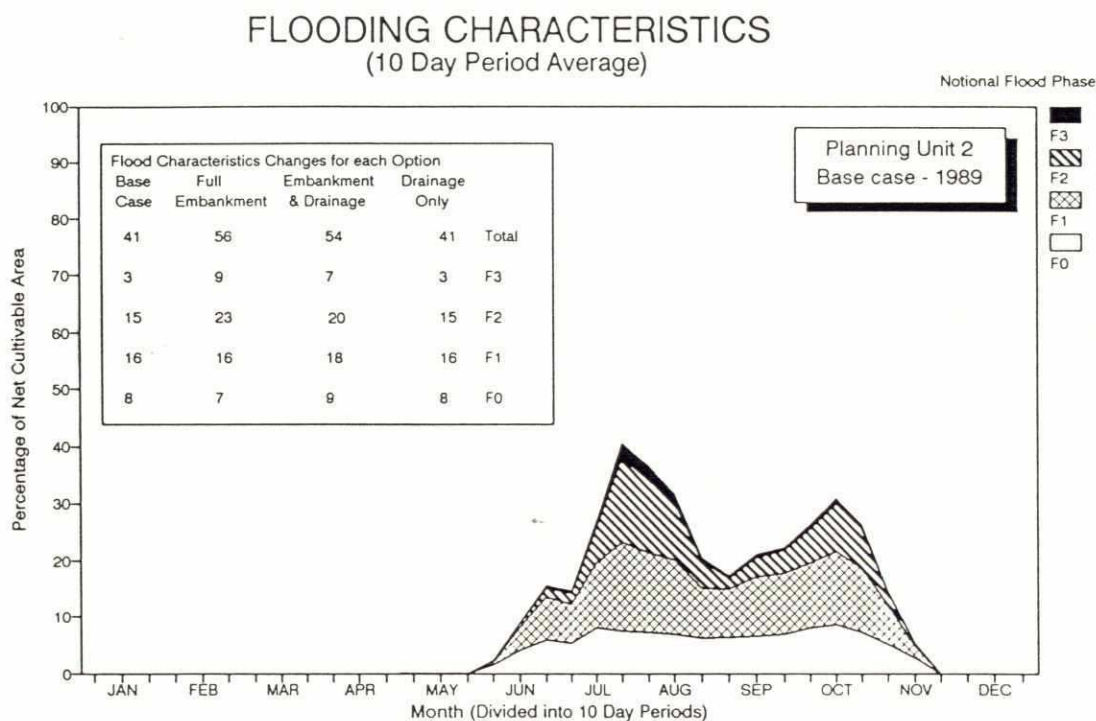
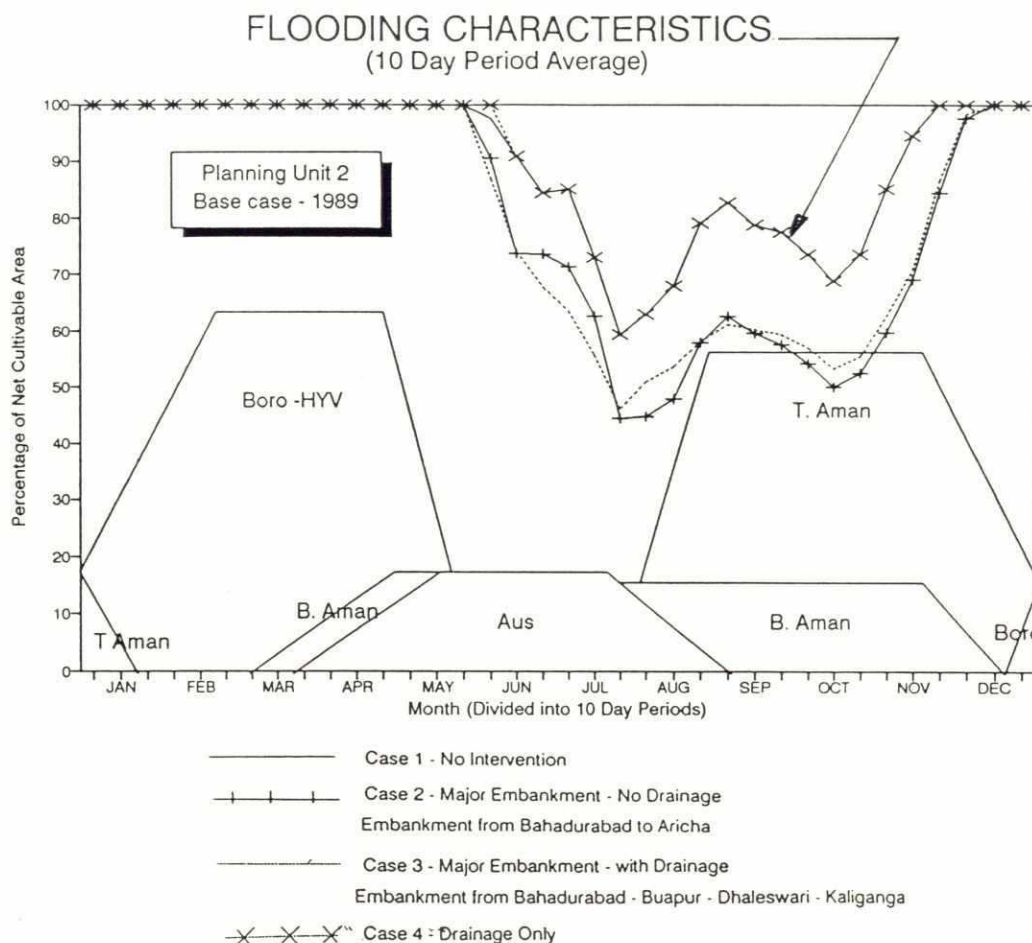
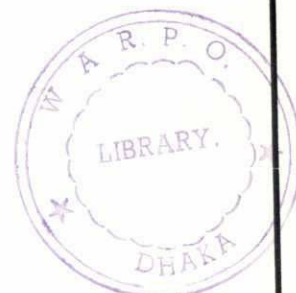
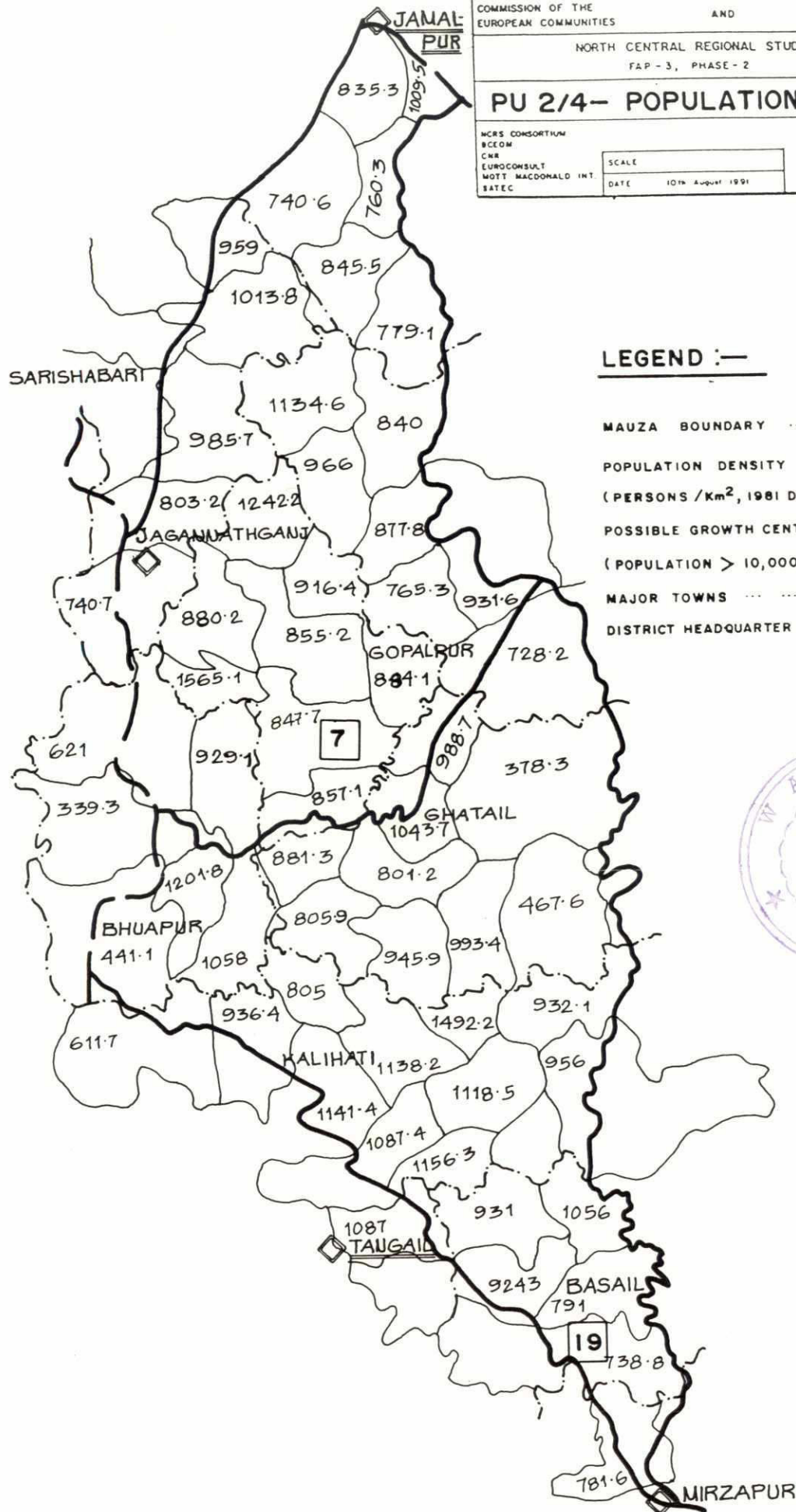


Figure 5.2.2

PU2 - Cropping Calendar and Flood Characteristics



GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH	
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL	
COMMISSION OF THE EUROPEAN COMMUNITIES	AND GOVERNMENT OF FRANCE
NORTH CENTRAL REGIONAL STUDY	
FAP - 3, PHASE - 2	
PU 2/4- POPULATION MAP	
<small> NCRS CONSORTIUM BCCOM CNR EUROCONSULT WOTT MACDONALD INT. SATEC </small>	<small> IN ASSOCIATION WITH DESH UPODESH LTD. BETE </small>
SCALE	DATE 10th August 1991



5.3 PU 3

5.3.1 Characteristics

Land Resources: Young Brahmaputra Flood Plain. Small area along Brahmaputra $\pm 15\%$
 Old Brahmaputra Flood Plain $\pm 80\%$
 Madhupur Tract $\pm 80\%$

Soils : Silt loam, silty clay loam, silty clay, clay loam, clay,

Floods : River valleys and depressions can be flooded during rainy season. Floods only from rainwater. Numerous beels and khals used for drainage purposes. Flash floods, early and late, are occurring.

Flood categories: Fo = 27%, F1 = 51%, F2 = 20%, F3 = 2%

Groundwater: The aquifer conditions are relatively unfavourable, with storage coefficient averaging only 1.8% and tubewell specific capacities of averaging 6.5 l/s/m. At present, maximum SWL averages 11.8m at the end of April, allowing STWs to operate only on the lowest land. Force mode tubewells required for irrigation over most of this area.

Minor irrigation: Currently meets some 34% of estimated irrigation demand. DTWs are the dominant technology. The assesement indicates that under present conditions, groundwater could supply a maximum of 60% of the estimated residual irrigation demand due to the unfavourable aquifer conditions. The introduction of partial flood protection would would have little effect on groundwater recharge (2% reduction), and would not affect resource potential, which is already constrained by aquifer conditions.

Agriculture Agricultural area (cultivated) = $\pm 127,979$ HA $\pm 75\%$ of gross area
 Irrigated area = $\pm 40,472$ HA $\pm 31.6\%$ of CTA
 Potential increase of irrigated area limited
 Cropped area = $\pm 241,622$ HA $\pm 189\%$ cropping intensity

<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-irrigated</u>
Single cropped	Boro	Aus/Jute, T.Aman, Vegetable, Spices
Double cropped	Boro-T.Aman Jute/Aus-Boro	Aus/Jute - T.Aman Aus/Jute - Rabi crops T.Aman - Rabi crops
Triple cropped	Aus/Jute-T.Aman-Boro T.Aman-Vegetables-Boro	Aus/Jute-T.Aman-Vegetables/Wheat/ Spices

Production	Area(Ha)	% of CTA	Production(Ton)	%
T.Aman	100,458	78	276,169	46.0
Boro	44,857	35	177,516	29.0
Aus	64,760	51	149,599	25.0
D.W.Aman	200	0.2	371	0.1
Total Rice	210,276	164	603,654	100.0
Jute	9,285	7	14,815	
Wheat	5,732	4	10,323	
Mustard	1,637	1	1,073	
Other Crops	14,692	11		

Limitation : Drainage of rainwater, rivers and khals are silted and even used to grow crops (boro).
Major drainage problems in SE area.

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5.3.2 Aims and Strategy

Development Aims:

- to reduce damage from floods by increasing the hydraulic efficiency of the regional rivers
- to utilise the Upper Shila scheme to bring the optimum benefits to the PU
- to improve the availability of irrigation water for agricultural development in the area
- to reduce crop damage in the pre-monsoon period

Development Strategy

- investigate the possibility of improving the drainage system
- identify potential compartmentalisation configurations to improve the water management in different parts of the area
- investigate the possibility of supplying additional water into the area (from the Old Brahmaputra) for irrigation use
- study the possibility of raising and strengthening the railway embankment to give greater protection against flooding from the Old Brahmaputra

Figure 5.3.1

PU 3 - PLANNING MAP

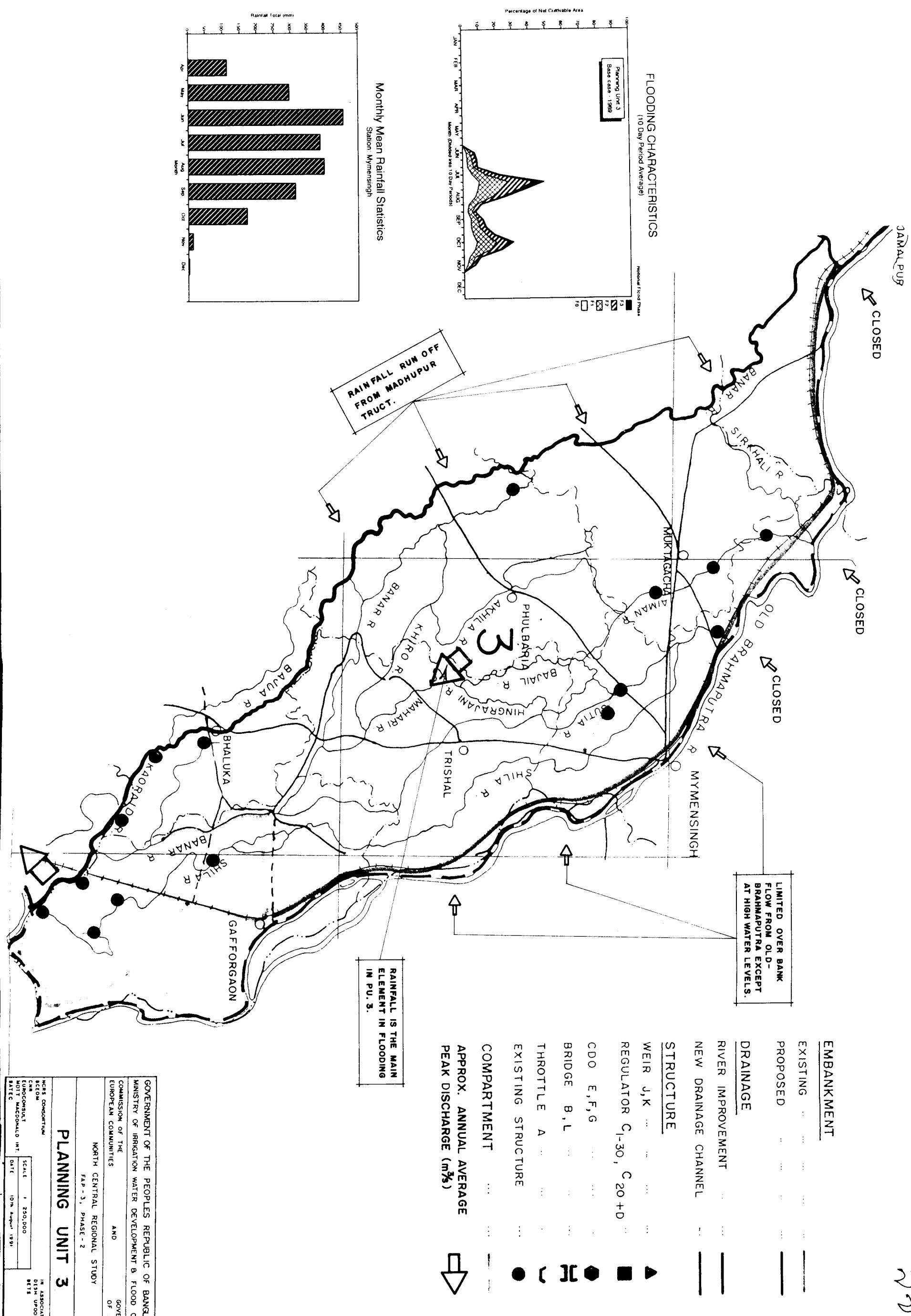
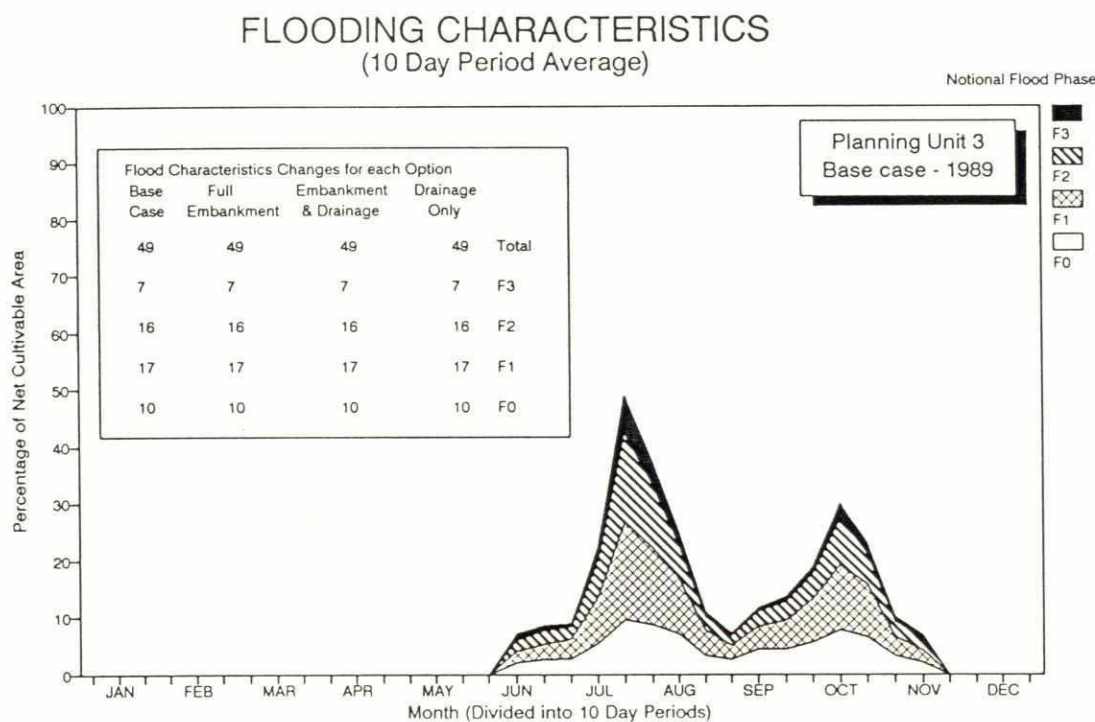
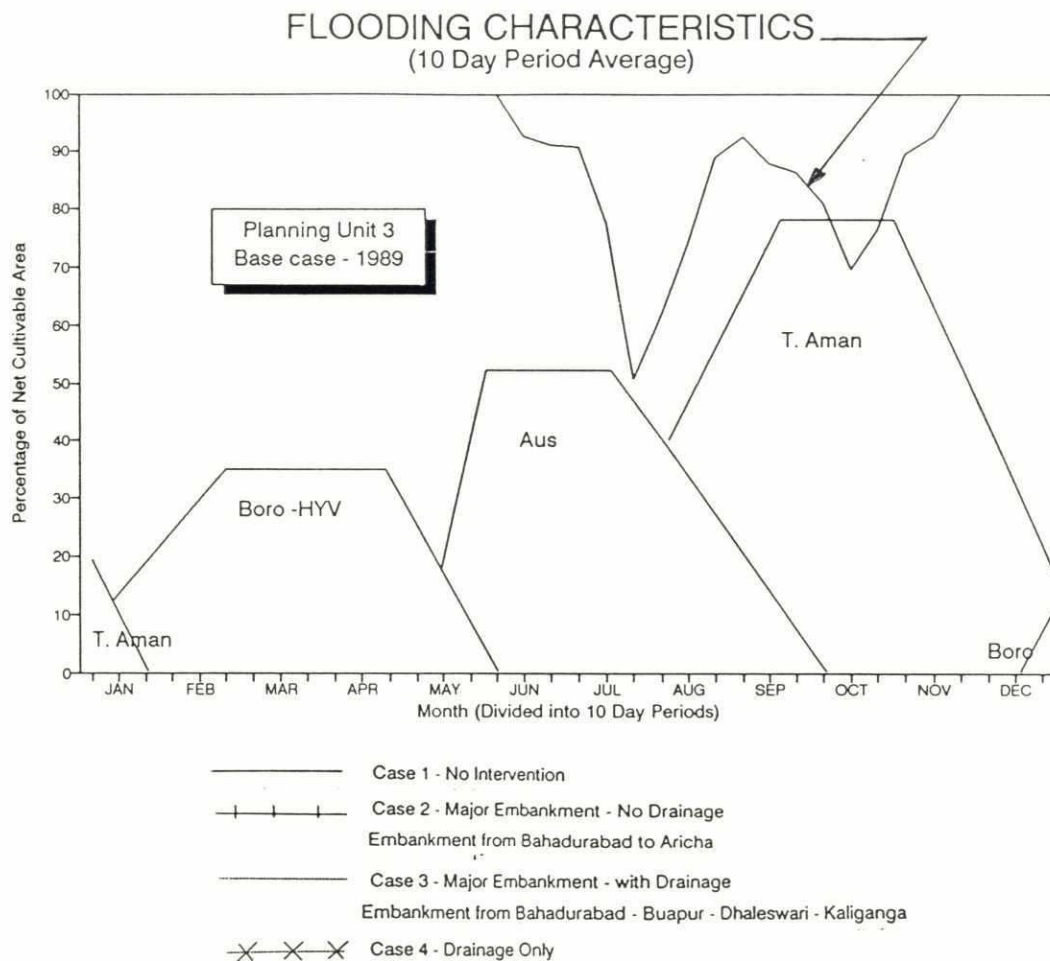


Figure 5.3.2

PU3 - Cropping Calendar and Flood Characteristics



GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL

COMMISSION OF THE EUROPEAN COMMUNITIES AND GOVERNMENT OF FRANCE

NORTH CENTRAL REGIONAL STUDY
FAP - 3, PHASE - 2

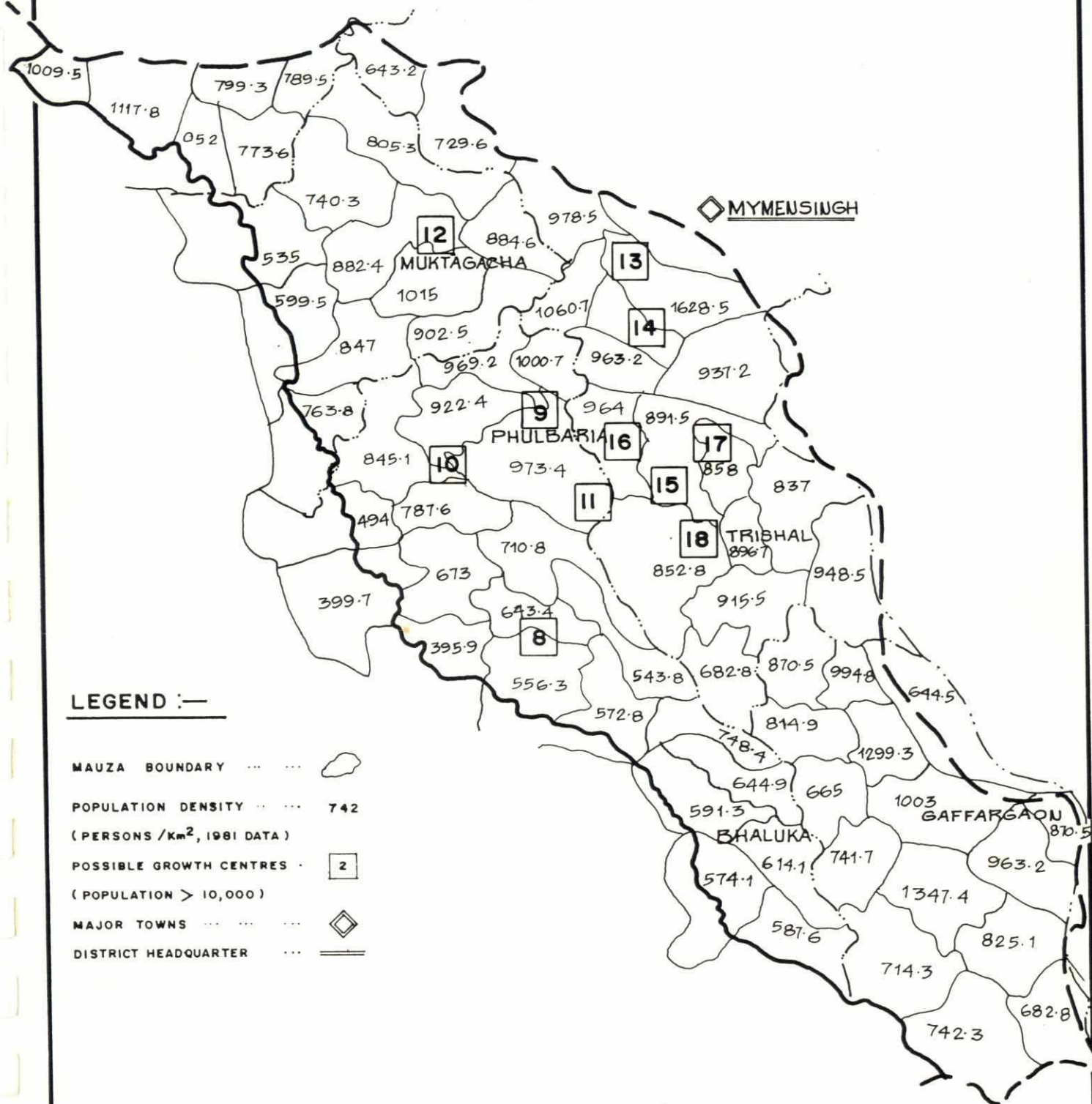
PU 3 - POPULATION MAP

HCRS CONSORTIUM
BCEOM
CNR
EUROCONSULT
MOTT MACDONALD INT.
BATEC

IN ASSOCIATION WITH
DASH UPDESH LTD.
BETS

SCALE
DATE 10th August 1991

AMALPUR



LEGEND :-

- MAUZA BOUNDARY
- POPULATION DENSITY 742
(PERSONS /km², 1981 DATA)
- POSSIBLE GROWTH CENTRES 2
(POPULATION > 10,000)
- MAJOR TOWNS
- DISTRICT HEADQUARTER

5.4 PU 4

5.4.1 Characteristics

Land Resources:	Madhupur Tract	$\pm 15\%$
	Young Jamuna Floodplain Western part	$\pm 15\%$
	Older Jamuna Floodplain middle part (M to S.)	$\pm 20\%$
	Old Brahmaputra Floodplain Eastern part	$\pm 50\%$
Soils :	<p>Silty clay to clay, silty loam to silty loam.</p> <p>Some areas with very firm subsoil (plastic), S.E. area around Basail and the Bangsi valley east of Ghatail (east of the outcrops of the Madhupur Tract), recent sand deposits up to 2m thick.</p>	
Floods :	<p>Mainly rainwater floods with some river water flood risk in the area near Bhuapur. Flood depth 6-14 feet during 4-6 month in the S.E. area, 6-12 feet during 4-6 month in Bangsi valley local basins flooded 1/2 month - 4 months. About 50-60% of the cultivated area is flooded every year.</p>	
Flood categories:	Fo = 24.7%, F1 = 39.5%, F2 = 27.2%, F3 = 8.6%	
Groundwater :	<p>The aquifer conditions are favourable, with average storage coefficient exceeding 10% and tubewell specific capacities averaging 11 l/s/m. At present, maximum SWL averages 7.1m at the end of April, allowing STWs to operate in almost all areas.</p>	
Minor irrigation :	<p>Well developed and already meets some 57% of estimated irrigation demand. STWs are the dominant method in this area. The assesement indicates that under present conditions, groundwater could supply 100% of the estimated residual irrigation demand. The introduction of partial flood protection would reduce groundwater recharge by about 7%, but this would have no significant effect on resources which could still satisfy irrigation demand. Although the assesement indicates a decline in groundwater resource potential in Ghatail by about 4%, this is considered to be insignificant relative to the precision of the estimate.</p>	
Agriculture:	Agric. area (cultivated)	$\pm 58,420 \text{ HA} \pm 76\%$ of gross area
	Irrigated area	$\pm 29,082 \text{ HA} = 50.6\%$
	Potential increase of irrigation is limited	(not more than 10%)
	Cropped area	121,066 HA = 207% cropping intensity

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<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-irrigated</u>
Single cropped	Boro	Vegetable-fruits/Aus+DW Aman/Jute
Double cropped	T.Aman-Boro	Aus/Jute-T Aman
	Aus/Jute-Boro	Aus/Jute-Rabi crops
	Aus + D.W.	Aus/D.W. Aman-Rabi crops
	Aman-Boro	Aus/Jute-T.Aman-Rabi crops
Triple cropped	T.Aman-Mustard/ Vegetables-Boro	Summer Vegetables-T.Aman-Rabi crops

<u>Production</u>	<u>Area(Ha)</u>	<u>% CTA</u>	<u>Production/Ton</u>	<u>%</u>
T.Aman	15,272	26.1	45,560	25.6 of rice crop
Boro	30,152	51.6	89,349	50.3 "
Aus	12,018	20.6	17,292	9.7 "
D.W.Aman	24,194	41.4	25,538	14.3 "
Total Rice	81,635	139.7	177,740	
jute	6,742	11.0	11,577	
Wheat	4,536	8.0	8,695	
Mustard	7,155	12.0	5,305	
Other crops	21,380	36.3		

Limitations: River floods in western part near Bhuapur. Floods in Bangsi valley.
Drainage constraints.

5.4.2 Aims and Strategy

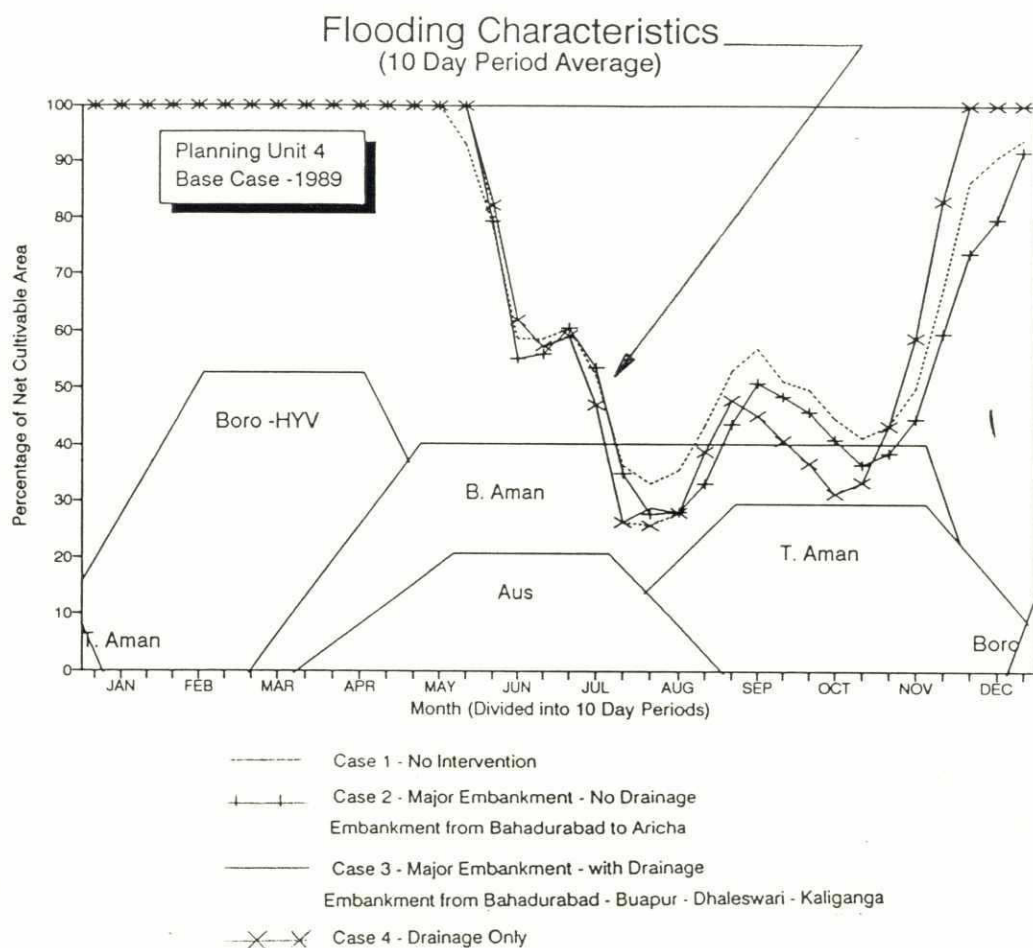
Development Aims:

- reduce the amount of damage/loss of land/homestead through river bank erosion;
- reduce the amount of spillage from the River Jamuna during high floods and thereby reduce crop loss and infrastructure damage in the area;
- improve the hydraulic efficiency of the Jhenai River (although this might not be necessary if spillage into Sub-Region A1 is reduced);
- further increase agricultural development in the area, increase the security of the T. aman cultivation enabling farmers to increase HY aman cultivation and yields;
- reduce crop damage in the pre-monsoon period;

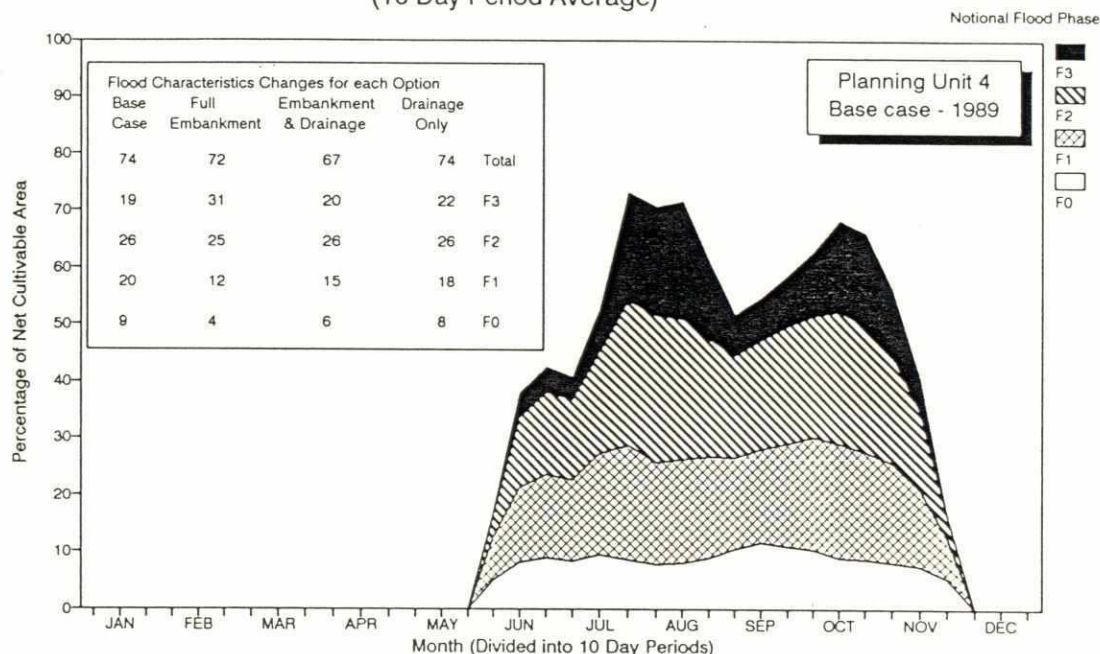
Development Strategy :

- investigate the viability of river training or bank protection on the River Jamuna; linking with the studies/requirements of the Jamuna Bridge Project and FAP-1;
- investigate and improve the quality of main embankment between Jagannathganj and Bhuapur. Review and revise the plans for improving the embankment for road construction in relation to the fertiliser factory.
- reduce inflow through Baushi Bridge into the Jhenai at peak flood periods
- Ensure that flow/channel functioning should be maintained to a certain level for fisheries, navigation and dry season requirements;
- identify potential compartmentalisation configurations to improve the water management in different parts of the area;
- by modifying the flooding regime promote agricultural development both of monsoon crops (rainfed) and irrigated crops;
- improve the natural drainage system by improving cross drainage facilities.

Figure 5.4.1
PU4 - Cropping Calendar and Flood Characteristics



FLOODING CHARACTERISTICS (10 Day Period Average)



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5.5 PU 5

5.5.1 Characteristics

Land Resources: Madhupur Tract 95%
Old Brahmaputra Flood Plain 5%

Soils: Highland soils: clay/clay loam, valleys and depressions, silt clay loam/clay.

Narrow valleys $\pm 30\%$ and broad valleys $\pm 10\%$ of the gross area, low soil fertility, some zinc deficiency and iron toxicity in the lower parts of valleys, which are deeply flooded and which stay wet for all or major part of the dry season.

Risks for erosion in areas with steep slopes.

Waterlogging in many parts of the highlands, poor drainage.

Prone to droughtiness during the dry season in most of the highlands and some valleys.

Floods Narrow valleys flooded 1-3 feet during the rainy season.
Broad valleys seasonally flooded deeper than 6 feet.
Some valleys in the S.E. of the area have a high flood risk.

Flood categories Fo = 57.2%, F1 = 29.3%, F2 = 9.3%, F3 = 4.2%

Groundwater The aquifer conditions are relatively unfavourable, with storage coefficient averaging 3.5% and tubewell specific capacities averaging 7.1 l/s/m. At present, maximum SWL averages 11.4m at the end of April, allowing STWs to operate only on the lowest land. Force mode tubewells required for irrigation over most of this area.

Minor irrigation Currently meets some 32% of estimated irrigation demand. DTWs are the dominant technology. Under present conditions, groundwater could supply a maximum of 65% of the estimated residual irrigation demand in PA5, due to the unfavourable aquifer conditions. The introduction of partial flood protection would have little effect on groundwater recharge (2% reduction), and would not affect resource potential, which is already constrained by aquifer conditions.

Agriculture Agricultural area(cultivated) $\pm 121,318$ HA=57,1% of gross area
Irrigated area $\pm 42,600$ HA=35% of CTA.
Potential increase of irrigation limited due to undulating land
Cropped area $\pm 203,803$ HA= $\pm 168\%$ cropping intensity
Forest area $\pm 39,000$ HA= $\pm 18\%$ of gross area

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<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-Irrigated</u>
Single cropped	Boro	Pineapples/Sugarcane/Fruittrees/ Aus/T.Aman
Double cropped	T.Aman-Boro Aus/Jute/D.W.Aman-Boro	Aus/Jute/Vegetables- T.Aman/Winter Vegetables
Triple cropped	Vegetables-T.Aman-Boro	Aus/Jute/Vegetables- T.Aman-Rabi crops

Production	Area (Ha)	% of CTA	Production(Ton)	%
T.Aman	70,850	58.4	213,992	49.6 of rice prod
Boro	42,461	35.0	155,832	36.1 "
Aus	45,274	37.3	58,153	13.5 "
D.W.Aman	2,669	2.2	3,363	0.8 "
Total Rice	161,254	132.9	431,340	100.0 "
Jute	1,203	1.0	1,925	
Wheat	3,847	3.2	6,925	
Mustard	1,109	0.9	665	
Other crops	36,400	30.0		

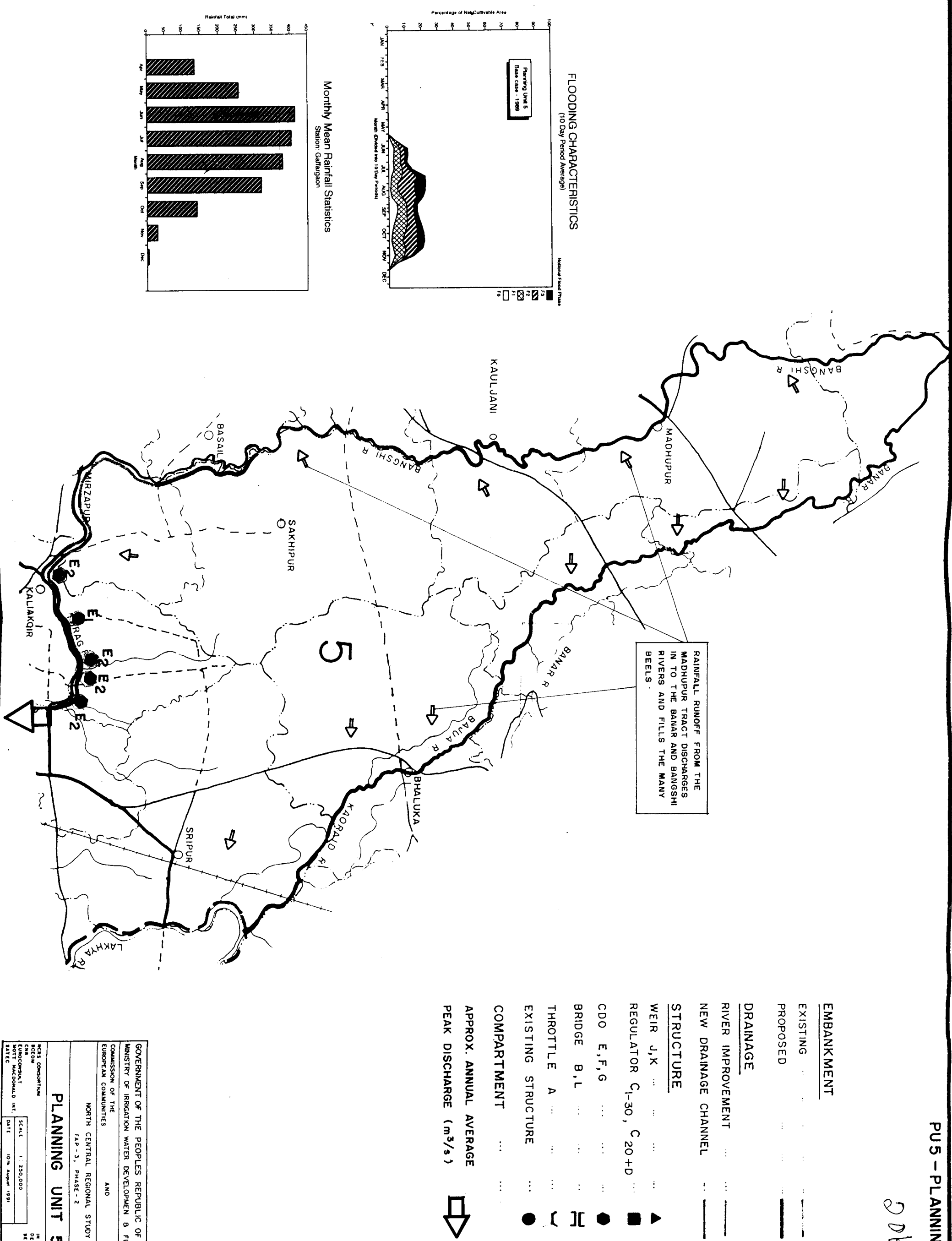
Limitations: Poor drainage and waterlogging on highlands.
Droughtiness during the dry season.
Flash floods in narrow valleys in the S.E. area

Remarks: Fruit trees, mainly jackfruit, are planted scattered around homesteads and as boundaries in farmplots. Forest area under forest is very limited. Major part of the forest area is used for homesteads and crops as pineapples, fruittrees, sugarcane, etc.

Figure 5-5.1

PU5 - PLANNING MAP

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002

Figure 5.5.2

PU5 - Cropping Calendar and Flood Characteristics

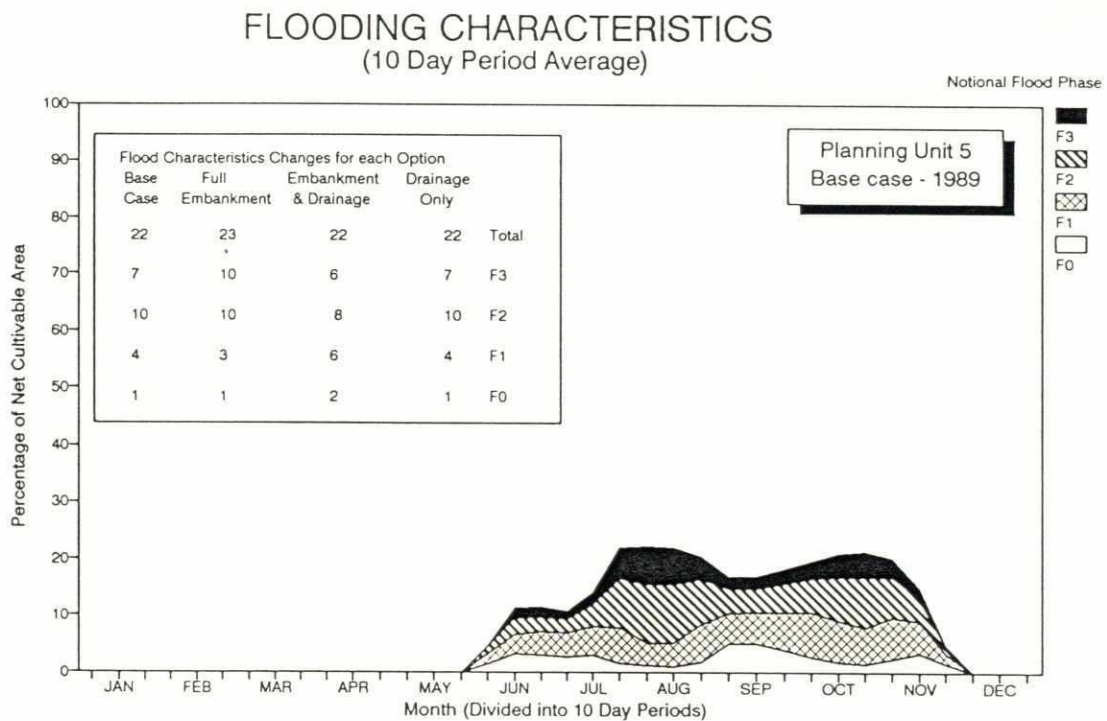
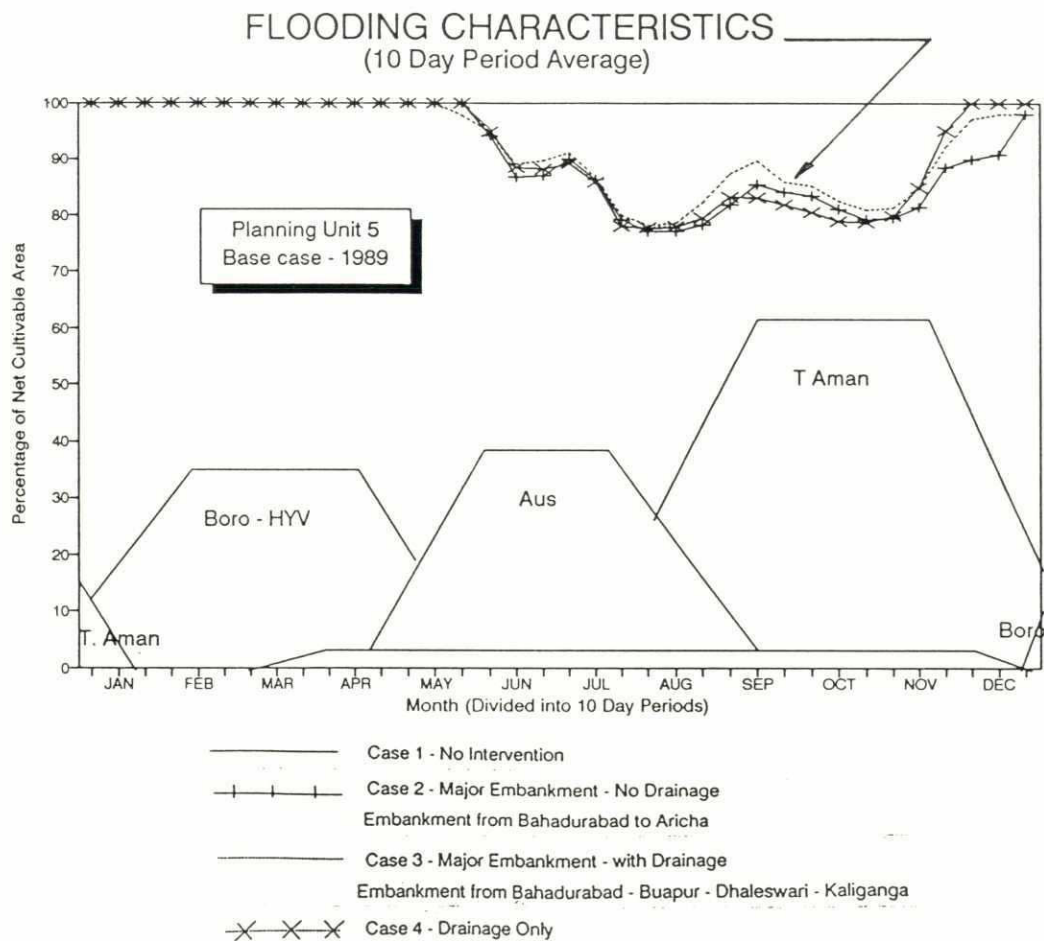






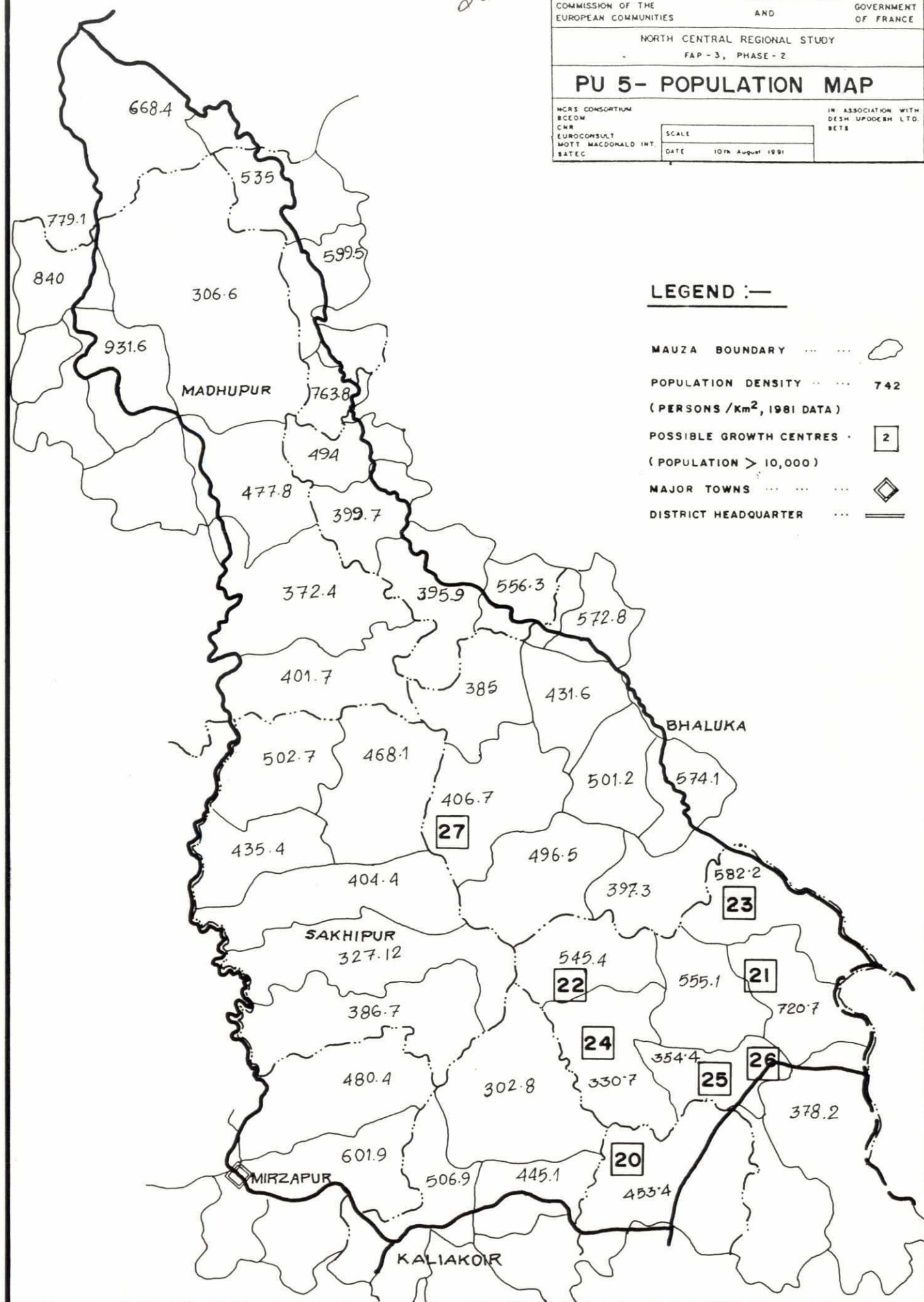
Figure 5.5.3

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GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH	
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL	
COMMISSION OF THE EUROPEAN COMMUNITIES	AND GOVERNMENT OF FRANCE
NORTH CENTRAL REGIONAL STUDY	
FAP-3, PHASE-2	
PU 5- POPULATION MAP	
WCRS CONSORTIUM BCCOM CWR EUROCONSULT MOTT MACDONALD INT. BATEC	IN ASSOCIATION WITH DESH UPODESH LTD. DETA
SCALE	DATE
	10th August 1991

LEGEND :—

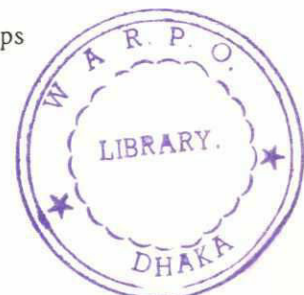
- MAUZA BOUNDARY 
- POPULATION DENSITY 742
(PERSONS /Km², 1981 DATA)
- POSSIBLE GROWTH CENTRES 
(POPULATION > 10,000)
- MAJOR TOWNS 
- DISTRICT HEADQUARTER 



5.6 PU 6

5.6.1 Characteristics

Land Resources:	Action Jamuna Floodplain Western part $\pm 15\%$ Young Jamuna Floodplain middle part $\pm 25\%$ Older Jamuna Floodplain Eastern + Southern Part $\pm 60\%$	
Soils:	Silt loam to silty clay loam, Silty and sandy in the Active Jamuna Floodplain, with slightly higher sand deposits locally.	
Floods	Flood water moves rapidly over the land during river floods in the Active Jamuna Floodplain. The numerous basins are flooded during 4-7 months, Moderately deep to very deep. About 80-90% of the cultivated land is flooded every year.	
Flood categories	$F_0 = 15.4\%$, $F_1 = 48\%$, $F_2 = 28.7\%$, $F_3 = 7.9\%$	
Groundwater	The aquifer conditions are favourable, with average storage coefficient exceeding 9% and tubewell specific capacities averaging 12.8 l/s/m. At present, maximum SWL averages 7.5m at the end of April, allowing STWs to operate in most areas.	
Minor irrigation	Moderately well developed and already meets some 46% of estimated irrigation demand. STWs are the dominant method in this area. The assesement indicates that under present conditions, groundwater could supply 100% of the estimated residual irrigation demand. The introduction of partial flood protection would reduce groundwater recharge by about 8%, but this would have no significant effect on resources which would still substantially exceed irrigation demand.	
Agriculture	Agricultural area (cultivated) $\pm 95,880$ HA $\pm 86\%$ of gross area Irrigated area $\pm 40,640$ HA = 42% Potential irrigation increase $\pm 17\%$ Cropped area $\pm 200,550$ HA = 209% cropping intensity	
Cropping pattern	<u>Irrigated</u>	<u>Non-Irrigated</u>
Single cropped	Boro	Aus/Aman/Millet
Double cropped	Aus/Jute-Boro D.W. Aman-Boro	Aus/D.W.Aman/Jute - Rabi crops Aus+D.W.Aman (Mixed)
Triple cropped	Aus/Jute - T.Aman-Boro T.Aman-Mustard/Vegetables - Boro	Aus/Jute-T.Aman-Mustard/ Rabi crops



Production	Area (Ha)	% of CTA	Production(Ton)	%
T.Aman	8,816	9.2	24,263	9.7 of rice prod
Boro	41,561	43.3	137,684	54.9 "
Aus	30,142	31.4	40,866	16.3 "
D.W.Aman	40,733	42.5	47,794	19.1 "
Total Rice	121,253	126.4	250,607	100.0 "
Jute	13,076	13.6	18,918	
Wheat	10,429	10.9	19,669	
Mustard	10,841	11.3	8,954	
Other crops	44,872	46.8		

Limitations: River floods from Jamuna/Dhaleswari in Western part. Rain water floods in the rest of the area. Impeded drainage in S.E. of the area and local drainage problems caused by roads, embankments raised river banks etc.

5.6.2 Aims and Strategy

Development Aims:

- reduce the amount of spillage from the River Jamuna/Dhaleswari during high floods and thereby reduce crop loss and infrastructure damage in the area;
- improve the hydraulic efficiency of the Dhaleswari/Kaliganga River system;
- further increase agricultural development in the area, increase the security of the T. aman cultivation enabling farmers to increase HY aman cultivation and yields;
- reduce the amount of damage/loss of land/homestead through river bank erosion;
- minimise any deleterious impact on fishery resources in the area;
- reduce crop damage in the pre-monsoon period;

Development Strategy :

- investigate and improve the quality of main embankment either along the Dhaleswari/Kaliganga or between Bhuapur and Aricha;
- Reviews and river plans relating to the possible Jamina Bridge construction;

- investigate the viability of river training or bank protection on the River Jamuna; linking with the studies/requirements of the Jamuna Bridge Project and FAP-1;
- separate the PU into two 6a and 6b. 6b to cover the area of active flood plain in the south west and its strategy to be linked to that of PU 10;
- ensure that flow/channel functioning should be maintained to a certain level for fisheries, navigation and dry season requirements;
- identify potential compartmentalisation configurations to improve the water management in different parts of the area;
- by modifying the flooding regime promote agricultural development both of monsoon crops (rainfed) and irrigated crops;
- improve the natural drainage system by improving cross drainage facilities.

FLOODING CHARACTERISTICS
(10 Day Period Average)

PU 6 - PLANNING MAP

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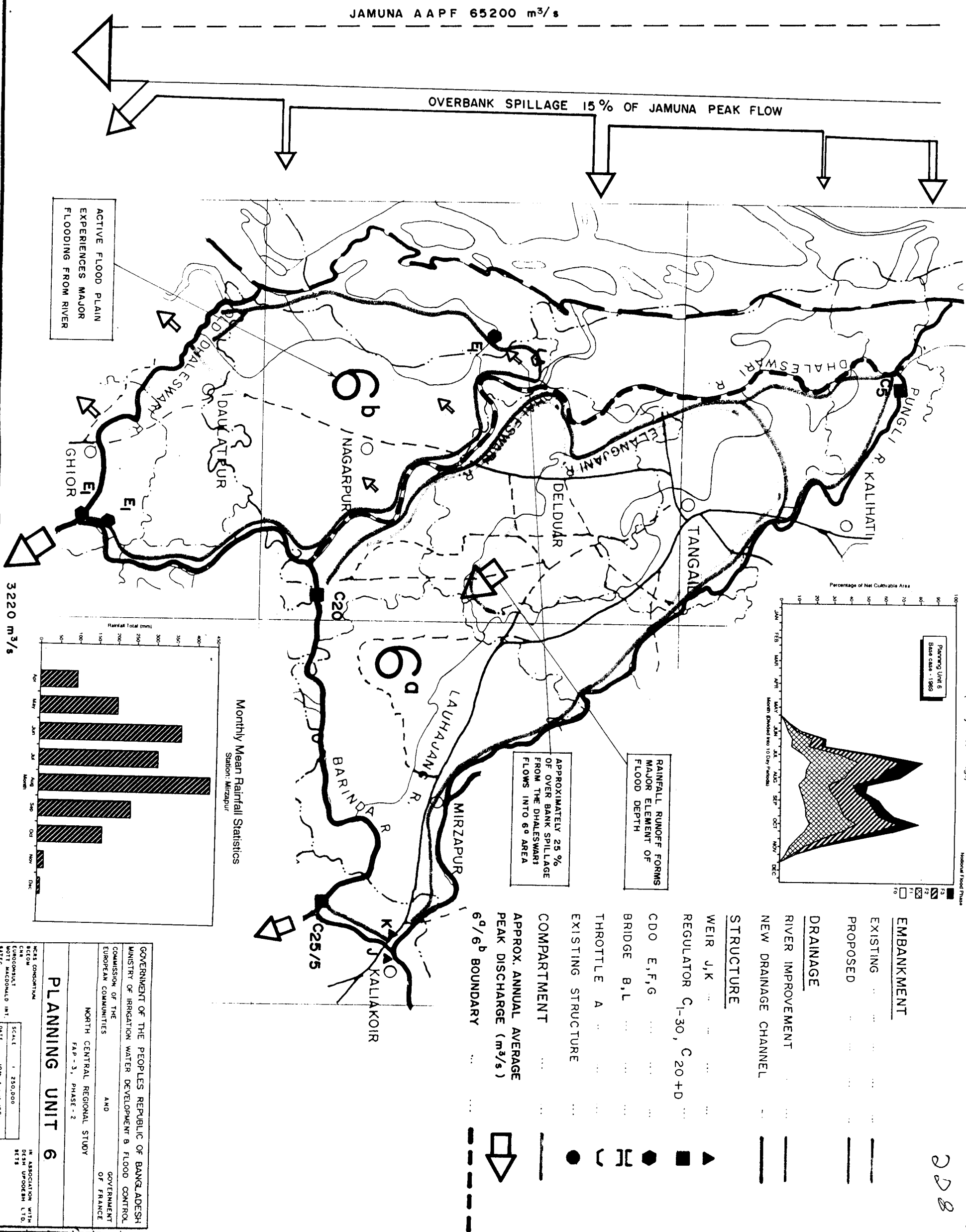
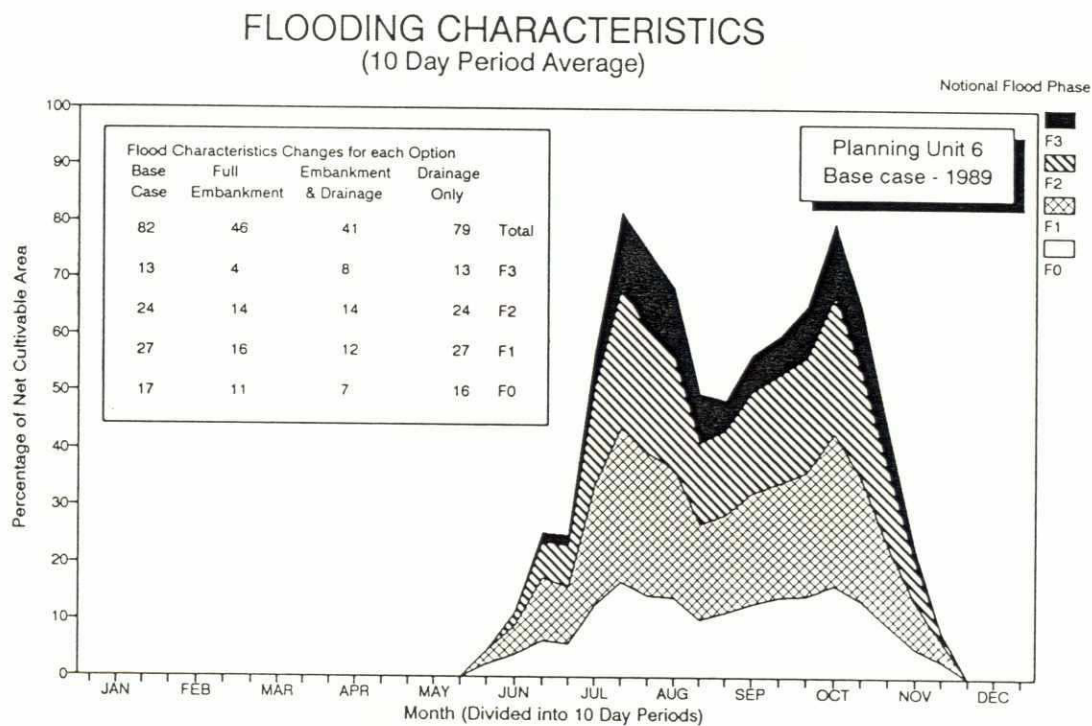
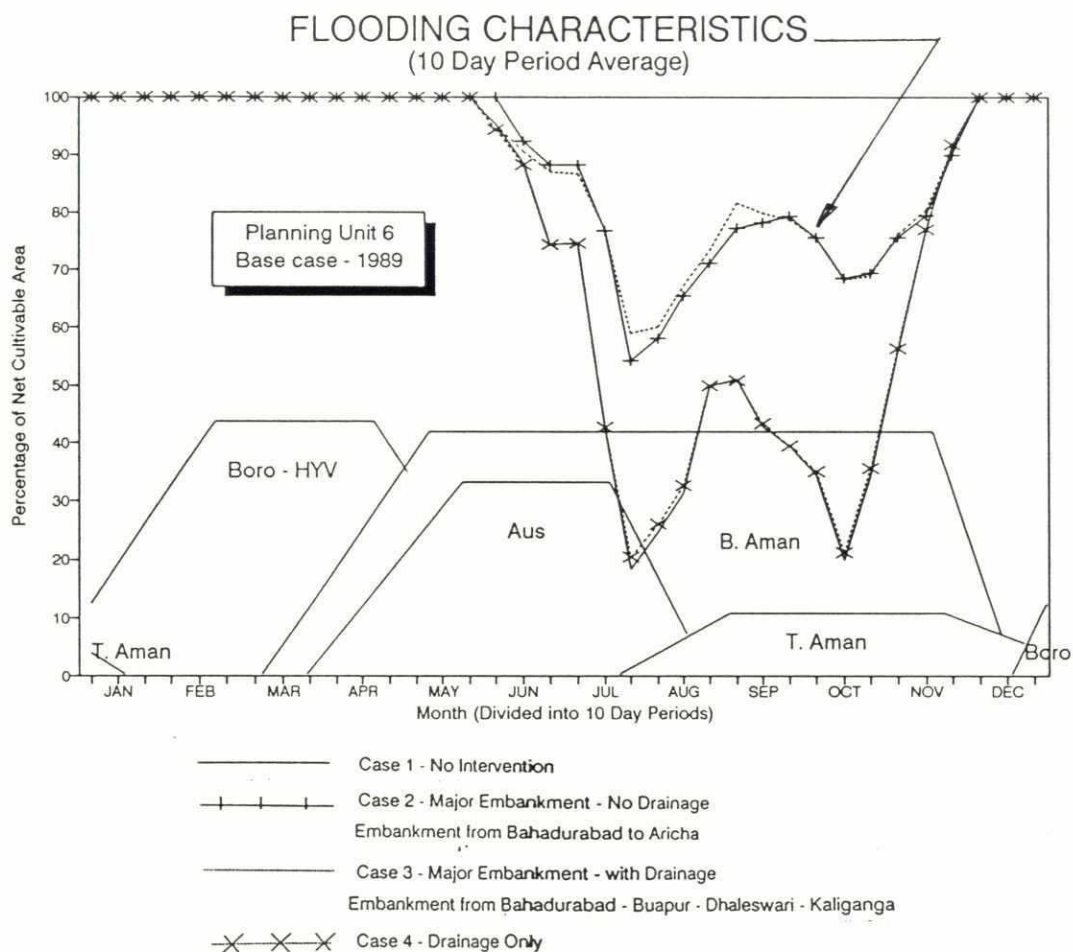


Figure 5.6.2

PU6 - Cropping Calendar and Flood Characteristics



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GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL

COMMISSION OF THE EUROPEAN COMMUNITIES AND GOVERNMENT OF FRANCE

NORTH CENTRAL REGIONAL STUDY
FAP - 3, PHASE - 2

PU 6 - POPULATION MAP

WCRC CONSORTIUM
BCEOM
CNR
EUROCONSULT
MOTT MACDONALD INT.
BATEC

IN ASSOCIATION WITH
DASH UPDESH LTD.
BETS

SCALE
DATE 10th August 1991

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5.7 PU 7

3.7.1 Characteristics

Land Resources	Young Jamuna Flood Plain	$\pm 95\%$
	Active Jamuna Flood Plain	$\pm 5\%$
	along side left and right banks of the Dhaleswari river (soil erosion)	
Soils	Active Flood Plain: silty and sandy with some silt loam, silty clay, silty clay loam, light soils. Young Jamuna Flood Plain: loam, clay, heavy soils.	
Floods	River water flood 3-6 feet on ridges, 5-15 feet in basins, Flooded up to 6 months. About 85-90% of the cultivated area is flooded every year.	
Flood categories:	Fo = 12,5%, F1 = 38,9%, F2 = 26,9%, F3 = 21.7%	
Groundwater:	The aquifer conditions, are favourable, with average storage coefficient exceeding 7% and tubewell specific capacities averaging 10.4 l/s/m. At present, maximum SWL averages 7.6m at the end of April, allowing STWs to operate in most areas.	
Minor irrigation:	Moderately well developed and already meets some 38% of estimated irrigation demand. Both STWs and DTWs are important in this area. The assesement indicates that under present conditions, groundwater could supply 100% of the estimated residual irrigation demand except in Kaliakoir. The introduction of partial flood protection would reduce groundwater recharge by about 7%, but this would have no significant effect on resources which would still substantially exceed irrigation demand.	
Agriculture :	Agricultural area (cultivated)	$\pm 67,238$ HA = 72.9% of gross area
	Irrigated area	$\pm 23,243$ HA = 34.6% of CTA
	Potential increase irrigation limited to	$\pm 10\%$
	Cropped area	$\pm 130,690$ HA = 194% cropping intensity
<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-irrigated</u>
Single cropped	Boro	Aus/Jute/D.W.Aman
Double Cropped	Aus/Jute-Boro	Aus/Jute - Mustard
	D.W.Aman-Boro	Aus/Jute/D.W. Aman-Wheat/Rabi crops
Triple Cropped	D.W.Aman-Mustard-Boro/Vegetables	Aus/Jute/D.W.Aman-Mustard-Rabi crops.

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Production	Area (HA)	%	Production(ton)	%
T.Aman	3884	5.8	10,366	5.8 of total rice prod
Boro	23423	34.8	109,179	60.9 "
Aus	27525	40.9	25,688	14.3 "
D.W.Amna	27473	40.9	34,167	19.0 "
Total rice	82302	122.4	179,400	100 "
Jute	6925	10.3	9,938	
Wheat	10886	16.2	19,554	
Mustard	13022	19.3	6,098	
Other crops	17555	26.1		

Limitation : Major limitation: deep river flooding

Remark: Soil moisture in dry season is quite high in most of the area. Irrigation need is less, compared with P.U. 2, 4 and 6.

5.7.1 Aims and Strategy

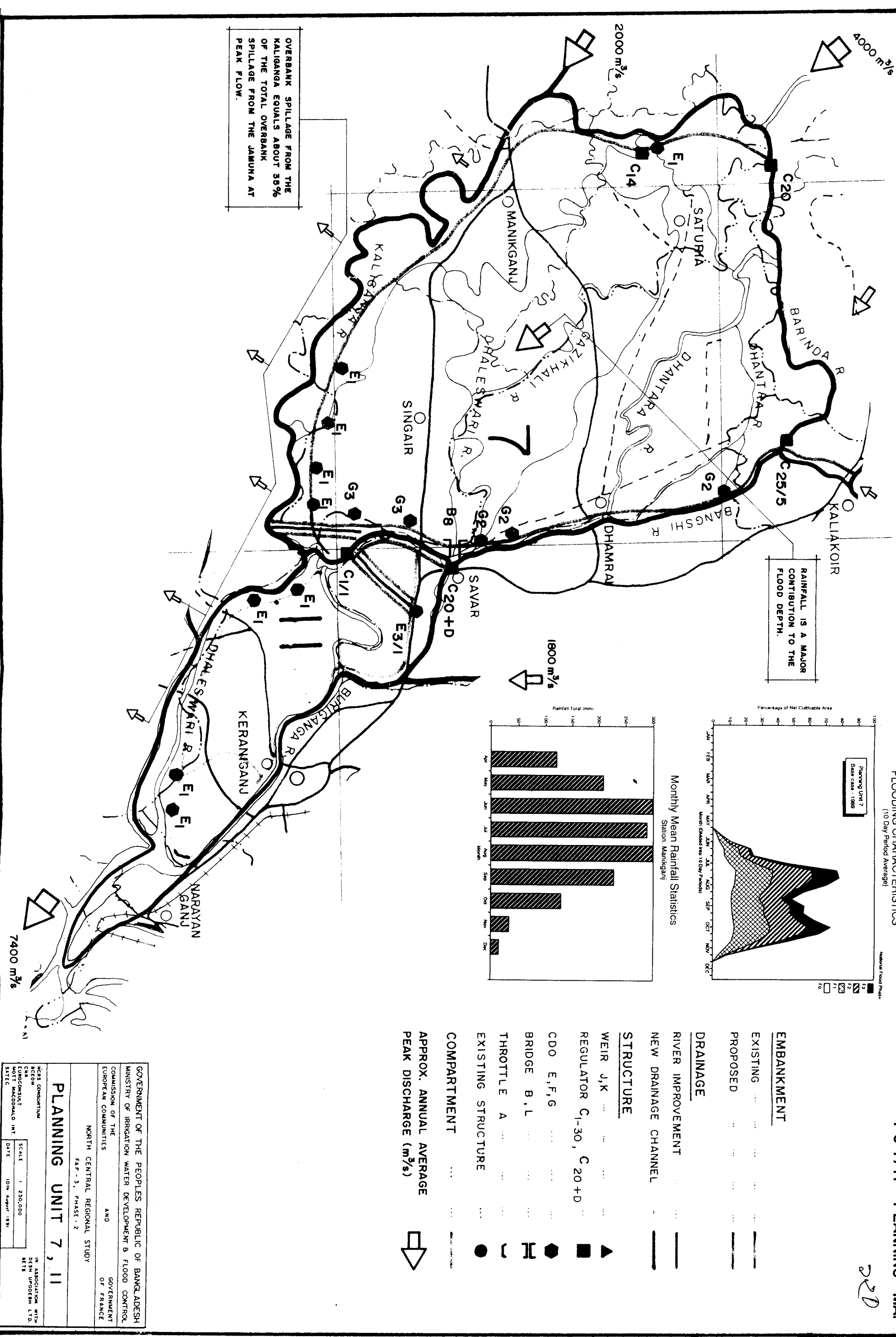
Development Aims:

- reduce the amount of spillage from the River Dhaleswari, and Kaliganga Rivers;
- reduce the amount of damage/loss of land/homestead through river flooding;
- improve the hydraulic efficiency of the Jhenai River (although this might not be necessary if spillage into Sub-Region A1 is reduced);
- further increase agricultural development in the area, increase the security of the T. aman cultivation enabling farmers to increase HY aman cultivation and yields;
- minimise any deleterious impact on fishery resources in the area;
- reduce crop damage in the pre-monsoon period;

Development Strategy :

- investigate and improve the quality of main embankment along the Dhaleswari, and Kaliganga;
- Ensure that flow/channel functioning should be maintained to a certain level for fisheries, navigation and dry season requirements;
- identify potential compartmentalisation configurations to improve the water management in different parts of the area;
- by modifying the flooding regime promote agricultural development both of monsoon crops (rainfed) and irrigated crops;
- improve the natural drainage system by improving cross drainage facilities.

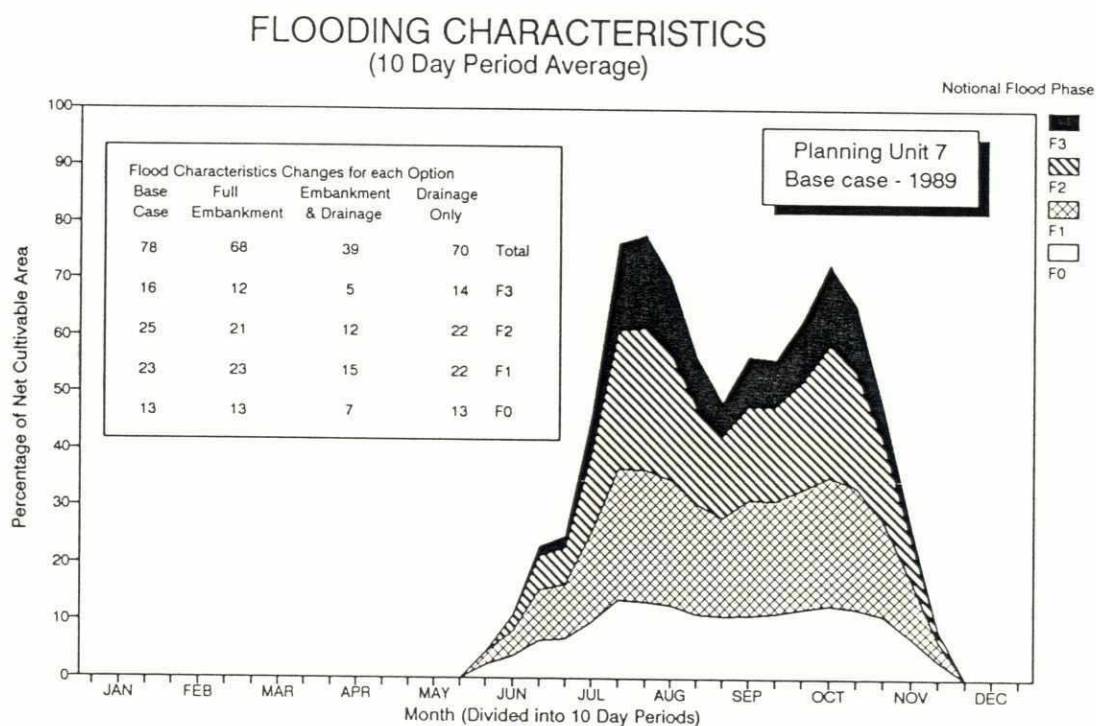
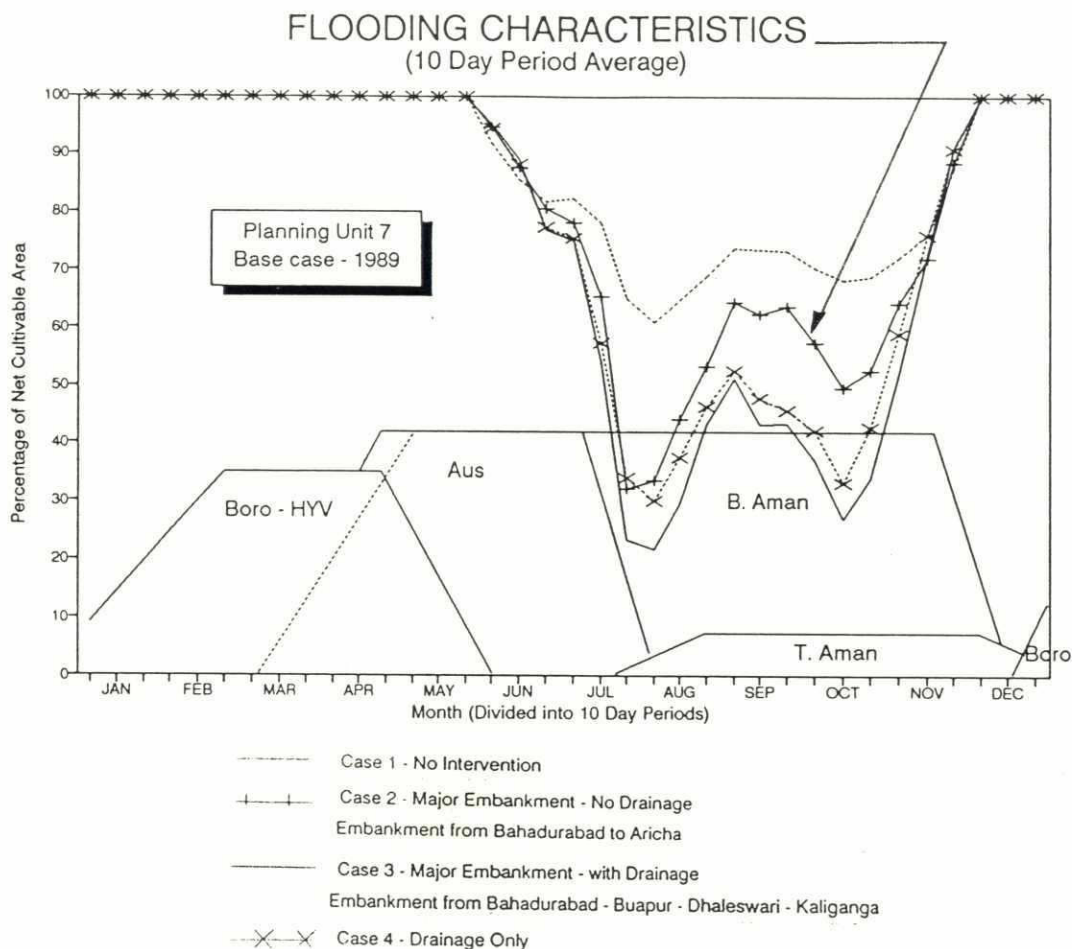
220







022

Figure 5.7.2

PU7 - Cropping Calendar and Flood Characteristics





MAUZA BOUNDARY	
POPULATION DENSITY	742
(PERSONS /Km ² , 1981 DATA)			
POSSIBLE GROWTH CENTRES	.		
(POPULATION > 10,000)			
MAJOR TOWNS	
DISTRICT HEADQUARTER	

GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH		MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL	
COMMISSION OF THE EUROPEAN COMMUNITIES		AND	GOVERNMENT OF FRANCE
NORTH CENTRAL REGIONAL STUDY			
FAP - 3, PHASE - 2			
PU 7/II - POPULATION MAP			
INCRS CONSORTIUM BCEOM CNR EUROCONSULT MOTT MACDONALD INT. SATEC		IN ASSOCIATION WITH DESH UPODESH LTD. BETS	
		SCALE	
		DATE	10th August 1991

5.8 PU 8

5.8.1 Characteristics

Land Resources: Madhupur Tract $\pm 100\%$

Soils : Generally clay high land soils, and silty clay/loam valley soils
 $\pm 60\%$ - high land and 20% narrow valleys and 20% broad valleys.
Low to moderate soil fertility, lower parts of the broad valleys may have some zinc deficiency or iron toxicity, especially on irrigated land. Poor drainage in some parts of the highlands, water logging, droughtiness in dry season.

Floods: Narrow valleys flooded 1-4 feet during rainy season, broad valleys up to 6 feet, lower Turag valley 8 to more than 15 feet.

Flood Categories: $F_0 = 53.8\%$, $F_1 = 19.1\%$, $F_2 = 16.3\%$, $F_3 = 10.9\%$

Groundwater : The aquifer conditions are unfavourable, with storage coefficient averaging only 3.2% and tubewell specific capacities of 6 l/s/m. At present, maximum SWL averages 11.3m at the end of April, allowing STWs to operate only on the lowest land. Force mode tubewells are required for irrigation over most of this area.

Minor irrigation : Currently meets some 36% of estimated irrigation demand. DTWs and LLPs are the dominant technologies. The assesment indicates that under present conditions, groundwater could supply a maximum of 80% of the estimated residual irrigation demand in PA8, due to the unfavourable aquifer conditions. The introduction of partial flood protection would have little effect on groundwater recharge (3% reduction), and would not affect resource potential, which is already constrained by aquifer conditions.

Agriculture : Agricultural area(cultivated) $\pm 27,192$ HA $\pm 59\%$ of gross area
Irrigated area $\pm 12,719$ HA $\pm 46\%$ of CTA
Potential increase of irrigation limited to $\pm 10\%$
Cropped area $\pm 46,620$ HA 171% cropping intensity
Forest area $\pm 7,500$ HA $\pm 16\%$ of gross area.

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<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-Irrigated</u>
Single cropped	Boro	Fruit trees/Sugarcane/Aus/T.Aman Vegetables
Double cropped	T.Aman - Boro D.W.Aman-Boro	Aus/Jute-T.Aman Aus/Summer Vegetables- T.Aman/Winter Vegetables/Rabi crops
Triple cropped	Vegetables-T.Aman-Boro	Jute/Aus/Vegetables- T.Aman-Rabi crops

Production	Area	% of	Production	%
	(HYV)	CTA	(Ton)	
T.Aman	7704	28.3	23655	26.4
Boro	12954	47.6	56154	62.6
Aus	4098	15.1	9162	10.2
D.W.Aman	529	2.0	733	0.8
Total Rice	25285	93.0	89705	
Jute	1406	5.2	2261	
Wheat	869	3.2	1787	
Mustard	1778	6.5	1170	
Other crops	17282	63.6		

Limitations: No major limitations, some local drainage problems in lower areas, water logging.

Remark : Forest area under forest is limited. Most of the area is used for homesteads, fruit trees, crops like sugarcane, etc.

5.8.2 Aims and Strategy

Development Aims:

- to reduce damage from floods by increasing the hydraulic efficiency of the regional rivers;
- to reduce crop damage in the pre-monsoon period;
- to improve local drainage and protect against flood from the Bangshi and Turag river;

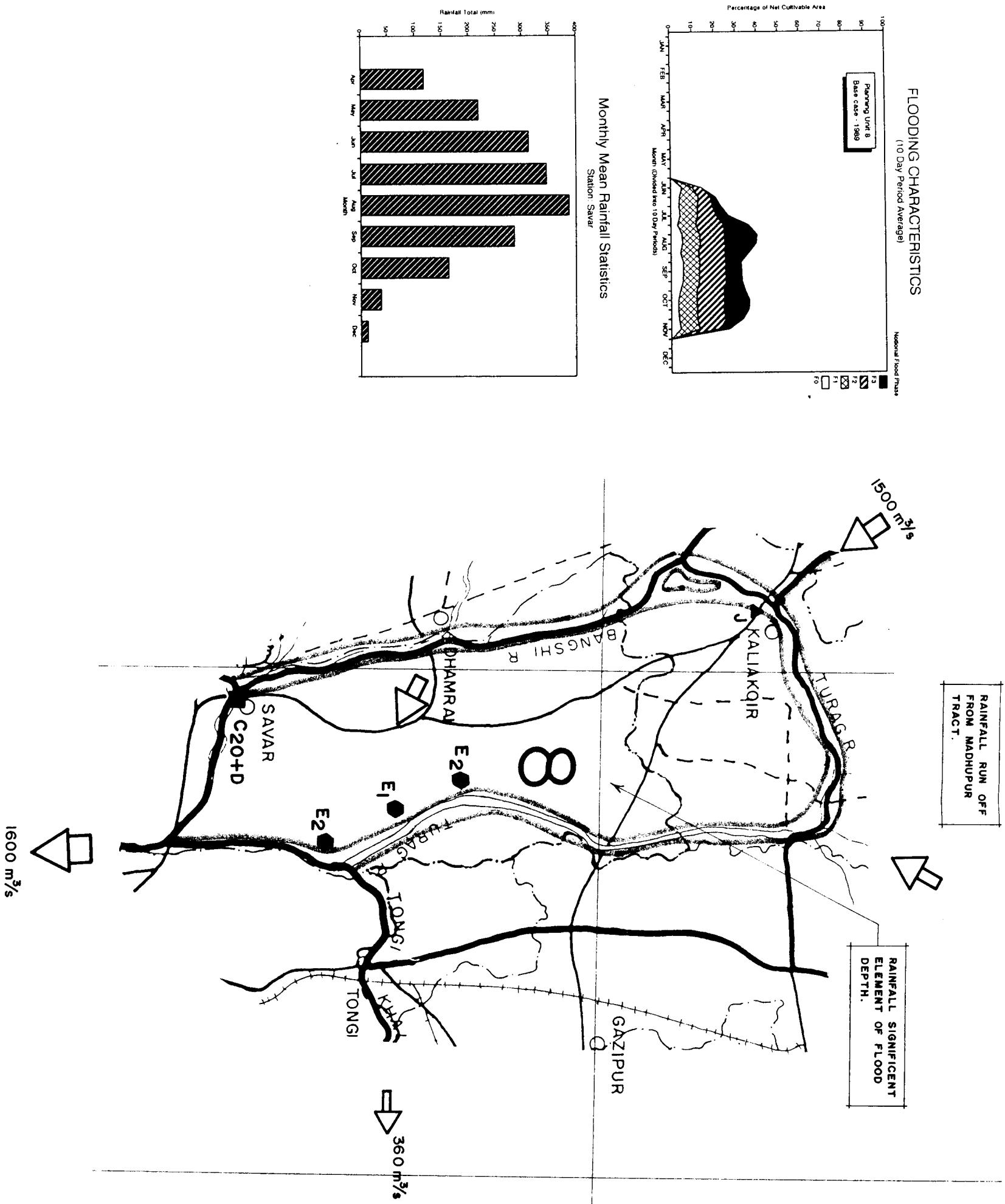
Development Strategy :

- investigate the possibility of improving the drainage
- raise the embankments of the Bangshi and Turag river to protect against flooding;

Figure 5.8.1

PUB - PLANNING MAP

22



EMBANKMENT	
EXISTING	---
PROPOSED	---
DRAINAGE	
RIVER IMPROVEMENT	---
NEW DRAINAGE CHANNEL	---
STRUCTURE	
WEIR J,K	▲
REGULATOR C ₁₋₃₀ , C _{20+D}	■
CDO E,F,G	●
BRIDGE B,L	⌈
THROTTLE A	⌋
EXISTING STRUCTURE	●
COMPARTMENT	---
APPROX. ANNUAL AVERAGE PEAK DISCHARGE (m ³ /s)	➡

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NORTH CENTRAL REGIONAL STUDY
FAP - 3, PHASE - 2

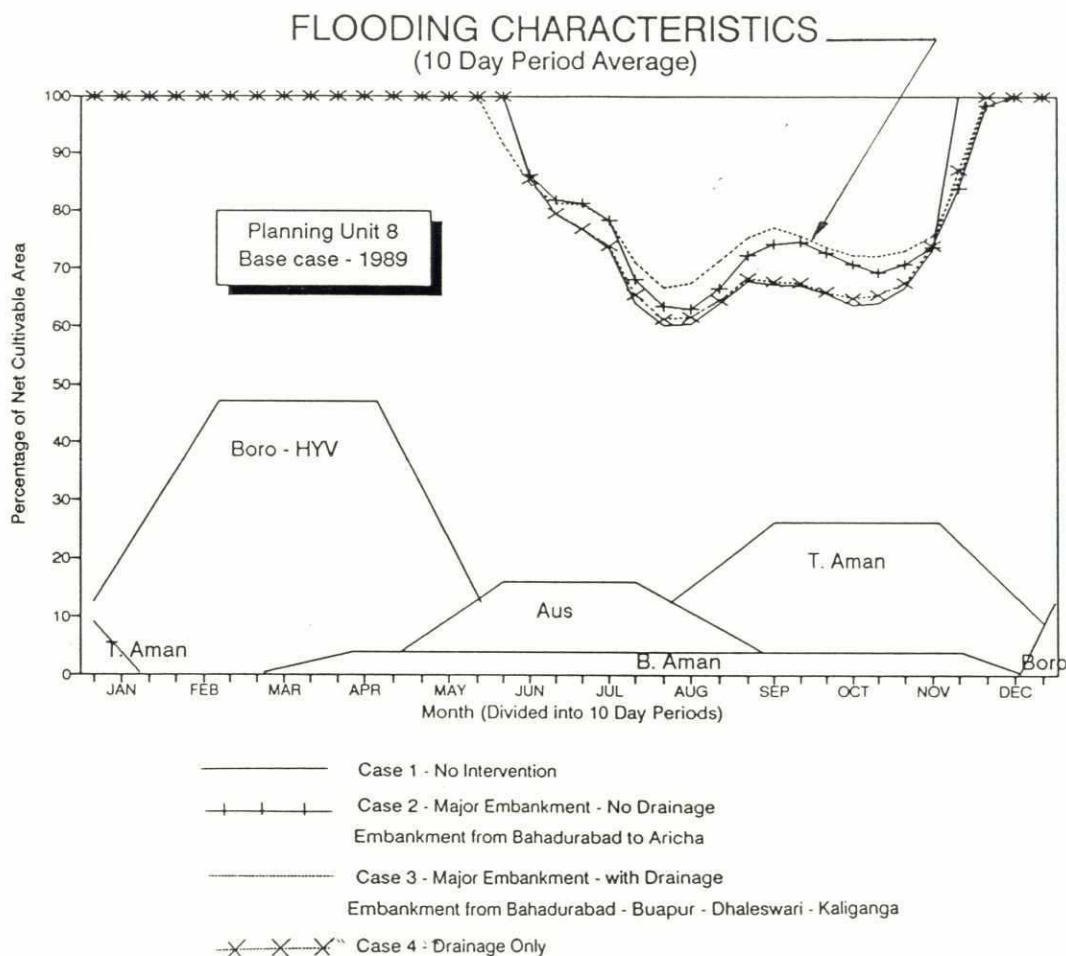
PLANNING UNIT 8

MC&S CONSULTING
RECORD
LUMPKEN & CO.
MOTT MACDONALD INT
SCALE 1:250,000
DATE 10th August 1991

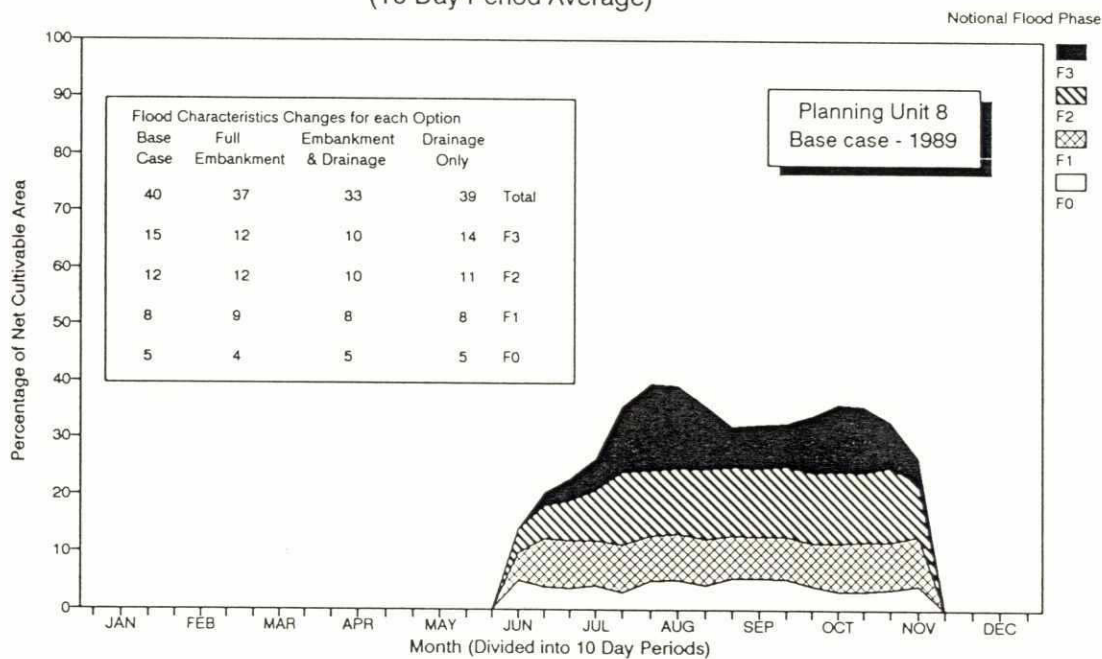
IN ASSOCIATION WITH
OCSM WORKSHOP LTD
BETS

Figure 5.8.2

PU8 - Cropping Calendar and Flood Characteristics







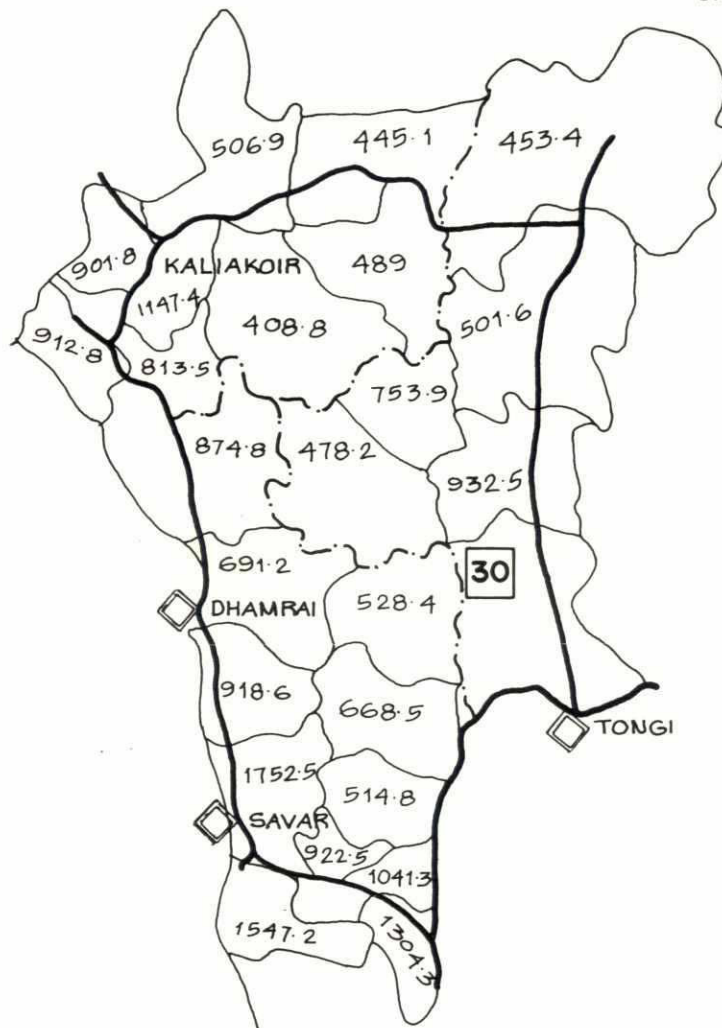
FLOODING CHARACTERISTICS
(10 Day Period Average)



229

LEGEND :—

- MAUZA BOUNDARY 
- POPULATION DENSITY 742
(PERSONS / Km², 1981 DATA)
- POSSIBLE GROWTH CENTRES · 
(POPULATION > 10,000)
- MAJOR TOWNS 
- DISTRICT HEADQUARTER 



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MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL	
COMMISSION OF THE EUROPEAN COMMUNITIES	AND GOVERNMENT OF FRANCE
NORTH CENTRAL REGIONAL STUDY FAP - 3, PHASE - 2	
PU 8 - POPULATION MAP	
WCRS CONSORTIUM BCEOM CNR EUROCONSULT MOTT MACDONALD INT. BATEC	IN ASSOCIATION WITH DESH UPODESH LTD. BETS
SCALE	DATE 10th August 1991

5.9 PU 9

5.9.1 Characteristics

Land Resources:	Madhupur Tract 90% Old Brahmaputra Flood Plain 10%
Soils :	Friable clay on the highlands clay, silty clay, silty clay loam, silty loam in the valleys, and on right bank of Lakhya river. Valleys 35-40% of the area, some zinc deficiency and risk for iron toxicity in deep flooded valleys. Low fertility.
Floods	Narrow and higher parts of the valleys flooded 1-3 feet, lower parts 3-6 feet, some valleys 5-15 feet deep.
Flood Categories	F ₀ = 53.6%, F ₁ = 18.7%, F ₂ = 12.2%, F ₃ = 15.5%
Groundwater	The aquifer conditions are the poorest in the North Central region, with storage coefficient averaging only 1.2% and tubewell specific capacities of 5.6 l/s/m. At present, maximum SWL averages 11.7m at the end of April, allowing STWs to operate only on the lowest land. Force mode tubewells are required for irrigation over most of this area.
Minor irrigation	Currently meets some 35% of estimated irrigation demand. DTWs and LLPs are the dominant technologies. The assesement indicates that under present conditions, groundwater could supply a maximum of 42% of the estimated residual irrigation demand due to the unfavourable aquifer conditions. The introduction of partial flood protection would would have little effect on groundwater recharge (4% reduction), and would not affect resource potential, which is already constrained by aquifer conditions.
Agriculture	Agriculture area (cultivated) ± 57,757 HA 73.2% Irrigated area ± 22,528 HA 39% of CTA Potential increase of irrigation is very limited (undulating land) Cropped area ± 102,304 HA 177% cropping intensity Forest area ± 5,000 HA 9% of gross are

827

<u>Cropping Pattern</u>	<u>Irrigated</u>	<u>Non-Irrigated</u>
Single cropped	Boro	Fruit trees/Sugarcane/Pineapple/Aus/T.Aman
Double cropped	T.Aman-Boro D.W.Aman/Aus/ Jute-Boro	Aus/Jute-T.Aman Aus/Summer Vegetables-T.Aman/ Winter Vegetables/Rabi crops
Triple cropped	Vegetables- T.Aman-Boro	Jute/Aus/Vegetables-T.Aman-Rabi crops

Production	Area(HA)	% of CTA	Production (Ton)	%
T.Aman	20564	35.6	62,179	28
Boro	26033	45.1	106,545	49
Aus	14716	25.5	38,072	17
D.W.Aman	6492	11.2	13,152	6
Total Rice	67804	117.4	219,948	
Jute	3071	5.3	5,390	
Wheat	864	1.5	1,283	
Mustard	1145	2.0	790	
Other crops	29420	50.1		

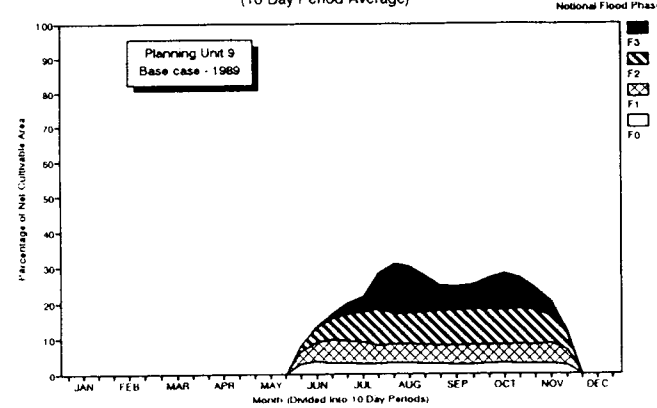
Limitations: No major limitations, some local drainage problems in valleys.

Remark: Forest area actually under forest is limited. Most of the area is used for homesteads, fruit trees and crops like sugarcane, pineapples, etc.

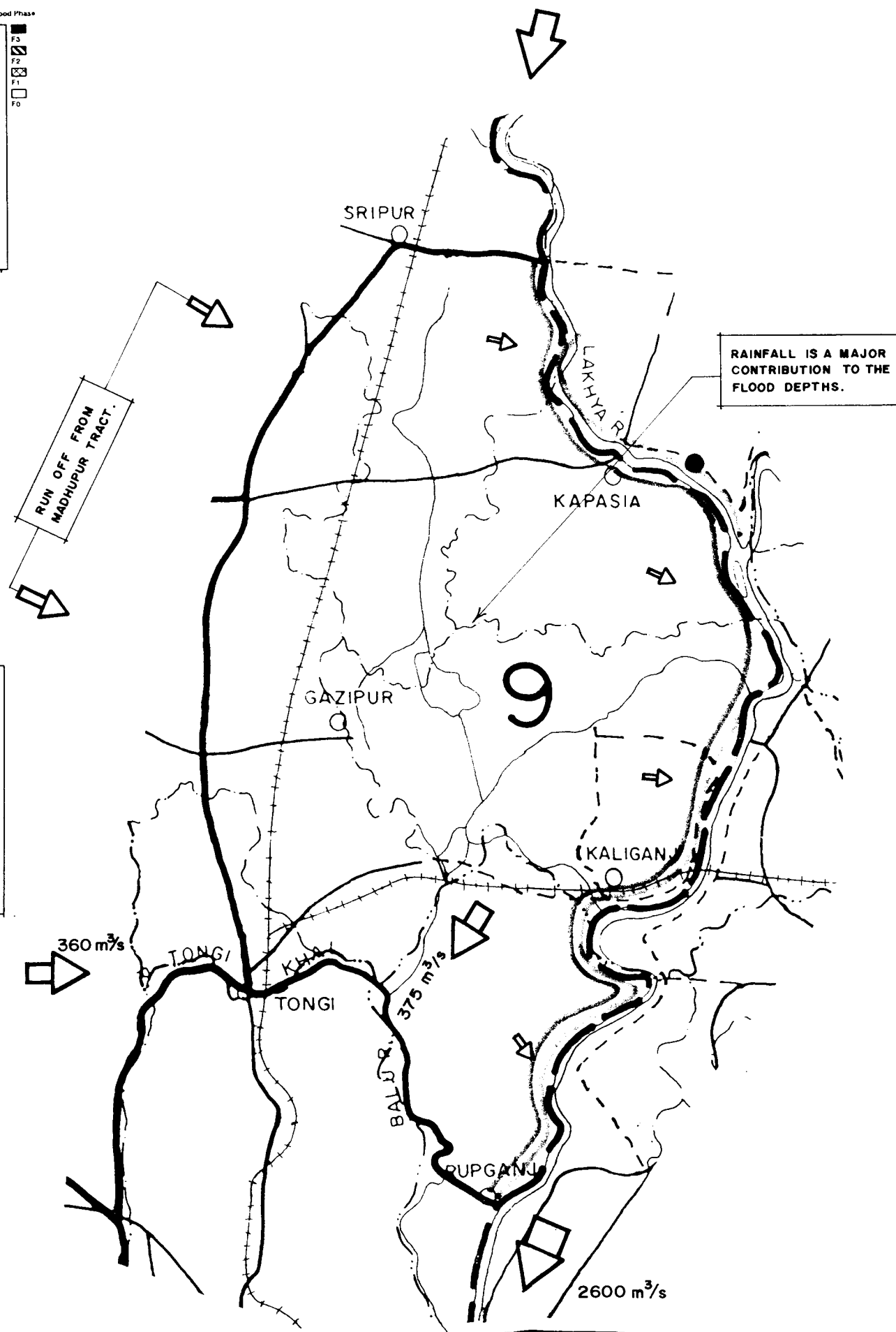
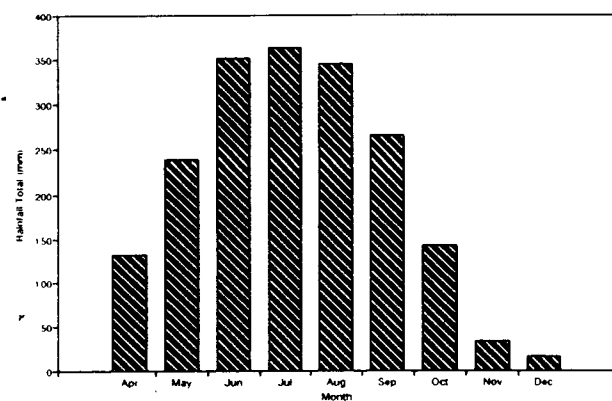
PU 9 - PLANNING MAP

200

FLOODING CHARACTERISTICS
(10 Day Period Average)



Monthly Mean Rainfall Statistics
Station: Kapasia



EMBANKMENT

EXISTING ———
PROPOSED ———

DRAINAGE

RIVER IMPROVEMENT ———
NEW DRAINAGE CHANNEL ———

STRUCTURE

WEIR J, K ▲
REGULATOR C₁₋₃₀, C_{20+D} ■
CDO E, F, G ●
BRIDGE B, L []
THROTTLE A)
EXISTING STRUCTURE ●

COMPARTMENT

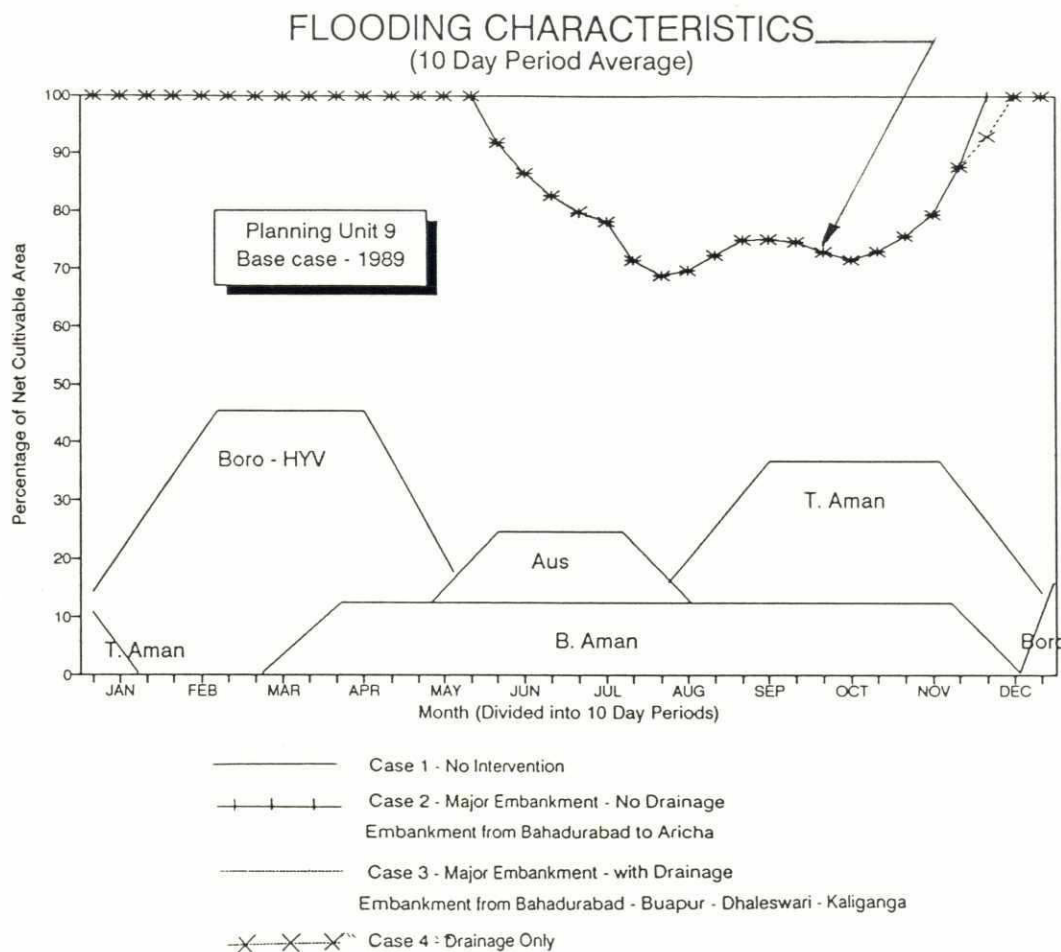
APPROX. ANNUAL AVERAGE
PEAK DISCHARGE (m³/s) ➡

GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL	
COMMISSION OF THE EUROPEAN COMMUNITIES	AND GOVERNMENT OF FRANCE
NORTH CENTRAL REGIONAL STUDY FAP - 3, PHASE - 2	
PLANNING UNIT 9	
NCRS CONSORTIUM BCEOM CMR EUROCONSULT WOTT, MACDONALD INT. SATEC	IN ASSOCIATION WITH DESH UPODESH LTD. BETS
SCALE 1:250,000 DATE 10th August 1991	

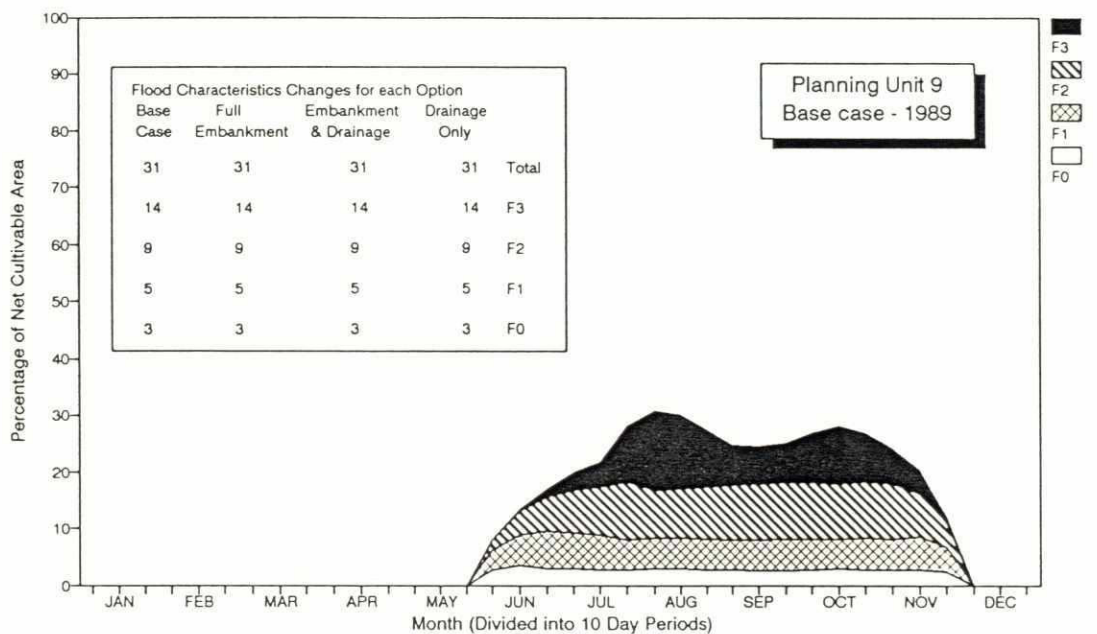
262

Figure 5.9.2

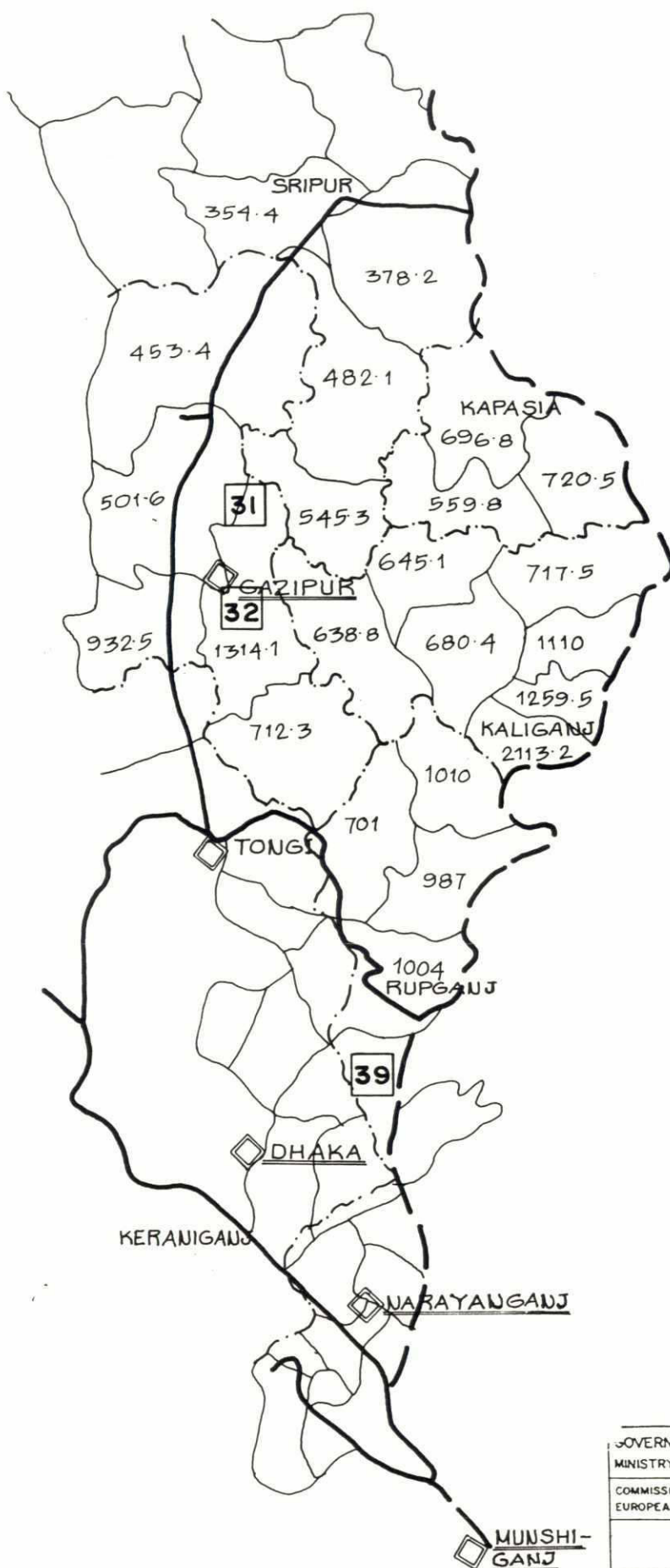
PU9 - Cropping Calendar and Flood Characteristics



FLOODING CHARACTERISTICS (10 Day Period Average)



202

**LEGEND :—**

- MAUZA BOUNDARY
- POPULATION DENSITY 742
(PERSONS / Km², 1981 DATA)
- POSSIBLE GROWTH CENTRES 2
(POPULATION > 10,000)
- MAJOR TOWNS
- DISTRICT HEADQUARTER



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FAP - 3, PHASE - 2

PU 9/12 - POPULATION MAP

WCRS CONSORTIUM
BCEOM
CNR
EUROCONSULT
MOTT MACDONALD INT.
SATEC

IN ASSOCIATION WITH
DESH UPODESH LTD.
BETS

SCALE
DATE 10th August 1991

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5.10 PU 10

5.10.1 Characteristics

Land Resources: Eastern Ganges Flood Plain

Soils : Silt loam-silty clay loam-clay

Floods : Seasonal flooding by river water 2-5 feet on the highest ridges, more than 10 feet in the lower basins/depressions during 4 to 6 months.

Flood Categories: Fo = 8.7%, F1 21.4%, F2 = 40.2%, F3 = 29.7%

Groundwater : The aquifer conditions are favourable, with average storage coefficient of 6% and tubewell specific capacities averaging 12.5 l/s/m. At present, maximum SWL averages 7.4m at the end of April, allowing STWs to operate in most areas.

Minor

irrigation Relatively limited and meets some 26% of estimated irrigation demand. STWs are the dominant technology in this area. The assesment indicates that under present conditions, groundwater could supply 100% of the residual irrigation demand. The introduction of partial flood protection would reduce groundwater recharge by about 9%, but this would have no significant effect on resources which would still substantially exceed irrigation demand.

Agriculture : Agricultural area (cultivated) $\pm 48,255$ HA = 71.8% of the gross area
 Irrigated area $\pm 13,094$ HA = 27.1% of CTA
 Potential increase of irrigated area is very limited
 Cropped area ± 90540 HA = 187.6% cropping intensity

<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-irrigated</u>
Single cropped	Boro	Sugarcane/Rabi crops
Double cropped	B.W.Aman/Aus/Jute-Boro	D.W.Aman/Aus/Jute-Rabi crops
Triple cropped	D.W.Aman-Mustard/ pulses-Boro	D.W.Aman/Aus/Jute - Mustard/ pulses - Rabi crops Winter Vegetables/Rabi crops- Aus - Summer Vegetables.

Production	Area(HA)	% of CTA	Production(Ton)	%
T.Aman	209	0.4	423	0.4 of rice prod.
Boro	13,379	27.7	63,301	59.9
Aus	13,535	28.0	12,190	11.5 "
D.W.Aman	24,784	51.4	29,844	28.2 "
Total rice	51,906	107.5	105,757	100.0 "
Jute	2,424	5.1	3,304	
Wheat	5,014	10.4	8,772	
Mustard	5,308	11.0		3,119
Other crops	25,888	53.6		

Limitations: Flooding during a long time of the year without any possibility to drain.

5.10.2 Aims and Strategy

Development Aims:

- reduce the amount of spillage from the Rivers Jamuna, Padma and Dhaleswari during high floods and thereby reduce crop loss and infrastructure damage in the area;
- reduce the amount of damage/loss of land/homestead through flooding;
- improve the hydraulic efficiency of the Dhaleswari, and Kaliganga Rivers;
- further increase agricultural development in the area, increase the security of the T. aman cultivation enabling farmers to increase HY aman cultivation and yields;
- minimise any deleterious impact on fishery resources in the area;
- reduce crop damage in the pre-monsoon period;

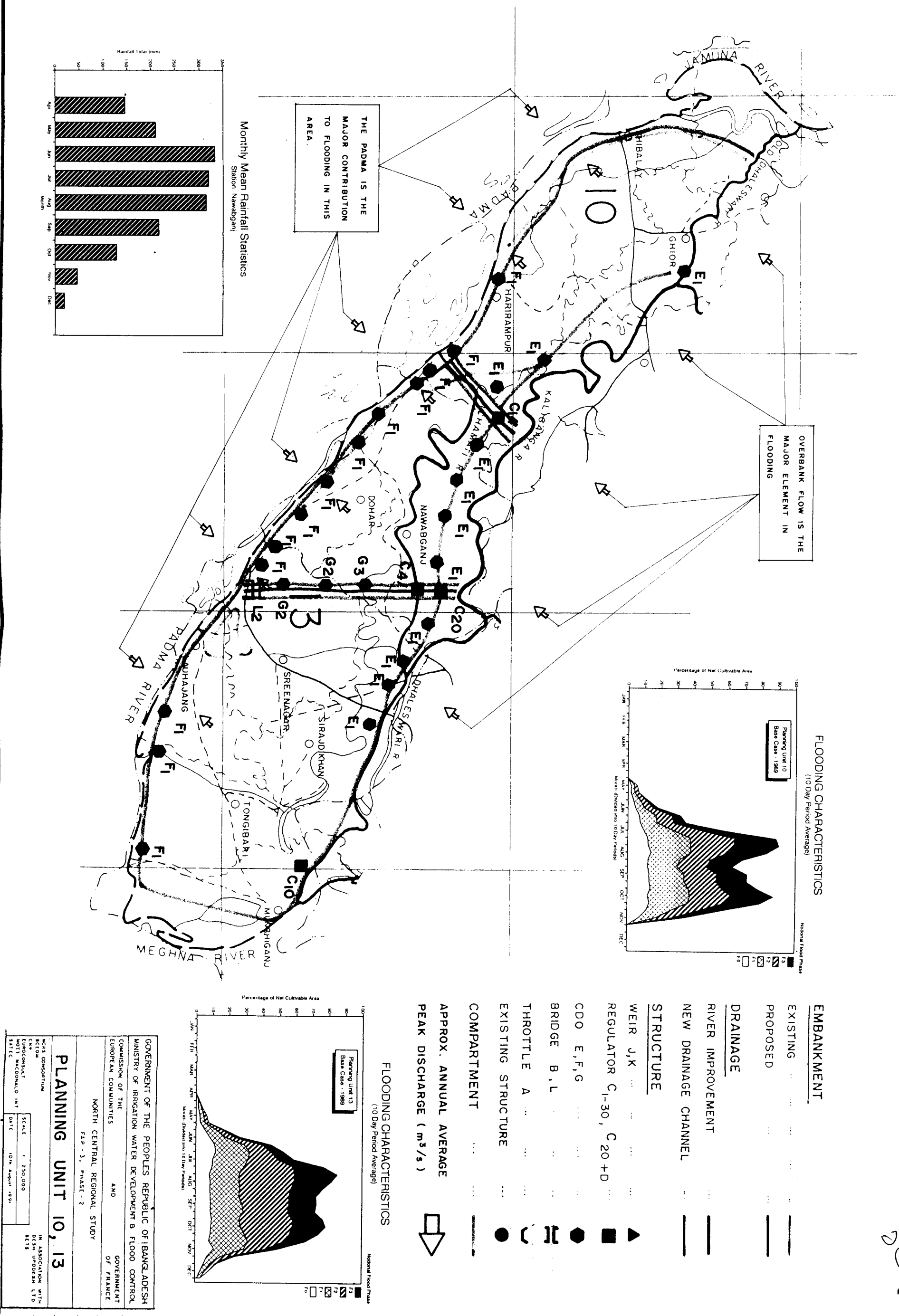
Development Strategy :

- study the possibilities of embankment along the main river and proposals given in the SW Dhaka project;
- ensure that flow/channel functioning should be maintained to a certain level for fisheries, navigation and dry season requirements;
- identify potential compartmentalisation configurations to improve the water management in different parts of the area;
- by modifying the flooding regime promote agricultural development both of monsoon crops (rainfed) and irrigated crops;
- improve the natural drainage system by improving cross drainage facilities.

Figure 5.10.1

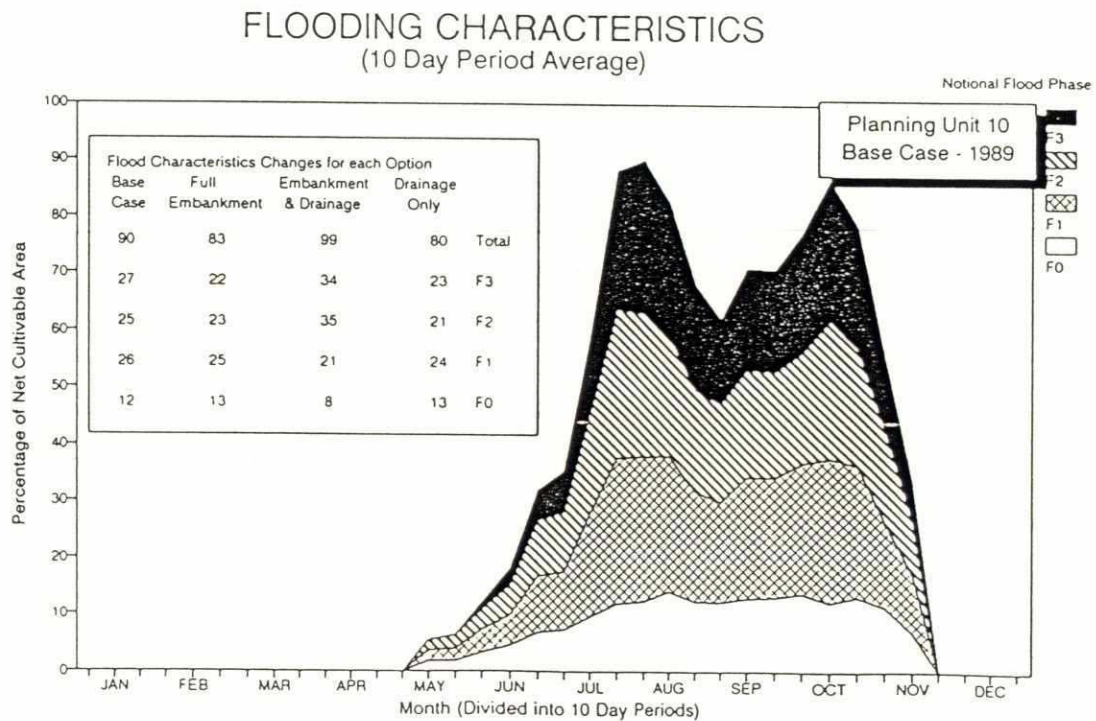
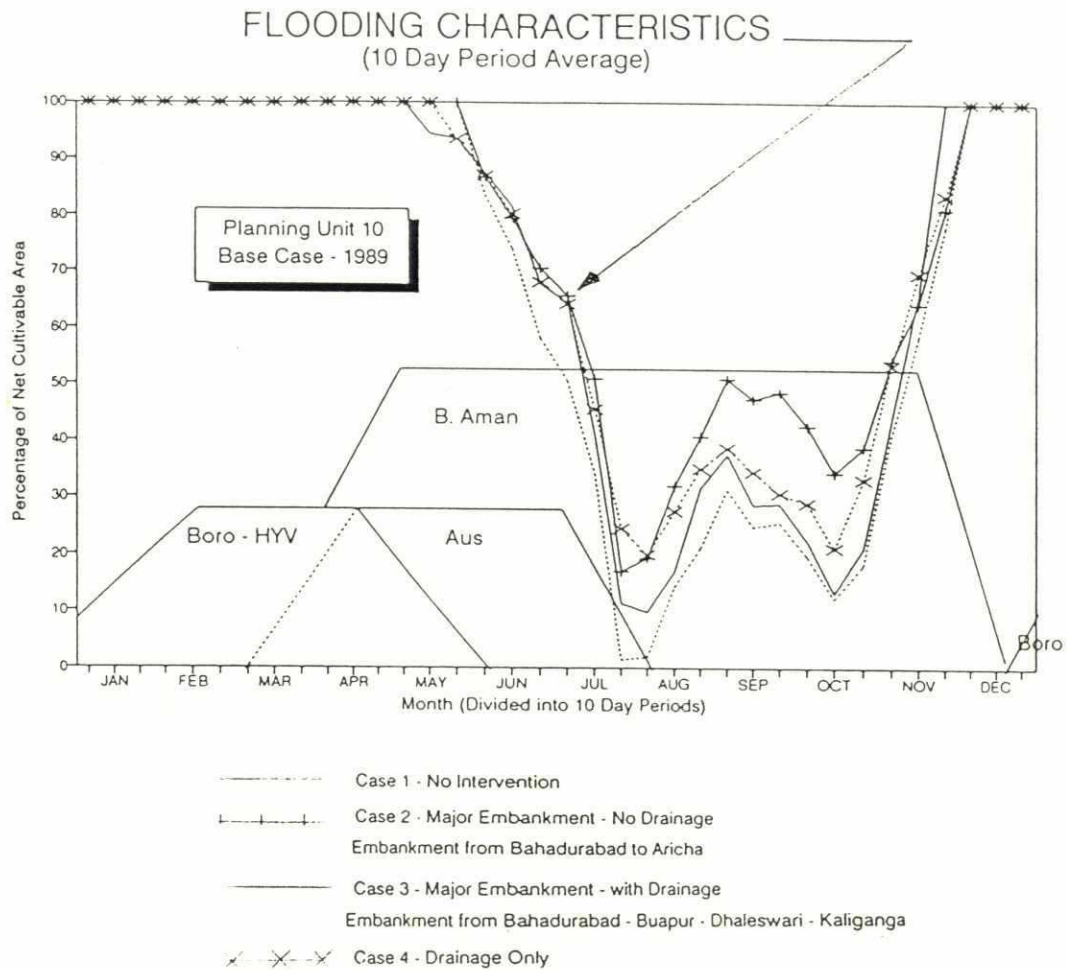
PU10/13 - PLANNING MAP

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Figure 5.10.2
PU10 - Cropping Calendar and Flood Characteristics





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5.11 PU 11

5.11.1 Characteristics

Land Resources:	Young Jamuna Flood Plain	± 90%
	Old Meghna Flood plain	± 10%, most eastern area
Soils:	Silty clay/loam, isolated some loam, sand and lime, heavy texture, possible iron toxicity in soil which stays wet during dry season (deep flooded areas). On river sides: silt loam, silty clay or clay.	
Floods:	Broad ridges flooded 5-10 feet, basins upto 15 feet during 4 to 6 months, deep flooded areas stay wet part or all of the dry season. About 85-90% of the cultivated area is flooded every year.	
Remarks	North East area of Keranigranj is urban area	
Flood categories	Fo = 12.4%, F1 = 24.4%, F2 = 21.6%, F3 = 41.6%	
Groundwater	Aquifer conditions are moderate, with average storage coefficient of 5% and tubewell specific capacities averaging 7.9 l/s/m. At present, maximum SWL averages 6m at the end of April, allowing STWs to operate in most areas.	
Minor irrigation	Relatively limited and meets some 31% of estimated irrigation demand. STWs and LLPs are the dominant technologies in this area. The assesement indicates that under present conditions, groundwater could supply 100% of the residual irrigation demand. The introduction of partial flood protection would reduce groundwater recharge by about 5%, but this would have no significant effect on resources which could still satisfy irrigation demand.	
Agriculture	Agricultural area/cultivated) = 18.564 HA = 67.3%	
	Irrigated area = 5.683 HA = 30.5%	
	Potential increase of irrigation is very limited	
	Cropped area = 20.408 HA = 109% cropped intensity	
Cropped pattern	<u>Irrigated</u>	<u>Non-Irrigated</u>
Single cropped	Boro	Sugarcane/Rabi corps
Double cropped	D.W.Aman/Aus/Jute-Boro	Aus/D.W.Aman/Jute - Rabi crops
Triple cropped	Boro-Vegetables-T.Aman	Summer Vegetables - T.Aman- Winter vegetables

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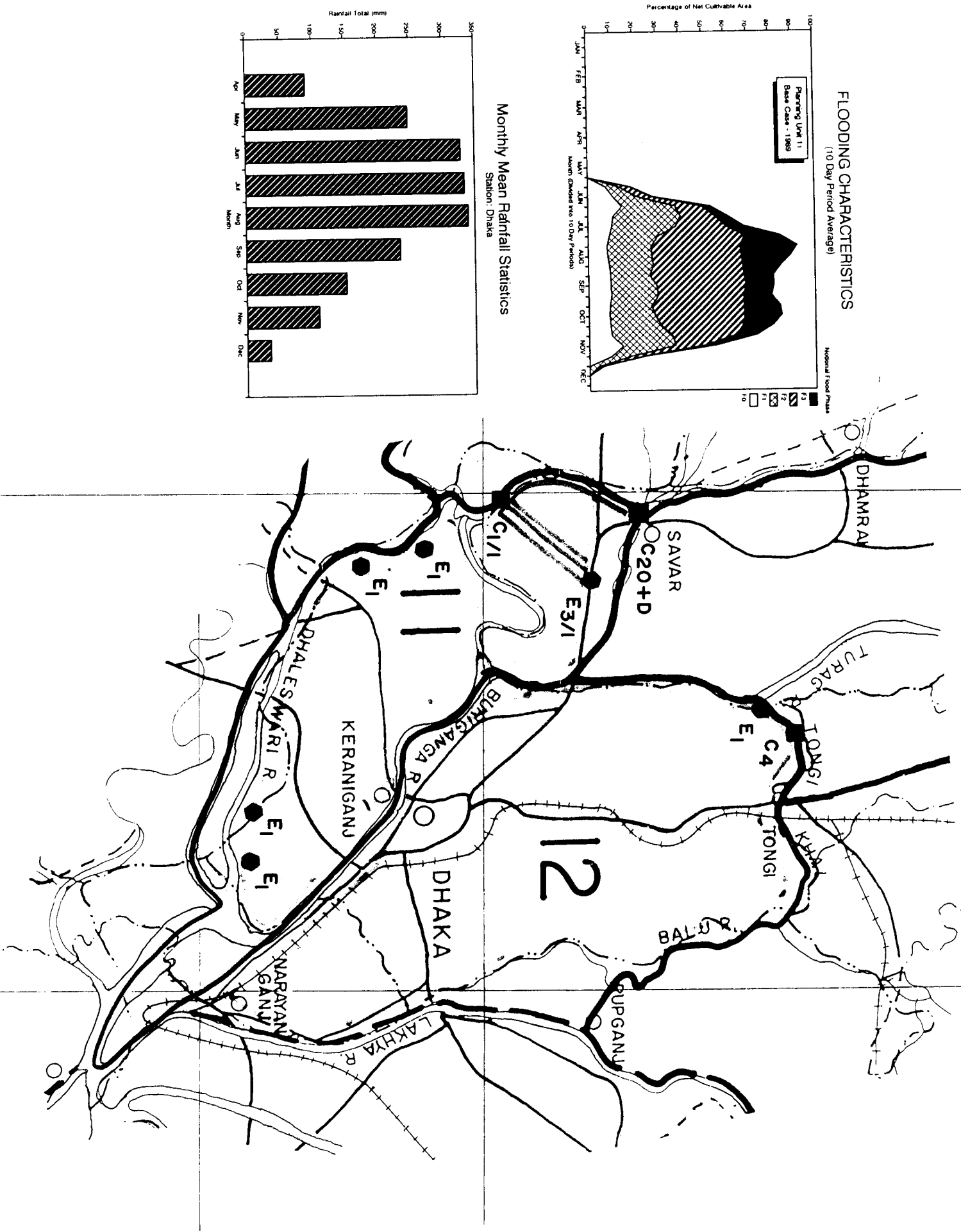
Production	Area (HA)	% of CTA	Production(Ton)	%
T.Aman	1,076	5.8	3,069	7.0 of rice prod.
Boro	5,943	31.9	31,419	71.8 "
Aus	1,885	10.2	3,715	8.5 "
D.W.Aman	3,438	18.4	5,533	12.7 "
Total rice	12,342	66.5	43,736	100 "
Jute	1,399	7.5	2,197	
Wheat	584	0.3	1,092	
Mustard	1,373	7.4	993	
Other crop	4,710	25.4		

Limitation : Seasonally deep flooding is major constraint.
No need for extension of irrigation, because of high soil humidity during dry season in most of the area.

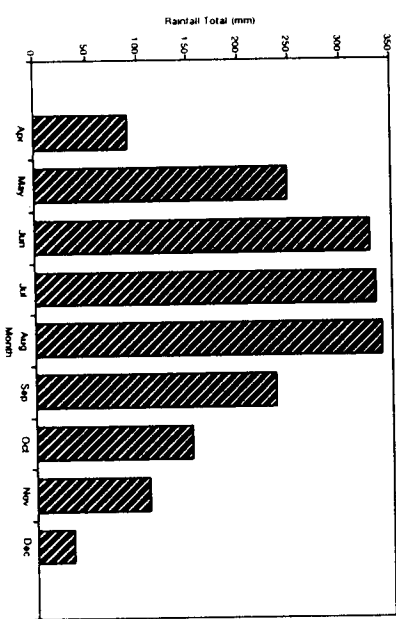
Figure 5-11.1

PU 11/12 - PLANNING MAP

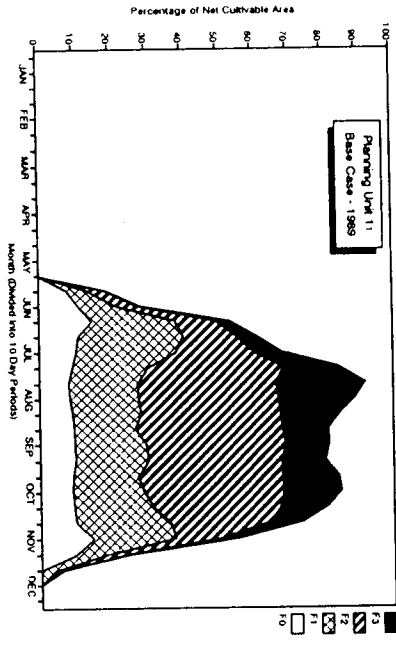
288



Monthly Mean Rainfall Statistics
Station: Dhaka



FLOODING CHARACTERISTICS
(10 Day Period Average)

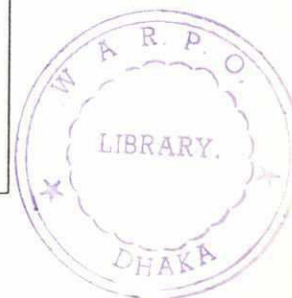
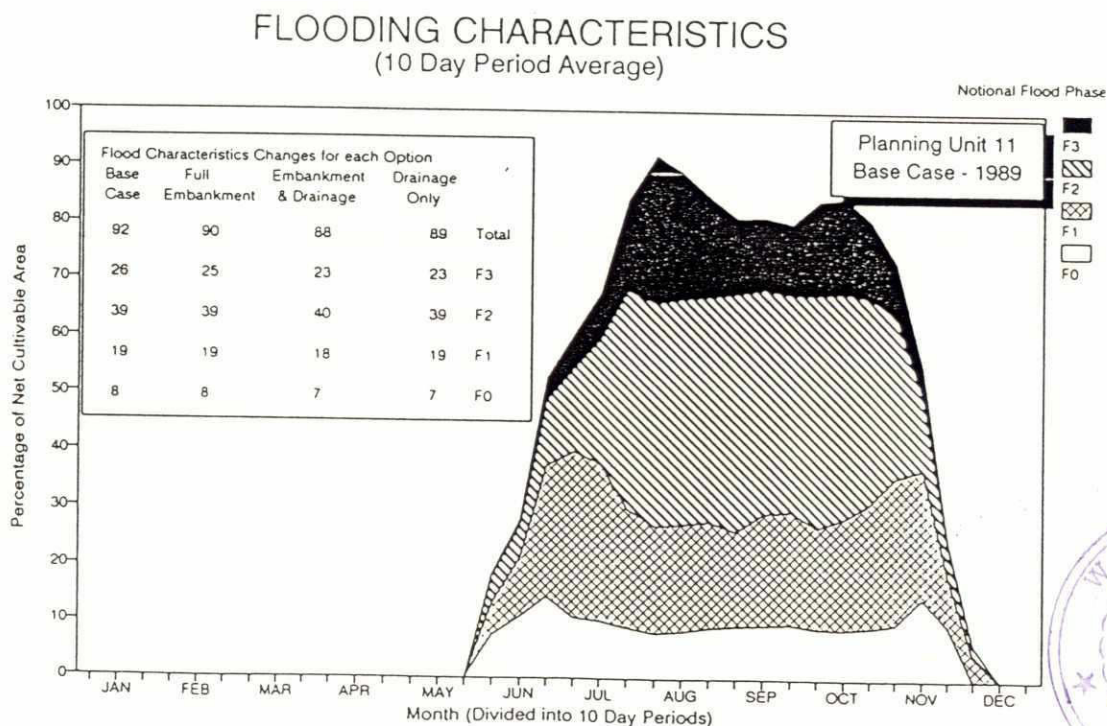
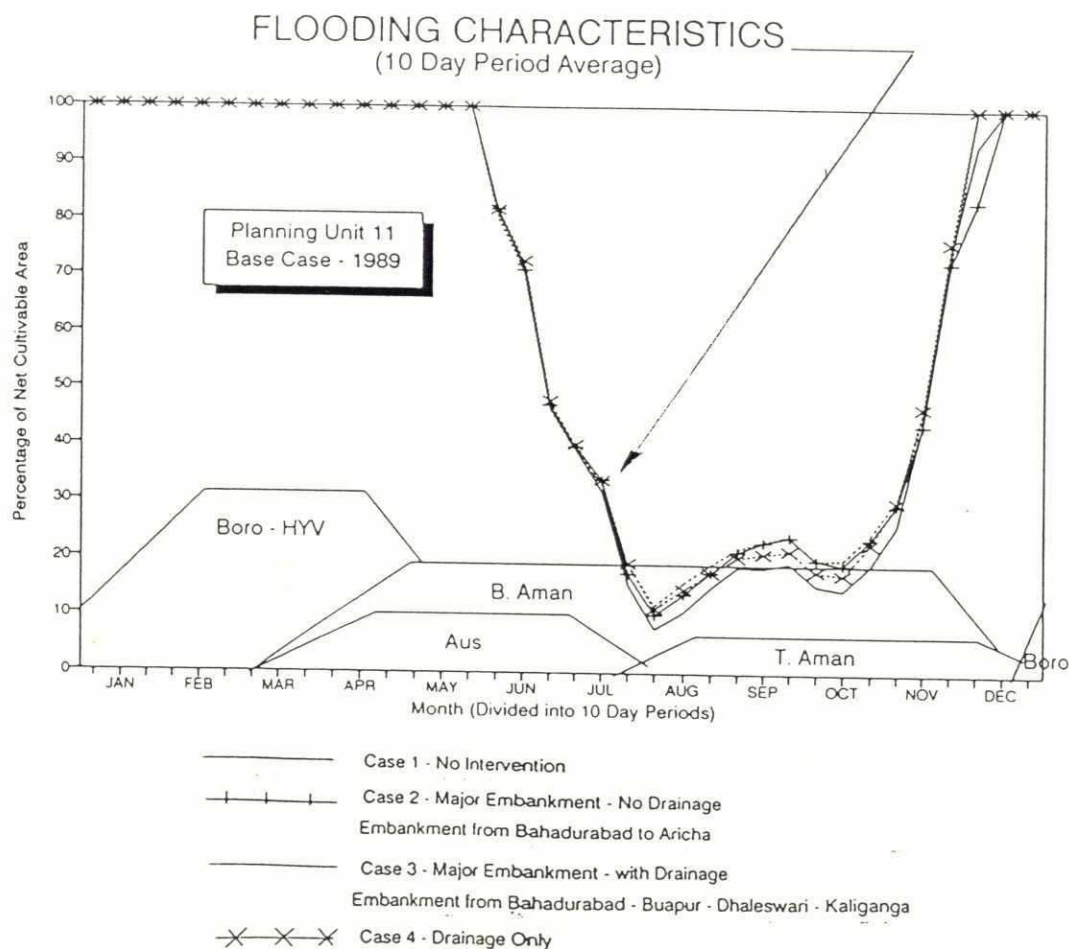


- EMBANKMENT
 - EXISTING
 - PROPOSED
- DRAINAGE
 - RIVER IMPROVEMENT
 - NEW DRAINAGE CHANNEL
- STRUCTURE
 - WEIR J,K
 - REGULATOR C₁₋₃₀, C_{20+D}
 - CDO E,F,G
 - BRIDGE B,L
 - THROTTLE A
 - EXISTING STRUCTURE
- COMPARTMENT

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MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL	
COMMISSION OF THE	AND GOVERNMENT OF FRANCE
EUROPEAN COMMUNITIES	
NORTH CENTRAL REGIONAL STUDY	
FAP - 3, PHASE - 2	
PLANNING UNIT 11, 12	
MCA'S CONSULTING	
CNA	SCALE 1:250,000
CURRICULUM	DATE 10th August 1991
DATE	BY

789

Figure 5.11.2
PU11 - Cropping Calendar and Flood Characteristics



5.12 PU 12

This Pu is Dhaka city. No information is presented on this area as it is covered by FAP 8A/8B

5.13 P.U.13

5.13.1 Characteristics

Land Resources:

Padma Active Floodplain	± 10%
Arial Beel	± 20%
Low Ganges Flood Plain	± 10%
Old Meghna Flood Plain	± 35%
Young Jamuna Flood Plain	± 25%

Soils:

Silt Loam - silty clay loam - clay - silty clay.

Arial beel : heavy texture. Raised platforms (man made) in the area of Munshiganj, Tongibari and Keraniganj.

Soil toxicity risk in areas which stay wet during dry season. River bank erosion in south and east of the area.

Floods

Seasonal flooding 3-5 feet on the high river banks and ridges 10-15 feet in the flood plain. Raised platforms mostly above normal flood level.

Arial beel flooded 10-20 feet with considerable areas flooded during dry season.

Flood categories

F₀ = 11.2%, F₁ = 21.8%, F₂ = 23.7%, F₃ = 43.3%.

Groundwater :

Aquifer conditions are moderate, with storage coefficient averaging 3.2%, and tubewell specific capacities of 10.5 l/s/m. At present, maximum SWL averages 5.6m at the end of April, allowing STWs to operate in most areas.

Minor

irrigation :

Relatively limited and currently meets some 24% of estimated irrigation demand. STWs and LLPs are the dominant technologies. The assesment indicates that under present conditions, groundwater could supply 100% of residual irrigation demand in PA13. The introduction of partial flood protection would reduce groundwater recharge by about 5%, but this would have no significant effect on resources which could still satisfy irrigation demand.

Agriculture :

Agricultural area (cultivated)	76,616 HA = 75.6% of gross area
Irrigated area (most L.L.Ps)	18,427 HA = 24% of CTA
Potential increase of irrigation is very limited	
Cropped area	140,433 HA = 183 % of CTA

286

<u>Cropping pattern</u>	<u>Irrigated</u>	<u>Non-Irrigated</u>
Single cropped	Boro	Potato/Pulses/Spices/Wheat/Vegetables
Double cropped	Aus/D.W.Aman-Boro Aus/jute/Aus+ D.W.Aman-Boro	Aus/D.W. Aman/Jute-potato and other Rabi crops.
Triple cropped	Boro-D.W.Aman-Pulses/Mustard/Vegetables	Aus/D.W.Aman/Jute-Pulses/Mustard/Vegetables- Potato/Rabi crops

Production	Area(HA)	%	Production (Ton)	%
T.Aman	514	0.7	1459	0.9 of rice prod.
Boro	21276	27.8	1013955	9.9 "
Aus	16717	21.8	32531	19.2 "
D.W.Aman	27422	35.8	33932	20.0 "
Total rice	65928	86.1	169316	100 "
jute	7750	10.1	11472	
Wheat	4051	5.2	6113	
Mustard	4896	6.4	3687	
Other crops	57808	75.5		

Remarks: P.U.13 is the main supplier of potatoes and vegetables for the Dhaka market. Area of potatoes in 1990/1991 has been 24,000 HA.

Limitations: Seasonal flooding without drainage possibilities.

5.13.2 Aims and Strategy

Development Aims:

- reduce the amount of spillage from the River Padma and Dhaleswari during high floods and thereby reduce crop loss and infrastructure damage in the area;
- reduce the amount of damage/loss of land/homestead through flooding;
- improve the hydraulic efficiency of the Dhaleswari Ichamoti and Kaliganga Rivers;

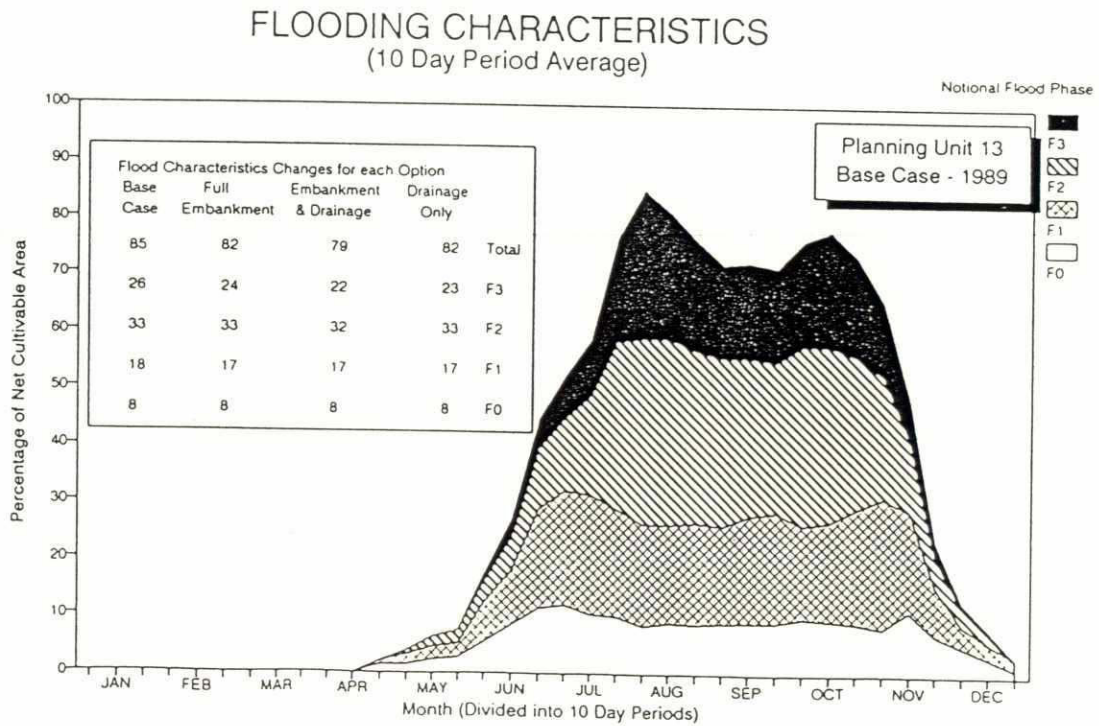
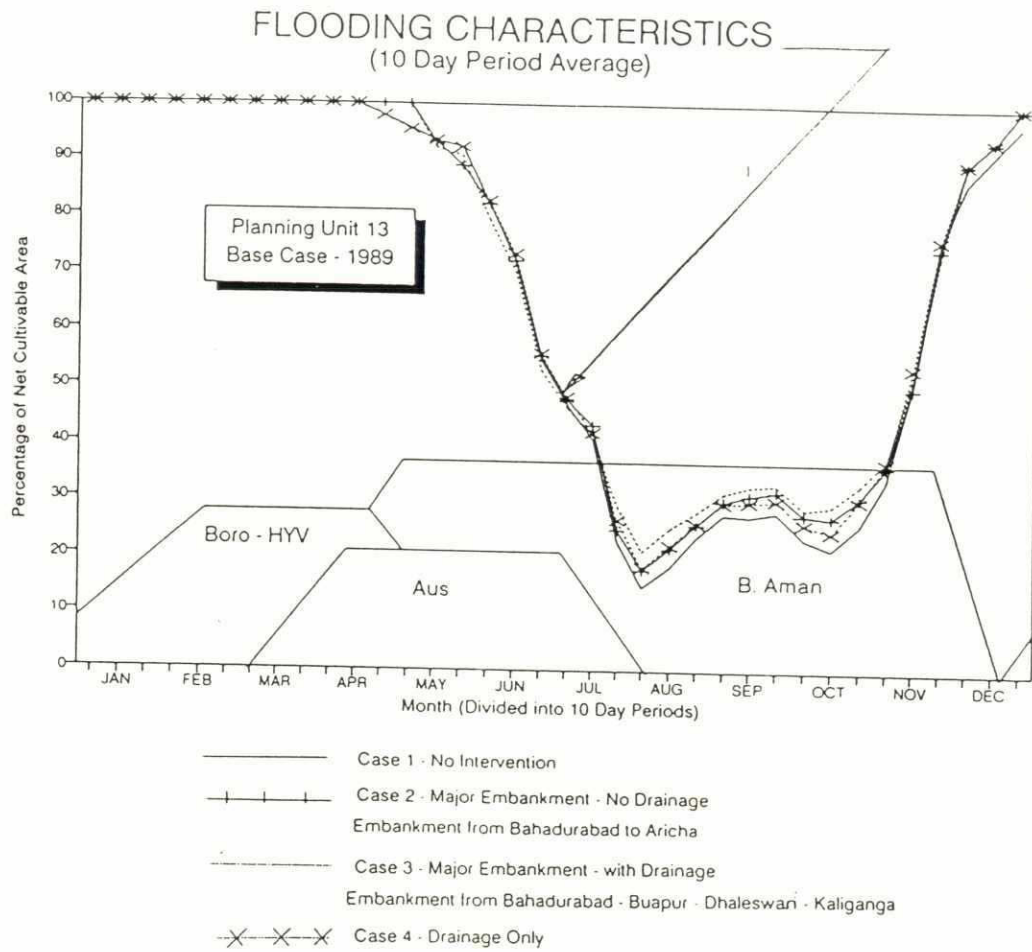
- further increase agricultural development in the area, increase the security of the T. aman cultivation enabling farmers to increase HY aman cultivation and yields;
- minimise any deleterious impact as fishery resources in the area;
- reduce crop damage in the pre-monsoon period;

Development Strategy :

- study the possibilities of embankment along the main rivers and proposal;
- ensure that flow/channel functioning should be maintained to a certain level for fisheries, navigation and dry season requirements;
- identify potential compartmentalisation configurations to improve the water management in different parts of the area;
- by modifying the flooding regime promote agricultural development both of monsoon crops (rainfed) and irrigated crops;
- improve the natural drainage system by improving cross drainage facilities.

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Figure 5.13.1
PU13 - Cropping Calendar and Flood Characteristics



CHAPTER 6

Preliminary Regional Plan

6.1 Pre-selection of Schemes

The development options have been studied for each PU and cost estimates derived for the engineering aspects.

The pilot hydraulic model has been run to establish flooding characteristics under present conditions and then to investigate the effect of structural investigations on the flooding characteristics, see Figures 5.1.2 to 5.11.2. This exercise illustrates that the flood characteristics vary significantly across the Region.

Generally it is the South-western region that suffers from heavy flooding, with PUs 4,6,7,10,11 and 13 having more than 50% of the net cultivable area flooded in a typical year. The other areas are less affected by flooding and the main constraints to agriculture in PUs 3,5 and 9 are water shortage rather than excess.

Preliminary runs of the hydraulic model have been made as shown in Table 6.1. The results are presented in Chapter 5 where relevant (and in Annex III for the 1988 year). Other results will be presented in the PSR II.5.

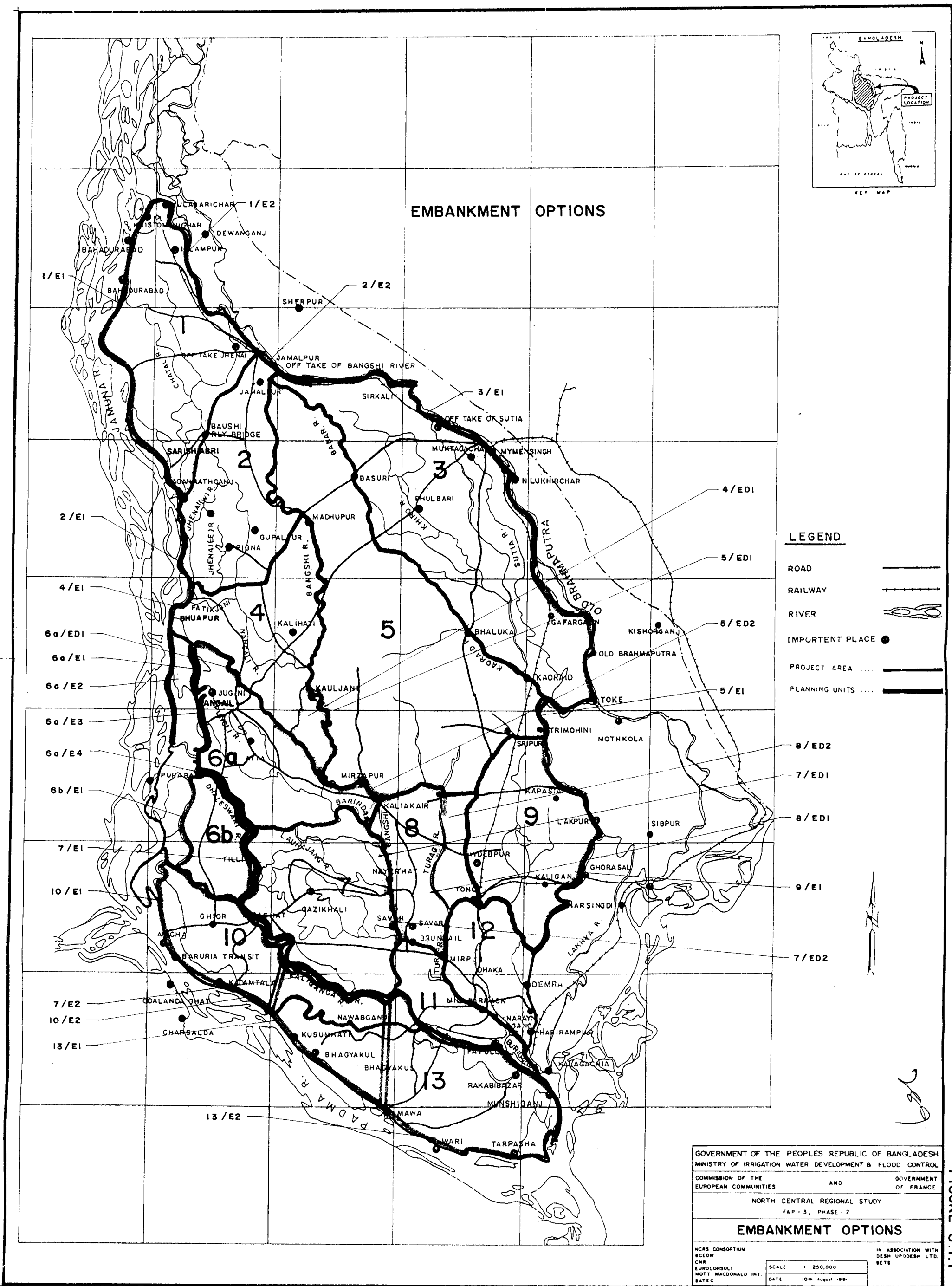
These preliminary runs have been made to show the effect of the following interventions (see Section 3.2.1 for more detailed explanation):-

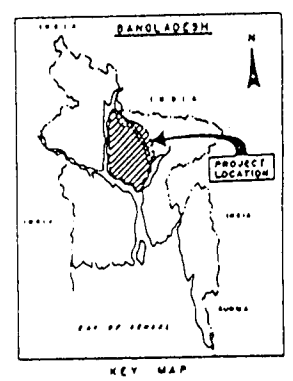
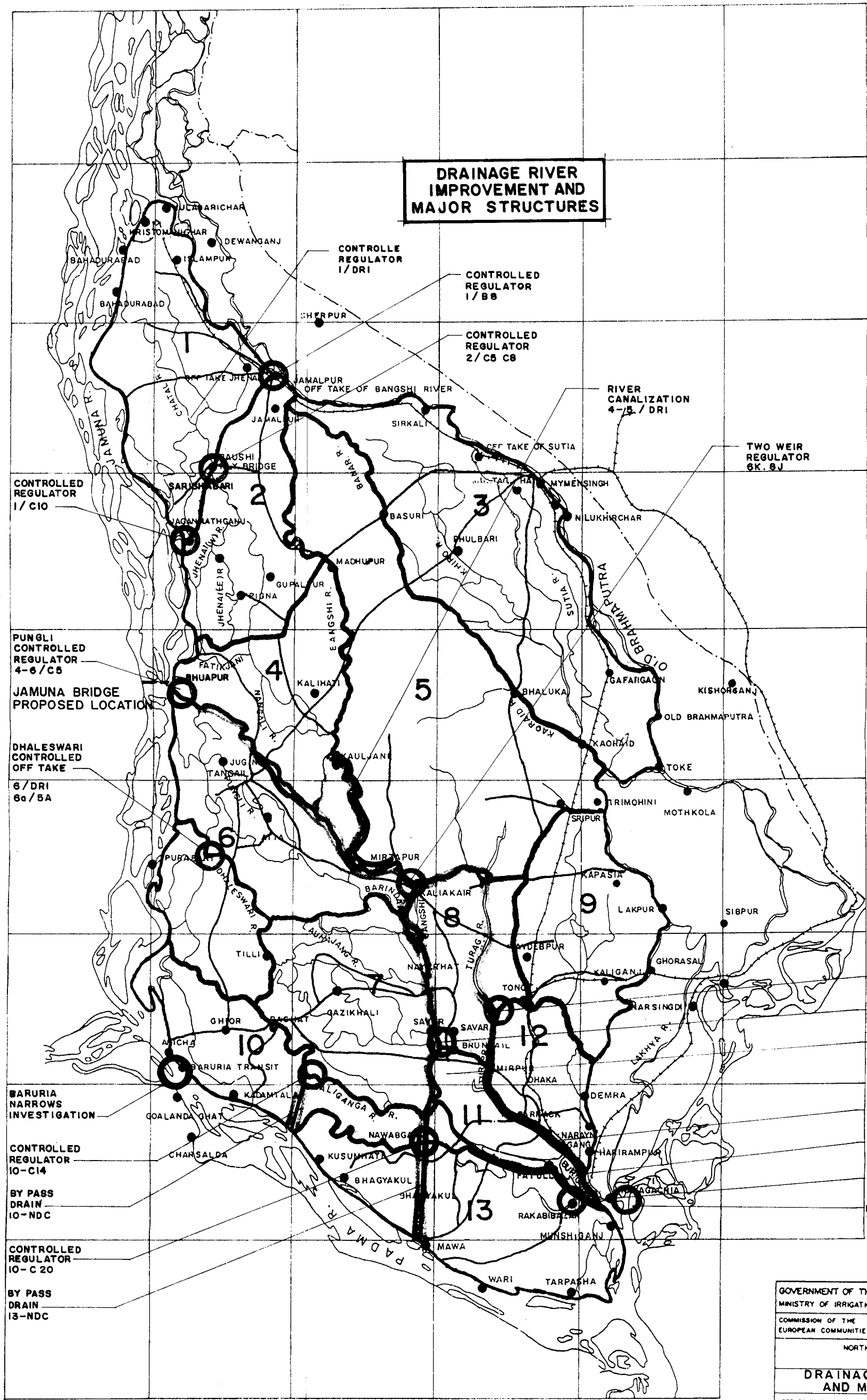
- construction of embankments only
- improvements to the drainage and river system
- embankments and drainage together
- as above but with control and/or restrictions of flow by structures (such as possible control of inflow to the Jhenai

The pre-selected schemes have been made after consideration of the apparent impact on flooding of the possible interventions as shown on the Figures in Chapter 5. These show that only a few PUs are significantly affected by such structural measures, and these combinations (of possible scheme and affected PU) have been pre-selected for impact assessment.

The result of this pre-selection is the list of schemes shown in Table 6.2. The list of such schemes are RS1 to RS11. The Table also includes possible schemes that have not yet been investigated using the hydraulic model - RS 12 to RS 16 and RO1 to RO3.

Table 6.2 details the scheme names and components, which are identified on Figures 6.1.1, 6.1.2 and 6.1.3. It also shows the PUs significantly affected by the proposed scheme.





- LEGEND**
- ROAD
 - RAILWAY
 - RIVER/KHAL
 - IMPORTANT PLACE
 - PROJECT AREA
 - PLANNING UNITS
 - COMPARTMENTS
 - BY PASS DRAINS
 - INTERNAL EMBANKMENT
 - EXISTING EMBANKMENT
 - CONTROL STRUCTURES
 - PROPOSED INVESTIGATIONS

- TONGI REGULATOR 8-C4
- SAVAR REGULATOR 8-C20
- SMALL BY PASS DRAIN 11-DRI NDC
- BURIGANGA CANALIZATION 11A/DRI
- DHALESWARI CANALIZATION 11B/DRI
- ICHAMATI REGULATOR 13-C10
- MEGHNA INVESTIGATION

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 FAP - 3, PHASE - 2

DRAINAGE RIVER IMPROVEMENT AND MAJOR STRUCTURES

HCPS CONSORTIUM
 BCDM
 CHB
 EUROCONSULT
 MOTT MACDONALD INT.
 BATEC

IN ASSOCIATION WITH
 DESH UPODESH LTD.
 BETS

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 DATE 10th August 1991

FIGURE 6.1.2

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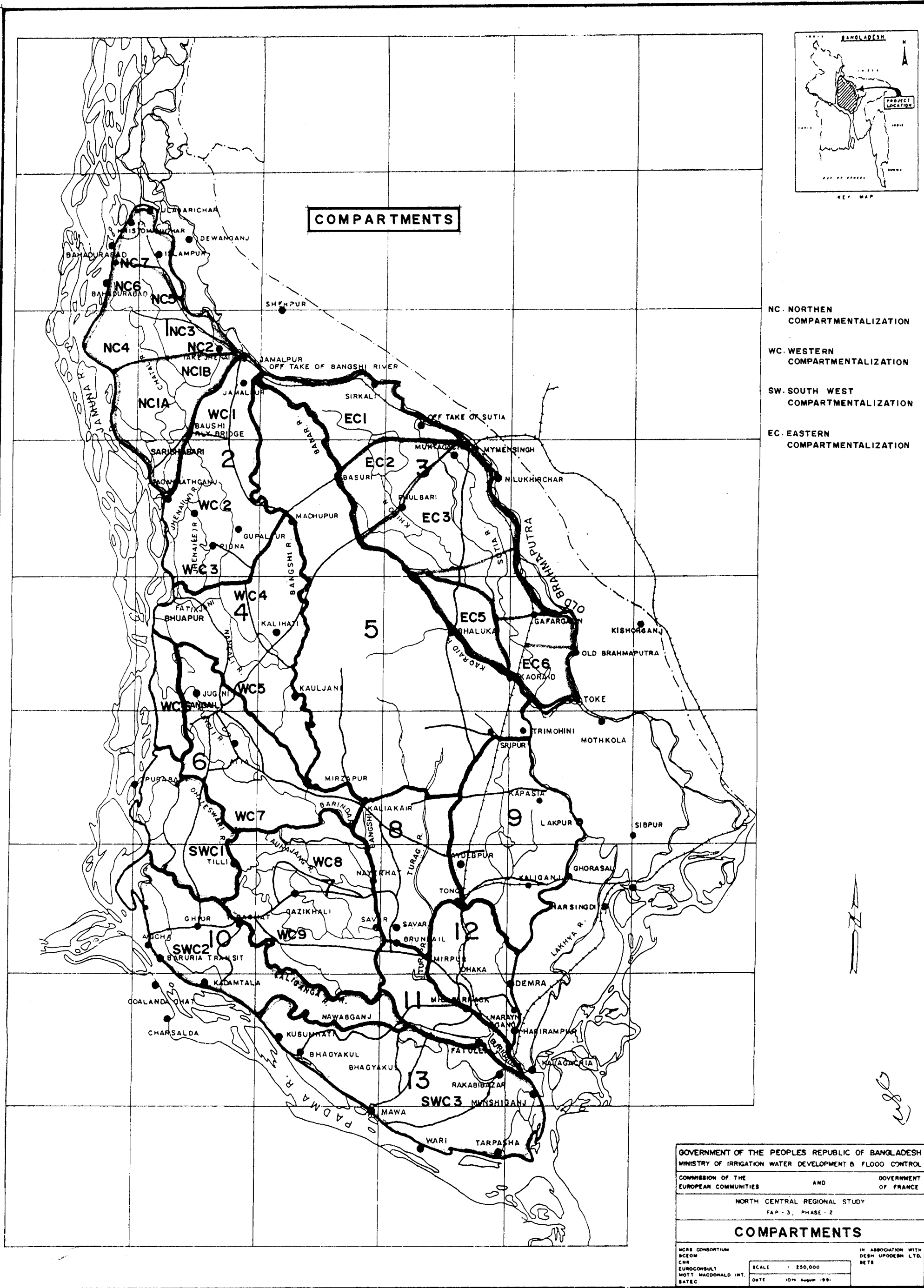


FIGURE 6.1.3

TABLE 6.1

Summary of Hydrodynamic Model Runs

Run No.	Year	Option No.	Description	Location Of Results
H00	1988	-	Existing Conditions	Annex III
H0 ¹	1989	-	Existing Conditions	Chapter 5
H1	1989	-	Conveyance improvement of 100% on lower Dhaleswari & Buriganga	PSR II.5
H2	1989	-	Conveyance improvement of 25% on lower Dhaleswari & Buriganga	PSR II.5
H3	1989	-	H2 + Canalization of Bangshi (Kauljani - Mirzapur)	PSR II.5
H4 ²	1989	RS4,RS9	H2 + Diversion channels from Kaliganga & Dhaleswari to Padma	Chapter 5
H5 ³	1989	RS6	Embankment on Jamuna from Bahadurabad to Aricha, only Dhaleswari open, no drainage options	Chapter 5
H6	1989	-	H5 with drainage options	PSR II.5
H7	1989	RS7,RS10	H6 with flows at Jhenai Offtake restricted to 75 cumecs max.	PSR II.5
H8	1989	-	Embankment on Jamuna from Bahadurabad to Bhuapur, along Dhaleswari & Kaliganga + drainage options + restricted Jhenai Offtake	PSR II.5
H9	1988	-	H8 + lower Chatal offtake open	Annex III
H10 ⁴	1989	RS1,RS2,RS5	H9 for 1989	Chapter 5
H11	1989	RS3	H10 without drainage	PSR II.5
H12	1989	RS8	Dhaka South-west Polder ⁵ (undrained), water accumulation	PSR II.5
H13	1989	RS1,RS2	H7 + controlled lower Chatal offtake + Baushi Bridge flows restricted to 50 cumecs max.	PSR II.5

Source: CS 1991

¹Base Case in Figure 5.1.2 to 5.13.1²Drainage only in Figure 5.6.2 etc.³Full Embankment in Figure 5.6.2 etc.⁴Embankment & Drainage in Figure 5.1.2 to 5.13.1⁵Only NAM model used for this run, no hydrodynamic routing

6.2 Preliminary Economic Analysis

6.2.1 Costs

The engineering costs (June 1991 prices) have been calculated following the guidelines as set out in Annex 1. These costs are to be presented in more detail in PSR VII. The summarised costs are presented in Table 6.2 for each scheme separated into Local and Foreign costs. The required land acquisition areas have been noted and the cost included in the Local costs.

All costs should be considered as preliminary. They will be revised and improved upon at the next (pre-feasibility) stage.

The costs for the compartmentalisation options (RS12 to RS16) have been given as a guide to the likely costs if a structural approach is taken to the compartments. The figures have been based on the experience of embankments and drainage works included in the Upper Shila project. It is appreciated that the policy on compartmentalisation is still under analysis (FAP 20) and it is quite possible that the approach recommended may be significantly less 'structural' thus requiring less capital investment but, probably more emphasis on water management through local participation and institutional measures.

Similarly the NCRS is aware of the study activities being carried out by FAPs 10,11,14 and 23. Due consideration of their results will be taken into account in assessing the application of the other Regional Options (ROs 1,2 and 3) for Flood Warning, Flood Proofing and Flood Preparedness in the Regional Plan. No costings have been done of these options at this stage.

6.2.2 Financial and Resource Benefits

The financial value of benefits has been estimated based on the impact of the pre-selected schemes on agriculture, fisheries, and general flood damage. The methodology of this approach is to be described in PSRs I,III and X. In general the approach set out in FPCO's Economic Guidelines has been followed.

The results of this preliminary analysis are presented in Tables 6.3 and 6.4.

It can be seen that only three schemes give an IRR of more than 12%. These are RS3 at 28%, RS6 at 26%, and RS2 at 14%. However it should be borne in mind that this is the result of only preliminary data and it is too early to rule out the other schemes showing marginal IRRs such as RS4 and RS7.

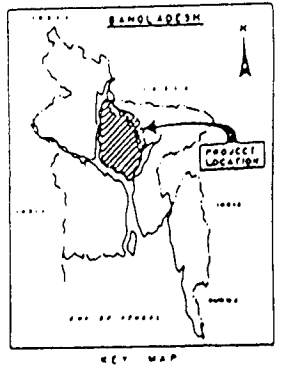
Although the preliminary approach to a scheme (RS1) for the Jamulpur Priority Project (JPP) Area (FAP 3.1) shows a negative rate of return, it should be noted that RS 2 includes the JPP area and this development option shows a favourable rate of return.

The preliminary estimate of impact on agriculture of the pre-selected schemes is shown in Table 6.4 and The impact on fisheries is given in Table 2.18

TABLE 6.2
Summary of Pre-Selected Schemes

Scheme Nr.	Scheme Name	Description	Scheme Components	Planning Units Affected	Costs inc. conting. (Tk. million)			Land Acq. (ha)
					Foreign cost	Local cost	Total* Capital Cost	
RS1	Jamulpur P.P. - main works	Major embankment + drainage/river improvement	1/E1+1/E2+1/DRI +1/SB8+1/SC10	PU 1	65	1200	1264	914
RS2	JPP-Jagannathganj-Bhuapur main embankment + Kauljani drainage	Major embankment + drain/river improvement (dependent on RS1)	2/E1+4/E1+4/DRI+ 4/ED1+5/ED1+2/SC5	PU 1, PU 2, PU 4	73	1892	1965	1420
RS3	Bhuapur-Dhaleswari-Kaliganga main embankment	Major embankment	6a/E1+6a/E3+6a/E4+7/E1 +7/E2+4-6/SC5	PU 6a, PU 7	53	1024	1077	755
RS4	Pungli-L. Bangshi-Buriganga river improvement/drainage	Main Drainage & River Improvement	6a/ED1+7/ED1+7/ED2+ 8/ED1+8/ED2+4-5/DRI+ S6K+S8J+S8-C20+S4-4/C5	PU 6a, PU 7, PU 8	472	3173	3644	1044
RS5	Bhuapur-Dhaleswari-Kaliganga main embankment + main drainage and river improvement[RS3+RS4]	Major embankment + drainage improvement	6a/E1+6a/E3+6a/E4+7/E1+ 7/E2+4-6/SC5+6a/SK +6a/ED1+7/ED1+7/ED2	PU 6a, PU 7, PU 8	525	4197	4721	1799
RS6	Bhuapur-Aricha Embankment	Major embankment	6a/E1+6b/E1+10/E1	PU 6a, PU 6b, PU 10, PU 7	1	1535	1536	820
RS7	Bhuapur-Aricha Embankment + river imp./dr.[RS6+RS4]	Major embankment + new drainage	6a/E1+6b/E1+10/E1+10/E2+ S10C14+6/DRI+S69/5A	PU 6a, PU 6b, PU 10, PU 7	473	4707	5180	1864
RS8	South West Dhaka Project - embankments	Major embankments	6b/E1+10/E1+10/E2 +13/E1+13/E2	PU 6b, PU 10, PU 13	40	2565	2605	1354
RS9	South West Dhaka Project - drainage only	New drainage channel + L. Dhaleswari river improvement	13-NDC+10-NDC+S13-C10+ S10-C20+11B/DRI	PU 6b, PU 10, PU 13	171	360	531	175
RS10	SWD Project - embankment + draina	Major embankment + drainage improvement	6b/E1+10/E1+10/E2+13/E1 +13/E2+13-NDC+10-NDC+ S13-C10+S10-C2+11B/DRI	PU 6b, PU 10, PU 13	211	2926	3137	1529
RS11	Savar Improvement	Drainage improvement (local scheme dependent on RS 5 being completed)	8/ED1+8/ED2+8/SJ+ 8/SC4+8/SC20	PU 8	72	400	472	328
RS12	Northern Compartmentalisation	Compartmentments & sub-compartmentments **	NC1	PU 1	319	149	468	164
RS13	Eastern Compartmentalisation	Compartmentments & sub-compartmentments **	EC1	PU 3	764	232	996	350
RS14	Western Compartmentalisation	Compartmentments & sub-compartmentments **	WC1	PU 2, 4, 6a, 7	1801	319	2120	745
RS15	South-Western Compartmentalisation	Compartmentments & sub-compartmentments **	SWC1	PU 6b, 10, 13	994	271	1266	445
RS16	Regional Main Drainage	Major new drains + improvements including control structures	10/NDC+13/NDC+11/NDC+ 11A/DRI+11B/DRI+ 13/SC10+10/SC14+10/SC20	to be ascertained	644	4396	5040	1219
RO1	Flood Warning - Regional	Flood Warning - Regional		All PU's		to be costed		
RO2	Flood Proofing	Flood Proofing		All PU's		to be costed		
RO3	Flood Preparedness	Flood Preparedness		PU's 4, 6, 7, 10, 11, 13		to be costed		

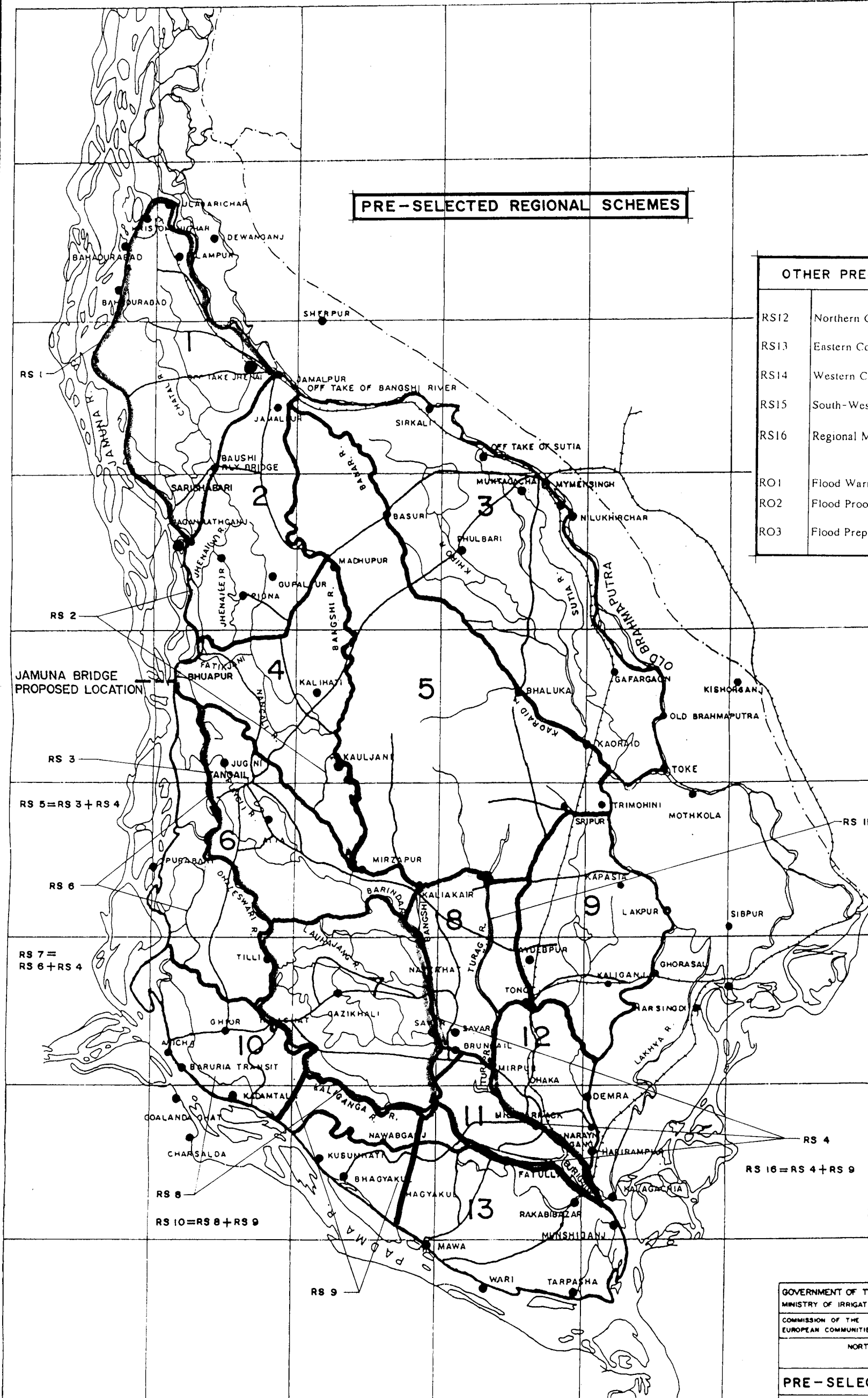
Source:- CS 1991 Note:- * Includes land acquisition costs, ** costs do not include an element for water management aspects
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PRE-SELECTED REGIONAL SCHEMES

OTHER PRE-SELECTED SCHEMES

RS12	Northern Compartmentalisation
RS13	Eastern Compartmentalisation
RS14	Western Compartmentalisation
RS15	South-Western Compartmentalisation
RS16	Regional Main Drainage
RO1	Flood Warning - Regional
RO2	Flood Proofing
RO3	Flood Preparedness



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PRE-SELECTED REGIONAL SCHEMES

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FIGURE 6.3.1

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TABLE 6.3
Preliminary Economic Analysis of Pre-selected Schemes

Alternative Number	Schemes	Planning Units	Million Taka							IRR (%)	NPV (Tk. mill.)
			Project costs (economic price)		Project benefits (economic price)			Decrease flood damage	Fishery income loss		
			Investm.	O & M	Without	With	Incram.				
A1	RS1	1	763	54	2285	2332	47	15	6	-13.7%	-709
A2	RS2	1+2+4	1187	83	4119	4454	335	47	20	14.4%	266
A3	RS3	6a+7	647	45	1917	2275	358	80	37	27.8%	1178
A4	RS4	6a+7	2552	164	1917	2558	641	0	6	11.4%	-136
A5	RS5	6a+7	3199	209	1917	2312	395	80	37	3.6%	-1856
A6	RS6	6+7+10	986	68	2485	2973	489	97	31	26.0%	1535
A7	RS7	6+7+10	3508	231	2485	3118	633	97	34	8.5%	-964
A8	RS8	6b+10	1680	113	1677	1836	159	17		-0.5%	-1256
A9	RS9	6b+10	363	18	568	581	13	0		-197.7%	-359
A10	RS10	6b+10	2043	131	1677	1822	145	17		-5.3%	-1754
A11	RS5+RS1	6a+7+8	3486	228	2499	2915	416	82	37	3.1%	-2100
A12	RS7+RS1	6+7+8+10	3795	250	3067	3722	655	100	34	7.9%	-1208

Incremental benefits including the decrease of flood damage to dwellings, household assets, public infrastructure and industry

Conversion factor of investment and O & M costs estimated at 0.75

Source:- CS 1991

TABLE 6.4
Expected Agricultural Impacts of the Project

Alternative Number	Schemes	Planning Units	Cropping intensity		Farm employment		Rice production increase		Added value per ha NCA		Added value per work-day	
			Without (%)	With (%)	Present	% incr.	tons	%	Present (Tk.)	Increase (Tk.)	Present (Tk.)	Increase (Tk.)
1	RS1	1	210.7	224.0	25634	5.8	19793	5.6	44902	1679	123	-2
2	RS2	1+2+4	212.1	231.0	66638	9.0	92171	11.8	33288	2919	94	0
3	RS3	6a+7	203.1	221.5	51153	10.5	93654	21.8	21529	3327	69	3
4	RS4	6a+7	203.1	205.2	51153	29.5	32114	7.5	21257	709	88	-18
5	RS5	6a+7	203.1	256.0	51153	28.8	185994	43.3	21529	5387	69	-2
6	RS6	6+7+10	199.6	220.3	64178	12.1	135551	25.3	21257	3524	70	3
7	RS7	6+7+10	199.6	224.7	64178	14.5	170565	31.9	21257	4489	70	4
8	RS8	6b+10	202.0	211.6	44747	5.6	43796	12.3	21382	1839	69	2
9	RS9	10	187.6	196.9	13025	5.8	10083	2.8	20337	742	75	-2
10	RS10	6b+10	202.0	213.7	44747	6.7	47813	13.4	21382	1848	69	1
11	RS5+RS1	6a+7+8	198.6	246.7	59065	26.4	200291	38.6	22850	4872	74	-3
12	RS7+RS1	6+7+8+10	196.4	220.8	72090	14.1	184907	29.6	22342	4180	74	3

Added value at market price

Source:- CS 1991

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Table 6.5
Quantitative Impact of Projects

Objectives/Criteria (Summary of Results)	Pre-selected Schemes									
	RS1	RS2	RS3	RS4	RS5	RS6	RS7	RS8	RS9	RS10
Economic Impacts										
Present net income (economic)	2285	4119	1917	1917	1917	2485	2485	1677	568	1677
Future net income with project	2332	4454	2275	2558	2312	2973	3118	1836	581	1822
Incremental benefit	47	335	358	641	345	489	633	159	13	145
O & M Cost	54	83	45	164	209	68	231	113	18	131
IRR	-	0.144	0.278	0.114	0.036	0.260	0.085	-	-	-
NPV (12%)	-709	266	1178	-136	-1856	1535	-964	-1256	-359	-1754
Impact on Agriculture										
Cropping Intensity	2.240	2.310	2.215	2.052	2.560	2.203	2.247	2.116	1.969	2.137
Increase of Paddy production (%)	5.6	11.8	21.8	7.5	43.3	25.3	31.9	12.3	2.8	13.4
Farm employment % (increase)	5.8	3.0	10.5	29.5	28.8	12.1	14.5	5.6	5.8	6.7
Added value/ha NCA (Fin.)	46581	36207	24856	22236	26916	24781	25746	23221	21079	23230
Added value/workday (Fin.)	121	94	72	70	67	73	74	71	71	77

Table 6.6
Qualitative Impact of Projects

Objectives/Criteria (Summary of Results)	Pre-selected Schemes									
	RS1	RS2	RS3	RS4	RS5	RS6	RS7	RS8	RS9	RS10
Impact on Fisheries										
Fishermen affected population	-1	1	-1	0	-1	-1	-2	-3	1	-1
Capture fisheries	0	-1	-1	-2	-3	-3	-3	-3	-1	-2
Culture fisheries	0	3	0	0	3	3	3	-2	0	3
Socio-economic Impacts										
Additional Support	2	3	2	1	3	3	3	2	1	3
Non agricultural employment	2	2	1	0	3	3	3	2	0	3
Transport communication	1	0	3	2	3	3	3	3	1	3
Population density	2	1	-1	0	0	0	0	0	0	0
People to be resettled	-2	-3	-3	-3	-3	-3	-3	-2	-2	-3
Nutrition	1	0	1	1	2	2	3	0	0	2
Environmental Impacts										
Soils	-3	-3	0	-1	0	0	0	-1	-2	0
Groundwater resources	-2	-2	3	0	0	1	0	-1	0	-2
Impact on neighbouring areas	-1	0	0	0	0	0	0	0	0	0
Nr. of plus ratings	5	5	5	3	5	6	5	3	3	5
Nr. of minus ratings	5	4	4	3	3	3	3	6	3	4
Rate of plus ratings	0.42	0.42	0.42	0.25	0.42	0.5	0.42	0.25	0.25	0.42
Algebraic sum of ratings	-1	1	4	-2	7	8	7	-5	-2	6
Average of ratings	-0.08	0.08	0.33	-0.17	0.58	0.67	0.58	-0.42	-0.17	0.5

Source: C:\123\Interim\Table6_5.wk1

6.3 Preliminary Ranking

The preliminary ranking has been done by referral to a multicriteria analysis as outlined by FPCO. The background to the approach used is detailed further in PSR X.3. At this stage all the analysis are at a preliminary quantitative or qualitative stage. Thus Tables 6.5 and 6.6 are given as an example of the approach. The multicriteria analysis is to be refined and used more thoroughly in the forthcoming stages of the Study.

The present results of this ranking (Table 6.7) are heavily biased towards the economic approach at present. Further weight will be given to the other factors as the study progresses.

TABLE 6.7

Preliminary Ranking

Rank Nr.	Scheme Nr.	Scheme Description
1	RS 3	Bhuapur-Dhaleswari-Kaliganga main embankment
2	RS 6	Bhuapur-Aricha embankment
3	RS 2	Jamulpur PP with control structures at Jhenai offtake, Baushi Bridge and Chatal outfall
4	RS 4	Pungli-L.Bangshi-Buriganga river improvement and drainage
5	RS 7	RS 6 + drainage

Source:- CS 1991

6.4 Preliminary Plan and Pre-Feasibility Studies

A preliminary plan has been given as Figure 6.4.1. This is given as an indication of the likely outcome of the planning procedure which will be taking place in the forthcoming months.

It illustrates that the priorities for major development works will be concentrated in the southwestern part of the region. This is the area where present agricultural productivity is lowest at present and where some control on flood levels will have the greatest impact.

The rest of the region is more suited to other development works and these will be identified further as the formulation of the plan progresses. The role of compartmentalisation has yet to be clarified but this

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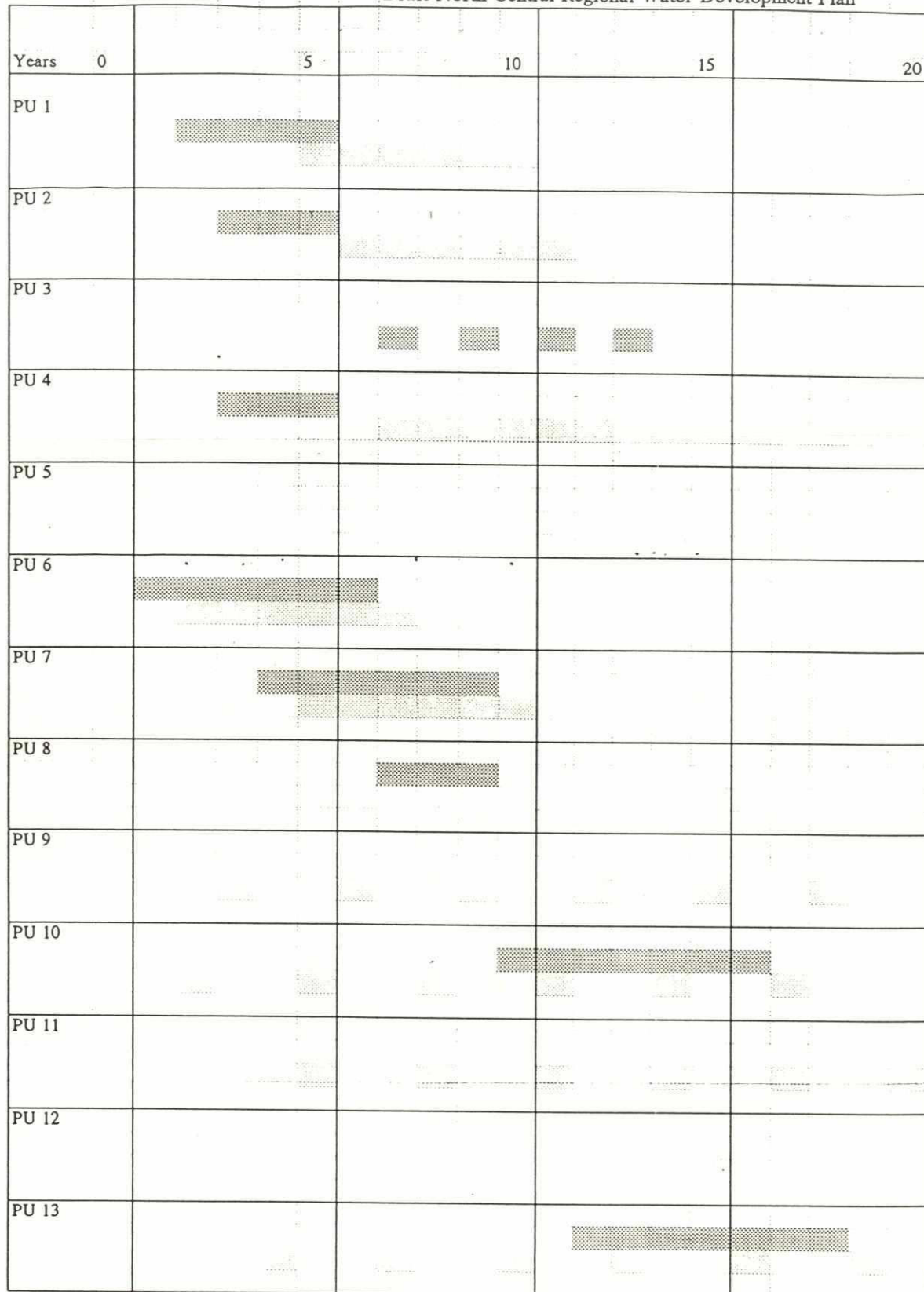
will be studied further in the next phase. Close liaison will be maintained with FAPs 20 and 3.1 in this regard.

It is proposed that Regional Schemes RS3, RS6, RS2 and RS4 be taken on to Pre-feasibility level. These Pre-feasibility studies will, by necessity, include further studies on the impact and possibilities of other related adjacent activities.

It is appreciated that further data is required on some of the other pre-selected schemes before their viability can be ascertained and for this reason the SW Dhaka project in particular will be studied further with better analysis carried out using the hydraulic model.

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Draft North Central Regional Water Development Plan



Structural Scheme

Compartmentalisation

Other Option e.g. flood proofing

File:\figure64



6.5 Summary Description of Pre-selected Schemes

The purpose of this section is to serve as a brief reference description of the pre-selected schemes referred to in the main report. It should be read in conjunction with Table 6.2 and Figures 6.1.1, 6.1.2 and 6.3.1.

Scheme Reference: RS1

Planning Units Affected: P.U.1

Scheme Components: Jamalpur Priority Project

Scheme Type: Major Embankments and Drainage/River Improvements

The scheme comprises the main embankment along the Jamuna from Jagannathganj to Kholabari Charia, (1/E1), and along the Old Bramaputra to Jamalpur, (1/E2), drainage and river improvements, (DRI), and controlled regulators at the offtake of the Jhenai, (1/SD8), and at the outfall of the hatal to the Jamuna, (1/SC10).

Scheme Reference: RS2

Planning Units Affected: P.U.1,2,4

Scheme Components: Jamalpur Priority Project, Jagannathganj-Bhuapur Main Embankment, Kauljani Drainage

Scheme Type: Major Embankments and Drainage/River Improvements

This scheme includes the main embankment from Jagannathganj to Bhuapur, (2/E1), and from Bhuapur to the Pungli River, (4/E1), and a short section of embankment from Jamalpur to the Banar River offtake, (2/E2). An internal embankment between the Pungli River and the Bangshi River, (4/ED1), drainage and river improvements, (4/DRI), and a controlled regulator at the Baushi Bridge on the Jhenai, (2/SC5).

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Scheme Reference: RS3

Planning Units Affected: P.U.6a,7

Scheme Components: Bhuapur-Dhaleswari-Kaliganga Main Embankment

Scheme Type: Major Embankments

This scheme consists of a main embankment extending from the south of the Pungli-Dhaleswari confluence, along the left bank of the Dhaleswari-Kaliganga rivers as far as Kalatia, (6a/E1, 6a/E3, 6a/E4, 7/E1, 7/E2), and a controlled regulator on the Pungli River, (4-6/SC5).

Scheme Reference: RS4

Planning Units Affected: P.U.6a, 7, 8

Scheme Components: Pungli-Bangsi-Buriganga Drainage/River Improvement

Scheme Type: Major Drainage/River Improvements

Provides for an embankment along the right bank of the Pungli from the offtake to Kaliakair, along both banks of the river, (6a/ED1, 7/ED1, 7/ED2,8/ED1, 8/ED2). A weir type regulator incorporating a navigation lock is envisaged for controlling the discharge from the Turag into the South Bangsi and a second similar regulator on a second overspill channel close by, (S6K, S8J). A controlled regulator on the Tongi Khal, (S8-C20), and another at Savar on the Karnatali River, (S4-4/C5).

Scheme Reference: RS5

Planning Units Affected: P.U.6a, 7, 8

Scheme Components: Bhaupur-Dhaleswari-Kaliganga Main Embankment, Main Drainage and River Improvement, (RS3 + RS4)

Scheme Type: Major Embankments and Drainage Improvements

This scheme option includes all the items described in RS3 and RS4 above.

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Scheme Reference: RS6

Planning Units Affected: P.U.6a, 6b, 10, 7

Scheme Components: Bhuapur - Aricha Embankments

Scheme Type: Major Embankments

This embankment extends from the Pungli river confluence south along the left bank of the Dhaleswari, an unnamed channel to the Old Dhaleswari channel, along the Jamuna up to Aricha, (6a/E1, 6b/E1, 10/E1).

Scheme Reference: RS7

Planning Units Affected: P.U.10, 7

Scheme Components: Bhuapur-Aricha Embankment and Drainage/River Improvements (RS4 +RS6)

Scheme Type: Major Embankments and New Drainage

This scheme option includes all the items described in RS4 and RS6.

Scheme Reference: RS8

Planning Units Affected: P.U.6b, 10, 13

Scheme Components: South West Dhaka Project - Embankments

Scheme Type: Major Embankments

This option comprises the embankment options proposed by the South West Dhaka Project, but excluding all other SWDP works, (6b/E1, 10/E1, 10/E2, 13/E1, 13/E2).

Scheme Reference: RS9

Planning Units Affected: P.U.6b, 10, 13

Scheme Components: South West Dhaka Project - Drainage Only

Scheme Type: New Drainage Channels, Lower Dhaleswari Improvement

Two new drainage channels between the Kaliganga and the Padma, downstream of Taraghat, and from the South Bangshi-Dhaleswari confluence to the Padma are provided, (10-NDC, 13-NDC). Controlled

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regulators are required on each drain, (S13-C10, S10-C20) and drainage and river improvements along the lower Dhaleswai River, (11B/DRI).

Scheme Reference: RS10

Planning Units Affected: P.U.6b, 10, 13

Scheme Components: South West Dhaka Project -Embankment & Drainage Improvements (RS8 + RS9)

Scheme Type: Major Embankment and Drainage Improvements

This option is a combination of RS8 and RS9 and all items have been described above.

Scheme Reference: RS11

Planning Units Affected: P.U.8

Scheme Components: Savar Improvements (Local schemes dependent on RS5 being completed

Scheme Type: Drainage Improvements

This option includes embankments on either side of the lower South Bangsi river, (8/ED1, 8/ED2), and controlled regulators, (8/SJ, 8/SC4, 8/SC20).

Scheme Reference: RS12

Planning Units Affected: P.U.1

Scheme Components: Northern Compartmentalization - NC1

Scheme Type: Compartments and sub-compartments

The compartmentalization option includes water control structures, minor embankments, drainage improvements and road improvements.

Scheme Reference: RS13

Planning Units Affected: P.U.3

Scheme Components: Eastern Compartmentalization - EC3

Scheme Type: Compartments and sub-compartments

As for RS12 above.

Scheme Reference: RS14

Planning Units Affected: P.U.2, 4, 6a, 7

Scheme Components: Western Compartmentalization - WC1

Scheme Type: Compartments and sub-compartments

As for RS12 above.

Scheme Reference: RS15

Planning Units Affected: P.U.6b, 10, 13

Scheme Components: South Western Compartmentalization - SWC1

Scheme Type: Compartments and sub-compartments

As for RS12 above.

Scheme Reference: RS16

Planning Units Affected: P.U.to be determined

Scheme Components: Regional Main Drainage

Scheme Type: Major New Drains, Improvements, Including Control Structures

This option includes two new drains between the Dhaleswari/Kaliganga and the Padma, (10/NDC, 11/NDC, 13/NDC), the improvements to the Lower Dhaleswari channel, (11A/DRI, 11B/DRI) and controlled regulators, (10/SC20, 10/SC14, 13/SC10).

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ANNEX I

Unit Rates Outline Designs and Preliminary Costs

I.1 Unit Rates

As per FPCO guidelines for project assessment, it is required that the cost estimate of structures and embankments are to be prepared with rates from BWDB' S schedule of Rates of May 1991 (to be updated to mid June if necessary). After contacting BWDB' S Design office and Division office it has been learnt that there are no schedules for Mymensingh and Dhaka Circle prepared in May 1991. The last Schedule of Rates of these circles as could be collected was published in September 1988.

The task of updating the rates to June 1991 has therefore been undertaken by the NCRS. Updated rates of Mymensingh and Dhaka Circle are attached along with comparison of rates of these two circles.

As an illustration of the effect of these unit rate differences on costing of works comparative calculations of a standard 2- vent sluice and of a 4m high interior embankment have been made under Mymensingh Circle as well as Dhaka Circle. For the sluice, the total cost under Dhaka Circle is 1.6% higher than under Mymensingh Circle and for the embankment the cost was 29.8% higher. To simplify our calculations, all our structures and earthwork will be calculated on the Mymensingh rate (60-70% of our area falls under Mymensingh Circle) and the percentages mentioned above added for all the structures and embankment under Dhaka Circle.

The detail analysis and calculation of these exercises are on project files and are not attached herewith as they are quite voluminous. The rate of any other item which may become necessary during the estimate will be prepared on the same basis as and when required.

I.2 Outline Designs

In general BWDB designs are to be used in the preliminary planning and cost estimates, however the NCRS consultants have prepared outline designs for the following particular situations :

I.2.1 Outline Design Structures

Accompanying figures are included using the same reference letter:-

A: Throttled inlet structure

This structure is envisaged to control the intake of the Dhaleswari offtake confluence to a max. of approx. 4000 m³/sec. (bankfull flow).

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The idea is to bring the Jamuna embankments at the offtake of the Dhaleswari to such a distance that the intake capacity will be limited and at the same time the water velocity remains acceptable and slope and bottom protection can resist the scour force.

A river works protection consisting of faggot mats (fascine mattresses) constructed of bamboo and two layers of heavy filter cloth and ballasted with a layer of approx. 0.5 m boulders. The upstream and downstream slope and bottom protection is envisaged to be placement of gabions/crates (0.5 m) filled with broken bricks placed on a filter cloth. In the detailed design stage a model test might be required.

B. Combination of a bridge with semi-controlled structure

After studying the local conditions of a river branch it might be possible that a combination of regulator and navigation lock can be omitted and a semi-controlled structure type B is feasible.

Part of the river flow can be regulated by gates and part is kept permanently open for the purpose of navigation and fish migration. At high river discharge, the gates have to be up to prevent excessive flow through the navigation opening only and subsequently preventing heavy local scour. This requires an operation warning system and preferably a coupled automatic (electric) operated gate lifting system. A system of 4 gates of 3.35m width or 7 gates of 1.52 m width between bridge piers and abutments leaves the choice of a concrete bridge or steel bridge open. Upstream and downstream of the piers a caisson type cut-off or sheet piles is envisaged which should not interfere with the (batter) pile foundation.

The foundation slab can be designed as stilling basin if the gates are placed at the upstream side, but a proper gabion (crates) type bottom protection upstream and downstream is always required. In order to keep a minimum water depth in the upstream river, a fixed sill can be designed in the navigation opening. A river traffic guide structure upstream and downstream of the navigation opening has to be included in the feasibility study. Careful planning the design stage makes it possible to execute the gated sections at a later stage.

C. Regulator with vertical sliding gates, if required, combined with flap gate(s)

The estimated capacity per gate is 10 m³/sec, based on a water level difference of 0.15m and a drainage co-efficient of 0.03. In case one or more gates are (temporarily) not placed the originally fully controlled structure becomes a semi controlled structure. The addition of one or more flap gates leaves the possibility of drainage of the country side (d/s) when all the gates of the fully controlled structures are lowered during low river water level. Since considerable u/s and d/s. water level differences can occur, piping under and around the piled structure can be omitted by a sheet piling screen.

U/s and d/s. slope and bottom protection is envisaged to be carried out by gabions (crates) filled with

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broken bricks placed on a filter cloth.

At the downstream side the embankment retaining walls are extended beyond the return wall. On the sketch they are marked as stream guide wall and serve the purpose of slope protection.

The 2.44x3.35 m (h x w) sliding gates can be operated from a service bridge or from a special bridge which can also be used to lower stoplogs in case of emergency.

This structure can be used as :

- flushing regulator
- intake regulator
- drainage regulator

D. Navigation lock

In case a regulator type C or weir type M is required to regulate the water flow, a bypass has to be constructed for the navigation. The sizes of the navigation locks depend on the boats that have to pass. This has to be investigated for each planned location. The set-up of the outline design is based on the standard navigation locks constructed in Bangladesh with plan dimensions 6.0m x 30.0m (w x l)

Filling/emptying of the lock compartment is envisaged through pipes circumventing the vertical sliding gates. A fixed bridge is preferred, to span the lock compartment. The vertical lifting gates are balanced with counterweights that can sink down in prepared box holes in the walls. A small electrical operated motor is required for operation of the vertical roller gates.

The sheet pile screen under the adjacent regulator has to be continued under the pile supported navigation lock. A wooden guide structure consisting of wooden piles and beams with small bollards are required to safely guide the boats into the navigation lock.

A strategic located operator room has to be considered in the detailed design stage.

E. Controlled Flooding Inlet(CFI) Controlled Drainage Outlet (CDO)

The C.F.I. is placed across a small river or khal. The gates are opened to let silt loaded water in that will spread over the fields to fertilize and saturate it. To control damage caused by high water velocities an u/s and d/s stilling basin has to be constructed. The structure can be designed for standard gates sizes 6' x 5' or 8' x 11' (h x w) and if required one or more barrels can be furnished with flap gates.

The structure is designed for reverse flow. When the river water level drops the gates can be opened to increase the drainage flow already taking place through the flap gates section (s).

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Slope and bottom protection u/s and d/s is envisaged to be constructed in gabions (crates) filled with broken bricks placed on a non woven filter cloth.

The advantage of this system is that in the dry season grass will start to grow in the cages and the grass roots will eventually take over the task of the wire mesh.

Depending on the subsoil conditions a sheet pile screen or concrete cut-offs are required under the raft foundation.

F. Controlled Drainage Outlet (C.D.O)

This structure is mainly designed as C.D.O for the Jamuna and Padma embankment. The standard 5' x 6' gate is placed on the main river side and the service platform has to be constructed above max. flood level.

In the upstream and downstream, a set of stoplog grooves are constructed in the walls to lower stoplogs in case the gate is jammed.

Concrete cut-offs if properly executed (no shuttering) are most likely sufficient to stop the piping under the raft foundation.

Slope and bottom protection are gabions (crates), similar to the one as described before.

Upstream the wingwalls are flared out and on the downstream such the barrel walls are extended into the canal to serve as stream guide walls.

G. Multiple barrel box culvert (C.D.O)

For fully controlled drainage, a number of standard barrels 6' x 5' or 8' x 11' (h x w) can be constructed at the confluence of drain and main canal. A minimum of 0.6 m soil cover is advised. This structure is proposed for relative large drainage capacities and the number of barrels can be adapted to the design requirements

A major road on top of the embankment can be included in the boundary conditions for the strength calculations of this type of structure.

H. Road pipe culvert (C.D.O)

The intake structure includes a stoplog groove in the side walls and a gate frame in the front wall. The gate frame will be bolted to an embedded hot dip galvanised frame. In this way the whole set can be removed for maintenance or replacement.

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Connected to the front wall is a reinforced concrete pipe founded on a mass concrete foundation.

To quantify the number of these structure it is assumed that at approx. 2 km c.to c. this type is constructed in the new embankments.

J. Weir, stepped weir, sluice

This semi controlled structure should have a max. capacity of approx. 1000 m³/sec. and is considered to be placed in the confluence Turag/Bangshi. The stepped weir allows an increased capacity at different river stages. The gated sections are designed to allow a minimum (bed) flow at all times and one gated section can be constructed in such a way that navigation of country boat can take place at low discharges while at higher discharges the boats can pass over the stepped weir. The gates can be operated from a platform at approx. embankment level. When the weir is submerged the platform can be reached by boat.

The fixed earth body weir has a protection of concrete blocks on khoa/filter cloth and the bottom protection throughout is gabions (crates) filled with broken bricks placed on filter cloth.

The gated section is piled and jointed to the raft founded stepped weir section.

Stepped weir and gated section have a down stream stilling basin.

K. Raised fixed sill (Weir)

This semi controlled structure can be executed with a perforation of pipes to allow a bed flow at low discharges.

The weir width and bank slopes can be adapted at the design stage to incorporate a road surface. Country boat can make use of a slipway with bullahs to negotiate the weir at low discharges. The construction of the weir is similar to the type J structure.

L. Outline design of a multiple span large bridge

This type of bridge is a standard construction in Bangladesh. The type of piles used are bore piles. The slope and bottom protection are by gabions (crates) filled with broken bricks placed on filter cloth.

The piers and abutments can also be designed to carry concrete bridge slabs of smaller spans.

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I.2.2 Additional Outline designs

Further outline design have been prepared of structures that may become more appropriate at later stages of the development programme. These include the following and can be found described in PSR VII:-

- Weir and navigation lock:
- Discharge Regulator: Maximum capacity $\pm 50\text{m}^3/\text{sec}$.
- Road Pipe Culvert
- Road Box Culverts
- Large box culvert with stilling basin
- Reinforced Concrete Bridge for Small Road
- Prepared Breach in Embankments
- Crump weir
- Side escape combined with causeway

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UNIT RATE OF MYMENSINGH CIRCLE UPDATED TO JUNE 1991

SL. Nr.	ITEM OF WORK	UNIT	BWDB SCHEDULE RATE OF SEPT'88 (TK)	UPDATED RATE OF JAN'1991 AS CALCULATED (TK)	INFLATION FROM SEPT'88 TO JAN'91 (ANNUAL)	INFLATION FROM JAN'91 TO JUNE 1991 (50%) HALF YEAR	UPDATED RATE OF JUNE 1991 (TK)
01.	Earthwork in flood Embankment						
1a.	From borrow pit	100 Cu.M	1275	1449	6.6%	3.3%	1496
1b.	With royalty	100 Cu.M	2100	2357	5.9%	2.95%	2426
02.	Earthwork in channel excavation						
2a.	Main channels	100 Cu.M	1800	1905	2.9%	1.45%	1961
2b.	Secondary channels	100 Cu.M	1601	1668	2.1%	1.05%	1665
03.	Earthwork in Diversion Channels	100 Cu.M	1601	1668	2.1%	1.05%	1665
04.	Fine dressing & close turfing	100 Sq.M	200	200	0.0%	1.0%	220
05.	Earthwork in foundation Excavation						
5a.	Regulators	100 Cu.M	2076	2149	1.8%	0.9%	2167
5b.	Others	100 Cu.M	1851	1970	3.1%	1.55%	2000
06.	Compacted backfill around structure						
a.	By sand	Cu.M	160	172	3.7%	1.85%	175
6b.	By Excavated Material	100 Cu.M	1326	1494	6.2%	3.1%	1540
7a.	C.C (1:4:8)	Cu.M	1544	1651	10.4%	5.2%	1624
7b.	C.C (1:3:6)	Cu.M	1765	2090	8.8%	4.4%	2162
7c.	C.C (1:2:4)	Cu.M	2418	2626	4.2%	2.1%	2681
08.	R.C.C including shuttering						
8a.	In foundation and base slab	Cu.M	2663	2965	5.1%	2.55%	3040
8b.	Above base slab	Cu.M	3036	3495	7.3%	3.65%	3622
8c.	Average	Cu.M	2824	3248	7.2%	3.6%	3364
09.	MS Re-inforcement	M.Ton	22500	23000	1.1%	0.55%	23126
10.	Brickwork (1:4)	Cu.M	1359	1619	9.1%	4.55%	1692
11.	Brick Block protection	Cu.M	1363	1412	1.8%	0.9%	1424
12.	3" flat brick soling	Sq.M	70	92	14.6%	7.3%	99
13.	R.C.C pipes						
13a.	Dia = 45 cm (5 cm thickness)	RM	623	746	9.5%	4.75%	764
13b.	Dia = 60 cm (7.5 cm thickness)	RM	1614	1935	9.5%	4.75%	2026
3c.	Dia = 90 cm (7.5 cm thickness)	RM	1994	2394	9.6%	4.8%	3074
14a.	Steel Flap Gates (1.5 M x 1.8 M)	Nr	70000	70000	0.0%	1.0%	70700
14b.	Steel Slide Gate (1.5 M x 1.8 M)	Nr	80000	85000	3.1%	1.55%	86316
14c.	Steel Slide Gate (0.9 M x 0.9 M)	Nr	30000	35000	8.0%	4.0%	36400
14d.	Steel Slide Gate (0.45 M x 0.45 M)	Nr	20000	22000	4.9%	2.45%	22539
15.	PVC water stop (23 cm)	RM	761	838	4.9%	2.45%	856
16.	Wooden stoplog	Cu.M	19768	21745	4.9%	2.45%	22277
17.	Land Acquisition	Ha	222390	259455	8.0%	4.0%	269833
18.	Clearing site	100 Sq.M	45	55	11.11%	5.55%	58
19.	Earthwork in construction of approach embankment	100 Cu.M	1475	1675	6.7%	3.35%	1731
20.	Khoa (Brick chip) bed	Cu.M	737	774	2.5%	0.62%	778
21.	Sand Filter (F.M. 71)	Cu.M	160	172	3.7%	1.85%	175
22.	C.C Block (1:3:6) of size 40cm x 40cm x 30 cm	Nr	121	125	1.65%	0.82%	126
23.	Caisson sinking	Sq.M	356	374	2.5%	1.25%	378
24.	Project Building	Sq.M	4950	5445	4.9%	2.45%	5578
25.	Extra over earthwork	100 Cu.M	100	100	0.0%	1.0%	101

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UNIT RATE OF DHAKA CIRCLE UPDATED TO JUNE 1991

SL. Nr.	ITEM OF WORK	UNIT	BWDB SCHEDULE RATE OF SEPT'88 (TK)	UPDATED RATE OF JAN'1991 AS CALCULATED TK)	INFLATION FROM SEPT'88 TO JAN'91 (ANNUAL)	INFLATION FROM JAN'91 TO JUNE 1991 (50%) (HALF YEAR)	UPDATED RATE OF JUNE 1991 (TK)
01.	Earthwork in flood embankment						
1a.	From borrow pit	100 Cu.M	3600	3838	6.6%	3.3%	3955
1b.	With royalty	100 Cu.M	5400	5719	5.5%	3.0%	5891
02.	Earthwork in channel excavation/ re-excavation and spread spoil for embankment						
2a.	Main channel	100 Cu.M	1600	1646	2.9%	1.5%	1671
2b.	Secondary channel	100 Cu.M	1500	1534	2.1%	1.0%	1550
03.	Earthwork in diversion channels	100 Cu.M	1600	1634	2.1%	1.0%	1650
04.	Fine dressing & close turfing	100 Sq.M	260	260	0.0%	0.0%	260
05.	Earthwork in foundation excavation	100 Cu.M					
5a.	Regulators	100 Cu.M	2300	2341	1.8%	0.0%	2362
5b.	Others	100 Cu.M	2300	2341	3.1%	1.6%	2409
06.	Compacted backfill around structure						
6a.	By sand	Cu.M	2600	2695	3.7%	1.9%	2747
6b.	By excavated materials	100 Cu.M	1500	1593	6.2%	3.1%	1642
7a.	C.C.(1:4:8)	Cu.M	1468	1621	10.4%	5.2%	1705
7b.	(1:3:5)	Cu.M	1578	1717	8.8%	4.4%	1793
7c.	(1:2:4)	Cu.M	1687	1966	4.2%	2.1%	2007
08.	R.C.C. including shuttering						
8a.	In foundation and base slab	Cu.M	2230	2344	5.1%	2.6%	2405
8b.	Above base slab	Cu.M	2230	2393	7.3%	3.7%	2482
8c.	Average	Cu.M	2230	2391	7.2%	3.6%	2477
09.	M.S.re-inforcement	M.Ton	25000	25275	1.1%	0.6%	25423
10.	Brickwork (1:4)	Cu.M	1269	1365	9.1%	4.6%	1449
11.	Brick block protection	Cu.M	1275	1298	1.8%	1.4%	1316
12.	3" flat soiling	Sq.M	73	64	14.6%	7.3%	90
13.	R.C.C. pipe						
13a.	Dia 45 Cm (5 cm thickness)	RM	-	-	-	-	675
13b.	Dia 60 Cm (7.5 cm thickness)	RM	-	-	-	-	900
13c.	Dia 90 Cm (7.5 cm thickness)	RM	-	-	-	-	1350
14a.	Steel Flap gate (1.5 M x 1.8 M)	Nr	35,000	35,000	0.0%	0.0%	35,000
14b.	Steel slide gate (1.5 M x 1.8 M)	Nr	69000	71139	3.1%	1.6%	72,277
14c.	Steel Flap Gates (0.9 M x 0.9 M)	Nr	43289	46752	8.0%	4.0%	48,622
14d.	Steel Flap Gates (0.45 M x 0.45 M)	Nr	22000	23078	4.9%	2.5%	23,655
15.	PVC water stop (23 cm)	RM	310	325	4.9%	2.5%	333
16.	Wooden stop log	Cu.M	20,370	21356	4.9%	2.5%	21902
17.	Land Acquisition	Ha	-	2,70,000	8.0%	4.0%	2,80,800
18.	Clearing site	100 Sq.M	56	62	8.0%	5.6%	65
19.	Earthwork in construction of approach embankment	100 Cu.M	3600	3841	6.7%	3.4%	3972
20.	Khoa (Brick chip) bed	Cu.M	557	573	2.9%	1.3%	582
21.	Sand filter (F.M > 1)	Cu.M	-	180	3.7%	1.9%	183
22.	C.C. Block (1:3:5)						

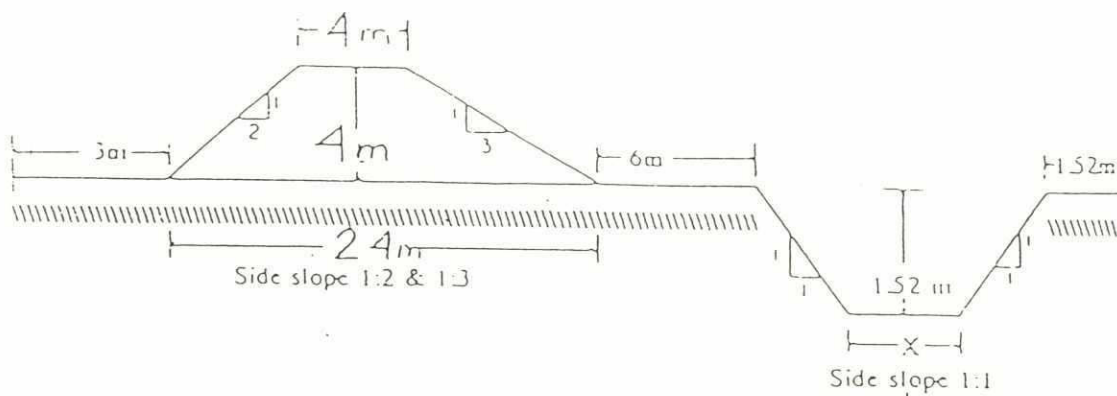
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COMPARISON OF DHAKA AND MYMENSINGH CIRCLE

Sl. No.	Item of Work	Rate of Dhaka Circle A	Rate of Mym. Circle B	Compare of Rate by % B/Ax100
1.	Earthwork in flood Embankment			
1a.	From borrow pit	3965	1496	(-) 38%
1b.	With royalty	5891	2426	(-) 41%
2.	Earthwork in channel excavation/ re-excavation and spread spoil for embankment			
2a.	Main channels	1671	1961	(+) 117%
2b.	Secondary channels	1650	1685	(+) 102%
3.	Earthwork in Diversion Channels	1650	1685	(+) 102%
4.	Fine dressing & close turfing	260	220	(-) 84%
5.	Earthwork in foundation Excavation			
5a.	Regulators	2362	2187	(-) 93%
5b.	Others	2409	2000	(-) 83%
6.	Compacted backfill around structure			
6a.	By sand	275	175	(-) 64%
6b.	By Excavated Material terials	1642	1540	(-) 94%
7a.	C.C (1:4:8)	1705	1624	(-) 95%
7b.	C.C.(1:3:6)	1793	2182	(+)122%
7c.	C.C.(1:2:4:)	2007	2681	(+)134%
8.	R.C.C.including shuttering			
8a.	In foundation and base slab	2405	3040	(+)126%
8b.	Above base slab	2482	3622	(+)146%
8c.	Average	2477	3364	(+)136%
9.	MS reinforcement	25423	23126	(-) 91%
10.	Brickwork (1:4)	1449	1692	(+)117%
11.	Brick Block protection	1316	1424	(+)108%
12.	3" flat brick soling	90	99	(+)110%
13.	R.C.C.pipes			
13a.	Dia = 45 cm (5 cm thickness)	675	784	(+)116%
13b.	Dia = 60 cm (7.5 cm thickness)	900	2026	(+)225%
13c.	Dia = 90 Cm (7.5 cm thickness)	1350	3074	(+)228%
14a.	Steel Flap Gates (1.5 M x 1.8 M)	35000	70700	(+)202%
14b.	Steel Slide Gate(1.5 M x1.8 M)	72277	86318	(+)119%
14c.	Steel Slide Gate(0.9 M x 0.9 M)	48622	36400	(-) 75%
14d.	Steel Slide Gate (0.45M x 0.45 M)	23655	22539	(-) 95%
15.	PVC water stop (23 cm)	333	856	(+)257%
16.	Wooden stoplog	21902	22277	(+)102%
17.	Land Acquisition	280800	269833	(-) 96%
18.	Clearing site	65	58	(-) 89%
19.	Earthwork in construction of approach embnk	3972	1731	(-) 44%
20.	Khoa (Brick chip) bed	682	778	(+)114%
21.	Sand Filter (F.M.71)	183	175	(-) 96%
22.	C.C.Block (1:3:6) of size 40cmx40cmx30cm	131	126	(-) 96%
23.	Caission sinking	629	378	(-) 60%
24.	Project Building	6150	5578	(-) 90%
25.	Extra over earthwork	110	101	(-) 91%

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BWDB Standard Section of Embankments



Cross sectional area of embankment = $(24+4) \times 4 / 2$
 Therefore, Volume of earth work/km = $56 \times 1,000 = 56,000 \text{ Cu.m}$
 Length of slopes : $16+144 = 160$ = 12.6 metre
 $\& 16+64 = 80$ = 8.9 metre
 Therefore, Length to be turfed = $12.6+8.9+1+1$ = 23.5 metre
 Therefore, Area to be turfed = $23.5 \times 1,000$ = 23,500 sq.m

Sl. No.	Item	Quantity	Unit	Dhaka Circle		Mymensingh Circle	
				Rate * (Tk.)	Amount (Tk.)	Rate * (Tk.)	Amount (Tk.)
01.	Earthwork	56000	Cu.m	19.70	1,103,200.00	13.75	770,000.00
02.	Turfing	23500	Sq.m	2.60	61,100.00	2.00	47,000.00
Total Cost/Km :					1,164,300.00		817,000.00

Difference in total cost = Tk. 11,64,300 - Tk. 8,17,000 = Tk. 3,47,300
Therefore, Tk. 3,47,300 - 100% = Tk. 3,47,300

Therefore, Tk. 3,47,300x100/11,64,300 = 29.83% (Percentage Increase with reference to Dhaka circle)

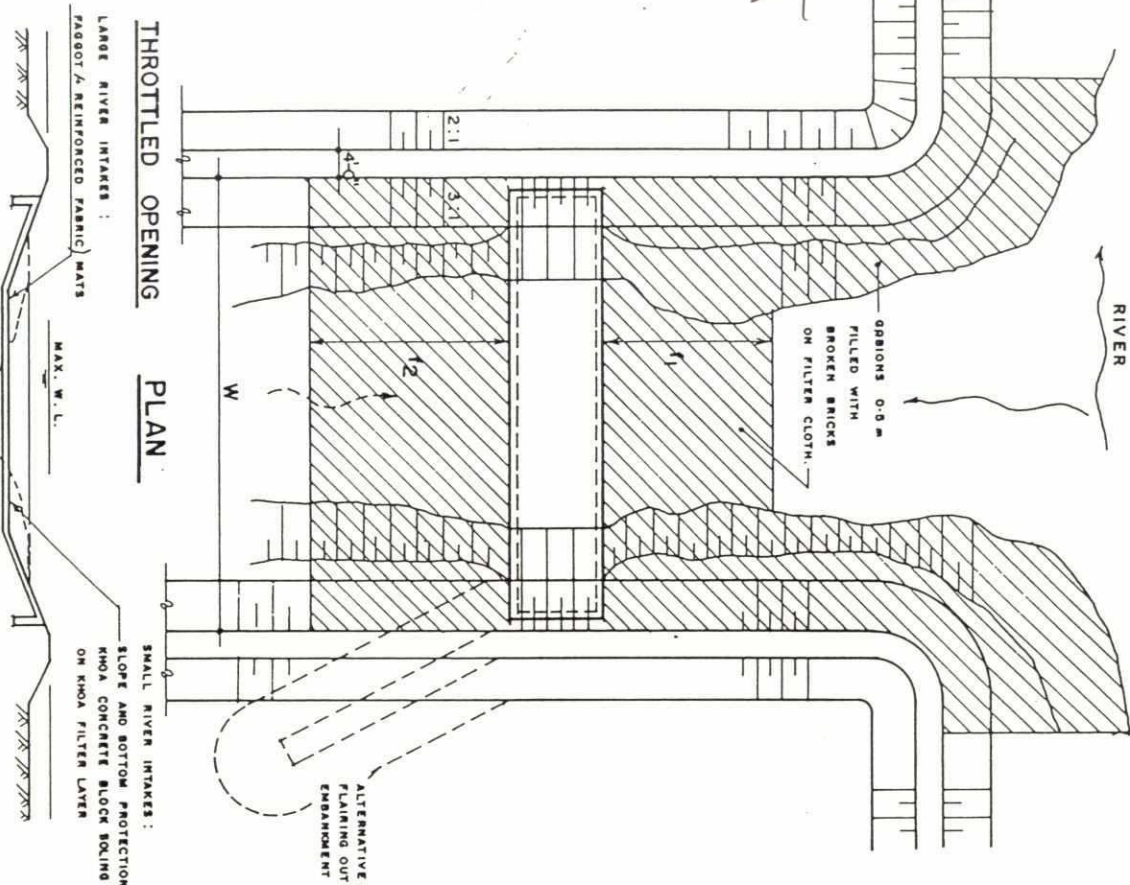
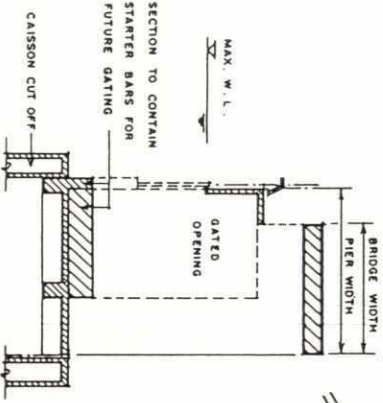
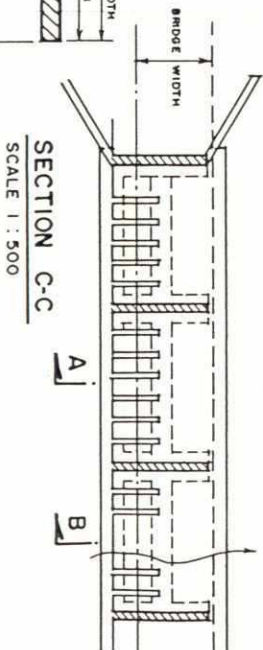
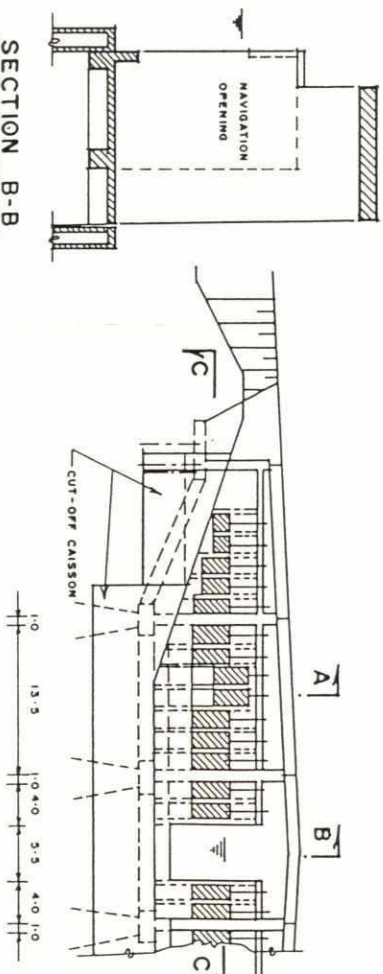
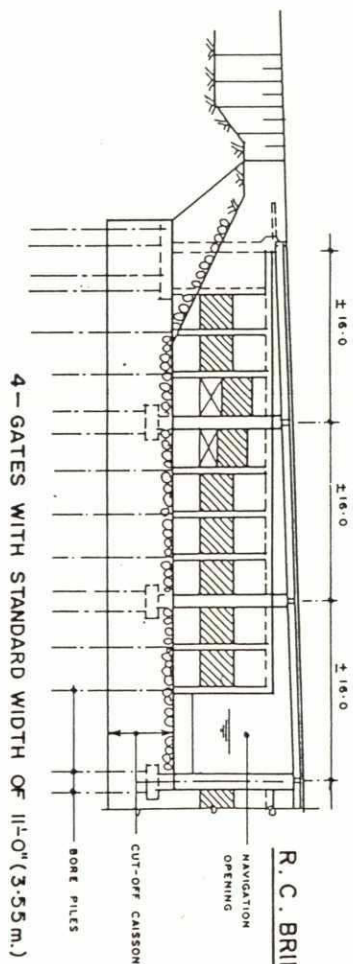
* Source : BWDB Schedule of Rates

Analysis for Earthwork of the Embankment in Figure above.

Vol. of earthwork = 56,000 cu.m

01.	Unskilled labour required = $56,000/2.8 = 20,000$ (as per BWDB Schedule an unskilled labour's earthwork output = 2.8 cu.m/day and rate of labour is Tk. 50.00 per day) 20,000 man day @ Tk. 50.00 per man day = Tk. 1,000,000.00	Tk.	1,000,000.00
02.	Skilled labour $56,000/453 = 124$ man day (a skilled labour per day can supervise earthwork of 453 cu.m as per BWDB's schedule) @ Tk. 100.00 per day 124 man day @ Tk. 100 per man day = Tk. 12,400.00	Tk.	12,400.00
03.	Contingency, Profit, Taxes etc.	L.S.	Tk. 90,800.00
	Total	Tk.	1,103,200.00
Total : (Taka One million one hundred and three thousand two hundred only).			

COMBINATION C. A BRIDGE WITH A SEMI CONTROLLED STRUCTURE
(THE LATER CAN BE INCORPORATED AT A LATER STAGE)



CHECK STRUCTURE

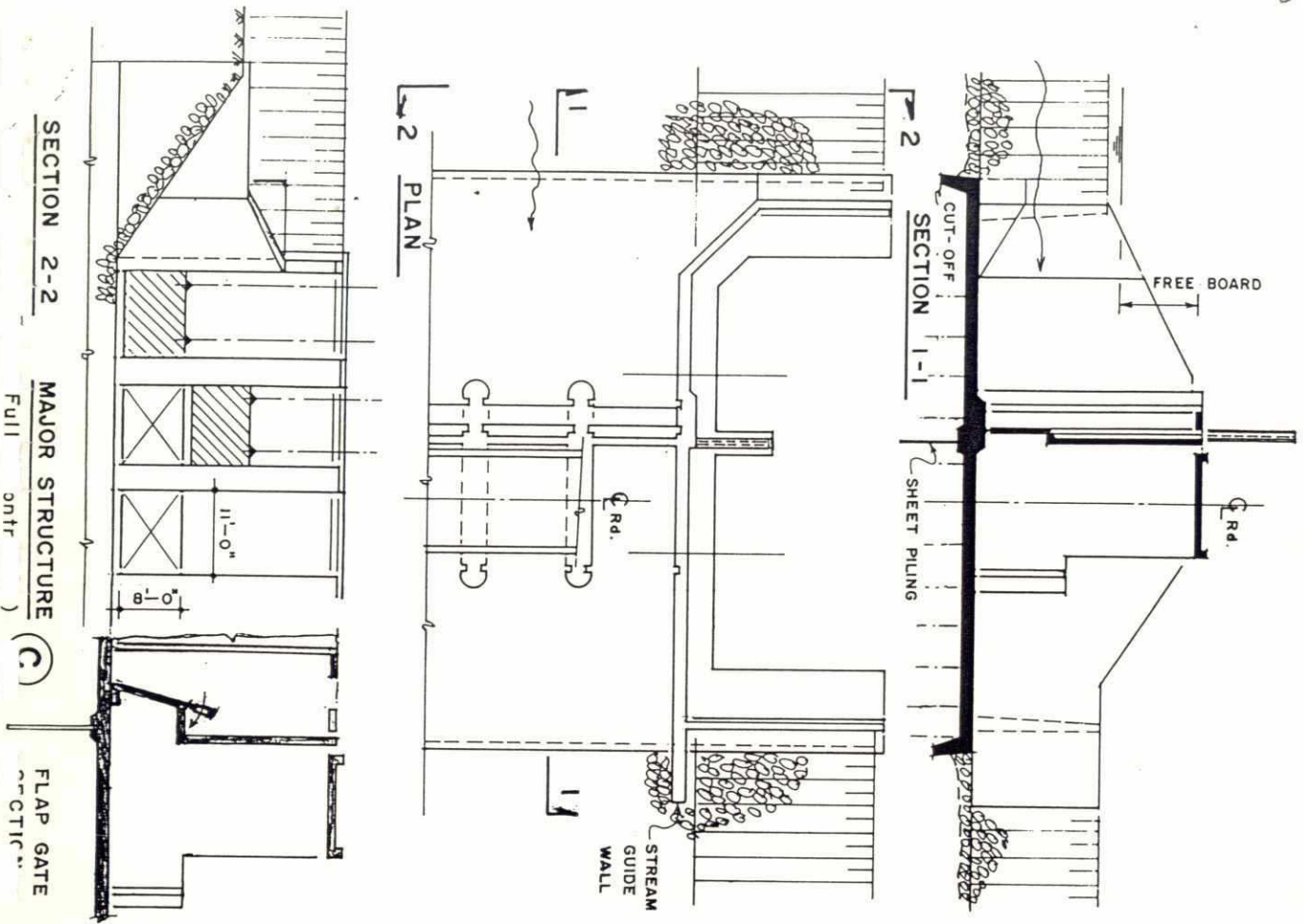
FIXED SECTION DOWNSTREAM AND IN THE KHAL
" W " WIDTH TO BE DECIDED, AFTER THE RESULTS
OF A HYDRAULIC CALCULATION OF ALLOWED
INTAKE AND DISCHARGE, ARE KNOWN.

A

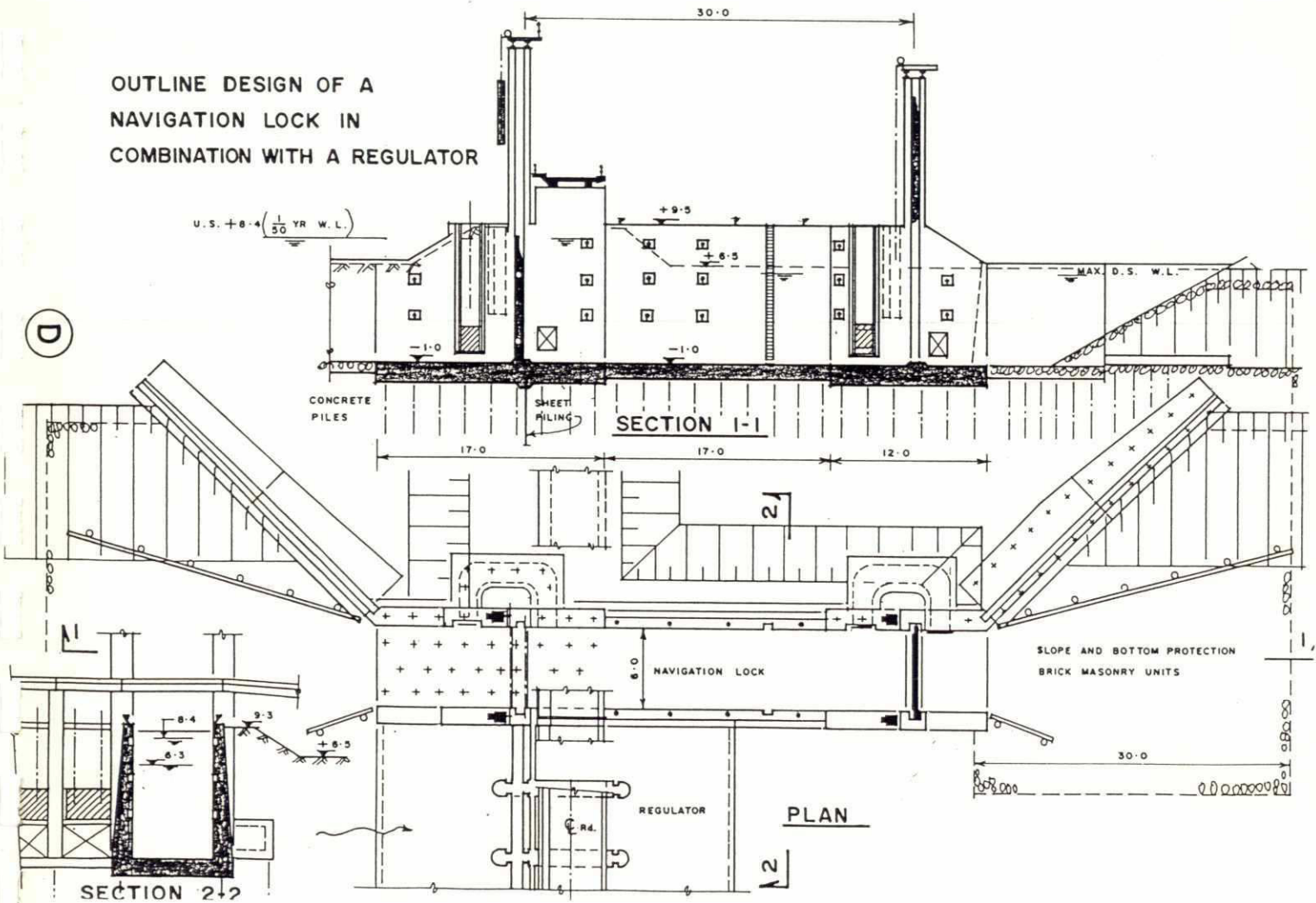
NOT TO SCALE

OUTLINE DESIGN OF A REGULATOR

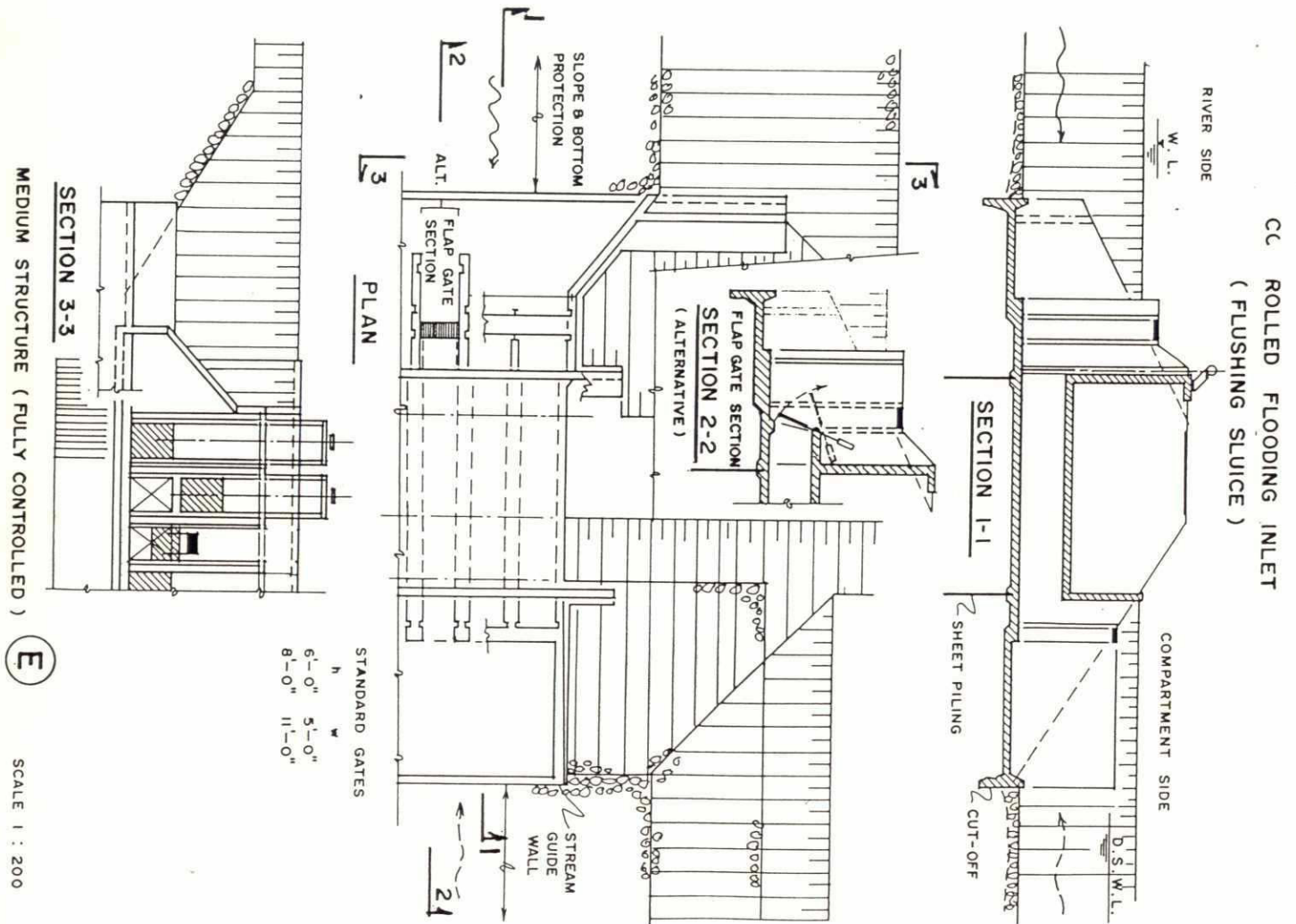
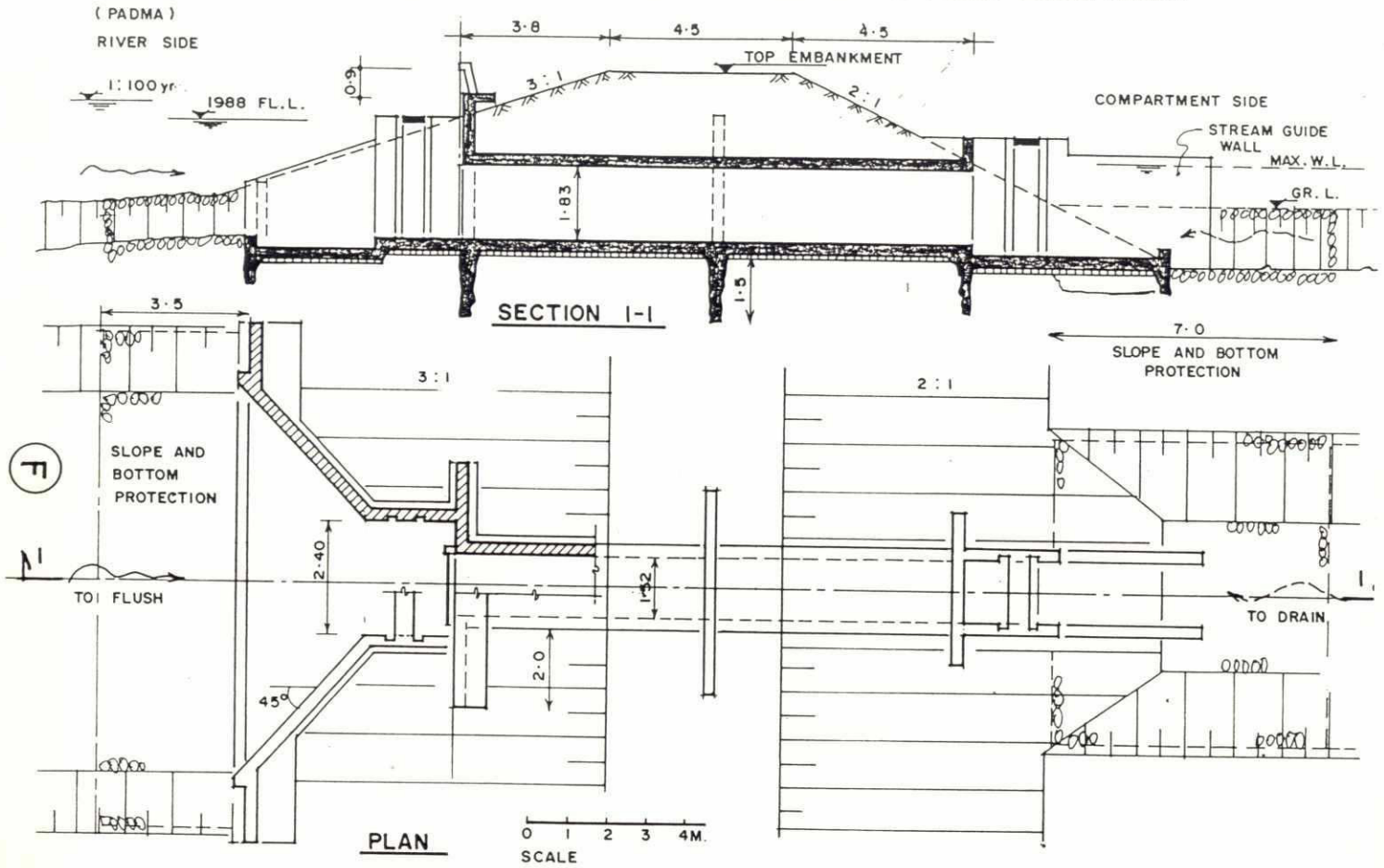
- FLOODING REGULATOR
- INTAKE REGULATOR
- DRAINAGE REGULATOR



OUTLINE DESIGN OF A NAVIGATION LOCK IN COMBINATION WITH A REGULATOR



CONTROLLED DRAINAGE OUTLET (C.D.O.) IN JAMUNA AND PADMA EMBANKMENT



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DEPENDING ON SUB SOIL CONDITIONS
EITHER CONCRETE CUT-OFF OR
WOODEN SHEET PILING TO BE USED
(SEE SH)

BARRELS - h m

0-0 0-0

SECTION B-B

[illegible]

6

WEIR / STEPPED WEIR / SLUICE

L = APPROX. 150 M.

* CONCRETE BLOCKS 0.3 X 0.3 X 0.3
ON KHOA/FILTER CLOTH

FIXED WEIR

FIXED STEPPED WEIR

GATED SECTIONS

NAVIGATION OPENING

SECTION 1-1

(SCALE 1:500)

PLAN

(SCALE 1:500)

TURAG

BANGSHI

FIXED WEIR SECTION

SECTION 2-2

(SCALE 1:200)

STILLING BASIN

SECTION 3-3

SECTION A-A

L = APPROX. 60.0 M.

BULLAHS
(TREE TRUNKS)

SLOPE AND BOTTOM PROTECTION :
(GABIONS) GABIONS FILLED WITH BROKEN
BRICKS ON FILTER CLOTH

CONCRETE BLOCKS
0.3 X 0.3 X 0.3
ON KHOA ON FILTER
CLOTH

RAISED FIXED SILL (WEIR)

WITH / WITHOUT Ø 300 ASBESTOS PIPES
TO ALLOW A BED FLOW TO PASS.

WITH SLIPWAY
FOR SMALL BOATS

WITH CAUSE WAY
PLAN

1

(K)

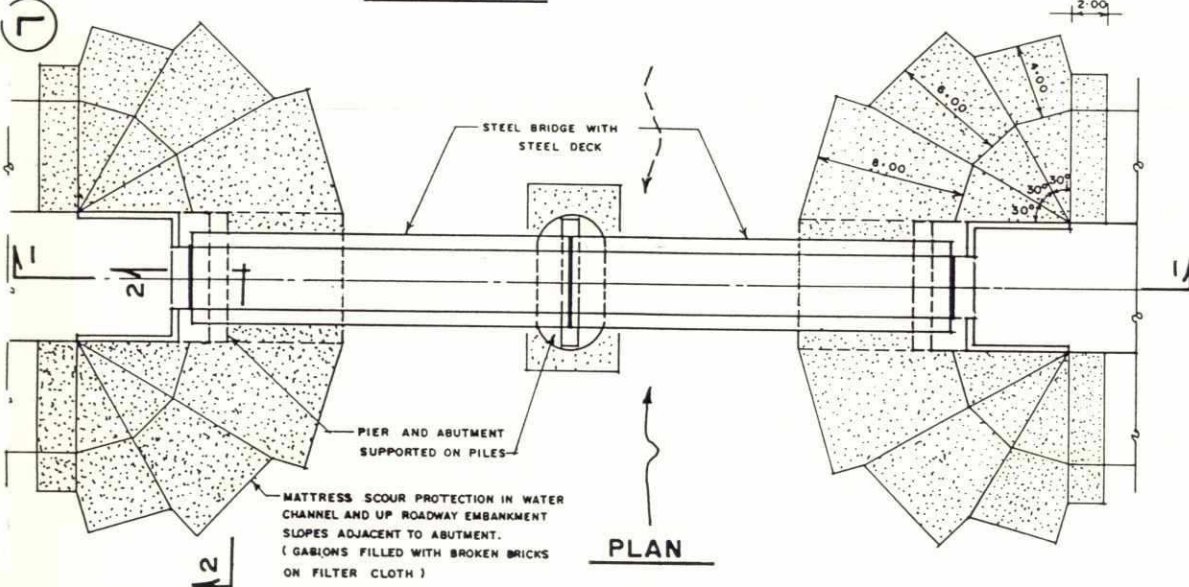
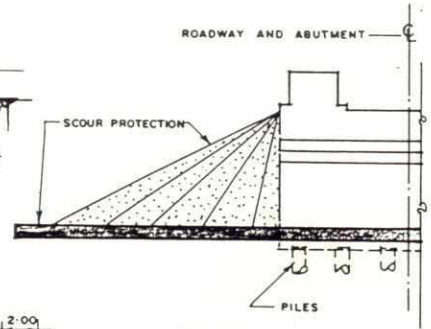
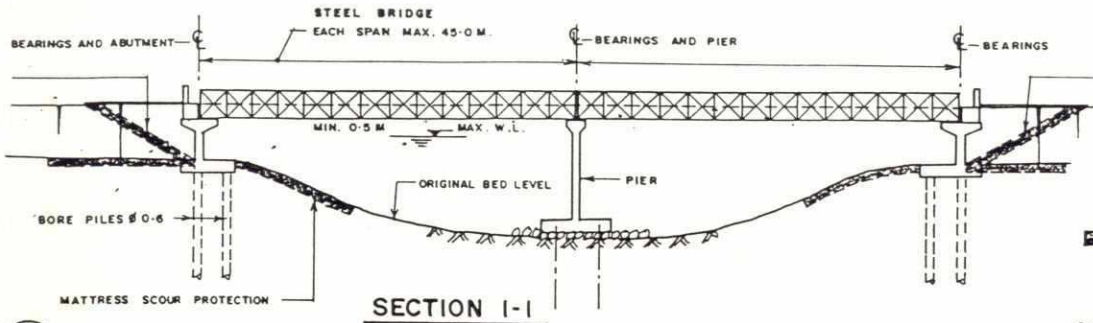
WEIR

A

A

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OUTLINE DESIGN OF A MULTIPLE SPAN LARGE BRIDGE



ANNEX II

Additional Studies

II. Additional Studies

II.1 Introduction

During the North Central Regional Study - Phase 2, it has become apparent that certain issues will be of particular significance in assessing any proposed works/initiatives as part of a Regional Water Resources Development Plan (RWRDP). These issues need to be considered immediately, as some of them are deserving of a high priority status and the opportune time to carry out the required investigations would (in some cases) be the dry season (i.e. January to May 1991).

Although the NCRS will address these issues and make recommendations where appropriate for such studies to be carried out subsequent to presentation of the RWRDP. If a decision is left to after presentation of the Final Report (due on May 8th 1992) then a critical study period opportunity will be lost; thereby putting back the possible development programme by almost one year.

The issues already identified during the Phase 2 studies include the following:-

- Char lands
- Old Brahmaputra
- Navigation
- Data base for hydraulic modelling

Some of the above were considered as issues during the preparation of the TOR for Phase 2 of the NCRS, but it is beyond the scope of Phase 2 of the NCRS to properly address these issues. Outlines are given below for the scope of work presently envisaged as appropriate to cover the above issues adequately. Timely instigation of such studies would enable the planning of the North Central Region (at subsequent feasibility study level) to be carried out with such essential information then in hand.

II.2 Char Lands Preliminary Study

II.2.1 Background

There are reports of some 1 million people living in (or depending on) the char¹ lands associated with the main rivers in Bangladesh (REIS 1990). Some of these char lands lie in the Jamuna, Padma, Old Brahmaputra-Lakhya-Meghna river systems that form the boundary to the North Central Region Study Area. The environment and the people living on and/or off these lands will be in some degree effected by proposals to alter the present flood regime of the rivers.

It is proposed that a 'Preliminary Char Lands Study (North Central Region Segment)' is carried out with the following objectives:-

II.2.2 Objectives

- Establish the physical and socio-economic characteristics of the char lands in the main rivers adjacent to the NCRS area so as to give a preliminary quantification of the scale of the char land resources that may be effected.
- Make preliminary assessments (largely qualitative) of the possible impact of structural measures that may be proposed by the NCRS.
- Prepare Terms of Reference for subsequent studies required for a more quantitative assessment of any significant impact that may be identified

II.2.3 Proposed Staffing

A. Expatriate

Study coordinator - The study coordinator should have a multi-disciplinary background (probably socio-economic/environmental) and would carry out various tasks including:-

- a survey of extent of char lands, using existing maps, aerial photography and satellite imagery
- a population count, both from field surveys, but predominantly by a household count using flights from light aircraft.
- assess the land tenure situation as applies to char lands
- literature review of other studies concerning the issue
- contact and discussion with other groups such as NGO's and other FAP studies (particularly FAP's 1,3,14,15 and 23) concerned with related issues.
- identification and description of further issues and studies needing to be carried out to quantify any significant impacts of FAP activities.

¹. **Char lands** : a mid-channel island that periodically emerges from the river-bed as result of accretion. Chars may be seasonal or may survive for several decades.

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It is anticipated that a 2 to 3 month input is required, preferably by March 1992.

River morphology

Although it is not recommended that significant studies are carried out at this stage on river morphology it is suggested that some time be allowed for a river morphologist to review the likely effects of possible FAP initiatives on the char lands. This work should be done utilising existing information collected for other studies and by analysing the results of runs of the general hydraulic model (to be carried out by FAP 25).

The river morphologist would also recommend what additional studies should be carried out in the future to better quantify any possible significant impacts as a result of this preliminary assessment. It is proposed that a 1 month input is required.

B. Local Staff

It is recommended that the following are required:-

socio-economist - 2 man-months

field teams - 6 man months

[primarily to carry out the household count, but also to carry out field enquiries, where appropriate]

Total Staffing

The recommended total staff requirement to carry out the preliminary study are 4 man months expatriate and 8 man months local staff.

II.3 Old-Brahmaputra Resuscitation Pre-feasibility Study

II.3.1 Background

In the previous years, the mouth of the Old-Brahmaputra has been the most important offtake located on the left bank of the Jamuna. At present, serious deposition has taken place at the mouth, induced by intense char movement and, more precisely, the full connection of a large char to the previous left bank.

The decrease of the Old-Brahmaputra in its role as a major waterway has had various effects on its area of influence. Before a study is instigated into the possibilities of resuscitation and/or maintenance of the Old-Brahmaputra, the objectives of such an initiative should be clarified. At this stage, only the subject areas are given, the priorities would have to be addressed at a later stage, if a pre-feasibility is undertaken.

If the mouth is resuscitated, it could be an important intake for irrigation, water supply, sanitation, fisheries and/or other uses. The possibilities for resuscitation include the following:-

- dredging of the mouth
- activation of spill channels (there are four main spill channel options)
- construction of a pump station

II.3.2 Constraints

The main constraints are :

- the water levels of the Jamuna river at each intake
- the water levels of the Jinjiram river system and the available natural discharges
- the topography of the flood plain and of the river beds (including the Old-Brahmaputra river bed downstream of the Jinjiram confluence).
- the geotechnical conditions
- the dynamic fluvial processes in the Jamuna and the Jinjiram river system.
- the environmental and socio-economic constraints.
- the proximity of the international border should be kept in mind.

II.3.3 Proposed surveys and studies

All these constraints have to be addressed in the prefeasibility study, which could include the following phases :

- collection of the relevant data : water levels and water discharges, satellite imagery, topographical maps, geological data
- topographical survey of the area between the Jamuna and the border, including cross-sections of selected channels.

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- assessment of the water demand
 - analysis of hydrological data (water levels, discharges) for available stations on the Jamuna, the Jinjiram, the Old-Brahmaputra
 - hydromodelling activity dealing with the Lower Jinjiram river system, part of the Old-Brahmaputra and the new canals. Simple computations taking into account steady gradually varied flows are only required for dimensioning new channels.
 - geomorphological study of the Upper Jamuna, the Old Brahmaputra and the Jinjiram river system
 - river engineering, including the dimensioning of new canals, channels and structures, and the prefeasibility design of river training works,
 - multi-criteria or cost-benefit analysis

II.3.4 Work schedule and staffing

The proposed work schedule and staffing requirements for a prefeasibility study are given in Figure II.3.1.

The hydrologist-hydromodeller would be entrusted with the data collection, the definition of the surveys, the hydrological studies and the hydromodelling activity.

The river engineer would be responsible for the prefeasibility design of infrastructures and for the study report.

Depending on the background of the specialists, the river morphology aspects could be performed by either the hydraulics engineer, the river engineer or an additional input from a river morphology specialist.

The environment-fishery expert would be entrusted with the assessment of the water demand and of the impacts on the environment.

The socio-economist would take part in the assessment of the water demand and would evaluate socio-economic constraints and impacts.

The economist would be responsible for the multi-criteria analysis and the cost-benefit analysis.

Local staff will be required to work alongside the expatriate specialists as shown on Figure II.3.1

The working paper should be prepared with the help of all the specialists.

Total Staffing

The recommended total staff requirement to carry out the pre-feasibility study are 9 man months expatriate and 12 man months local staff.

II.4 Regional Navigation Study

II.4.1 Background

The Bangladesh Inland Water Transport Authority (BIWTA) has carried out a Master Plan Study (BIWTA 1989) in which the waterways of the North Central Region are described (these are listed in Annex 1.3.4.2.A of NCRS Phase 1 Report; NCRS 1990).

The Master Plan also indicates the present importance and indicates the priority routes for the future. However the Master Plan is restricted to the main BIWTA classified channels. It does not address the smaller country boat system.

The Terms of Reference for FAP 3 only allows for the issue of water transport to be covered under the studies on environmental impact of proposed water development studies. This is being done, but it has become apparent that the inland water transport plays a significant role in the communications of the Region, particularly in terms of marketing, both locally (by small country boats) and regionally. It is therefore proposed that a fuller assessment is justified in the form of a Regional Navigation Study.

II.4.2 Objectives

- Establish the contribution of inland water transport to the region's economy
- Determine the type, size and channel requirements for boats on the various waterways in the region
- Determine the consequences of disrupting navigation patterns by the construction of structures
- Set out suitable modifications to structure designs to allow for water transport to pass or to facilitate transfer of goods as appropriate

II.4.3 Proposed Staffing

Discussions should be held with the BIWTA to establish the scale and scope of such a study. No detailed staffing requirements are thus given at this stage.

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II.5 Data Base for Hydraulic Modelling

II.5.1 Background

It has become clear during the course of both calibration of the North Central Regional Model and the execution of runs to test the various engineering options, that the quality of data available for use as input has not met the standards required for developing the model for feasibility level studies and beyond. Indeed, the quality of the data available for use in the present study, particularly that related to the flood plain topography, has been a severely limiting factor.

Prior to the continuation of modelling activities, either on a smaller scale, (smaller areal extent), or to a greater level of detail, (feasibility level and beyond), the question of data adequacy should be addressed. It is of no value to proceed with studies which expect greater accuracy with data of the present quality.

This section, whilst not intended to define specific studies or projects, seeks to identify and highlight those areas of model data requirements which are presently considered to be inadequate and which must be rectified without delay.

II.5.2 Hydrometric Data

Hydrometric data, supplied by BWDB Hydrology Section, has been used both to supply boundary conditions to the model and to provide comparison stations for calibration purposes. All data originates from observed readings of staff gauges. Spot checks on the efficiency of these observers have been made by the SWMC North Central Model Group and the results indicate that the reliability of some data may be suspect. It would be impossible to identify such data by inspection, but any possibilities of errors in just some of the data give rise to misgivings in the use of all data.

Little can be done with the existing raw data, should it contain significant errors, except simply to attempt the identification of possible errors and to place an appropriate caveat on the results generated. Improvements could be significant, however, if an intensive quality check of discharge measurements and rating curve generation is undertaken. There is evidence to show that the conversion of stage to discharge is somewhat suspect.

II.5.3 Model Set-up

During the course of model calibration, evidence began to point to the incorrect location of some BWDB river gauging stations, as supplied on a map provided by BWDB. In an attempt to clarify the situation, the SWMC carried out a GPS, (Global Positioning System), survey of all hydrometric stations in the region. The results justified the exercise in more than one case.

The aspect of set-up that remains to be addressed is that which relates to the location of the cross-

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sections used in the model.

It is only half an answer to refine the position of the hydrometric stations, but remain uncertain as to their location relative to a nodal point, (cross-section), in the model. If this relationship is not precisely known, the observed water level or discharge could be compared with the value at the wrong nodal point. Experience with the calibration of the North Central Model has highlighted that this could be a sensitive factor, if water surface slopes are large or where tributary inflow/outflow is significant.

It is recommended that a survey of the location of the BWDB Morphology Section cross-sections be initiated without delay, such that the cross-sections may be referenced precisely using the GPS.

II.5.4 Topographical Data

The major component of the hydrodynamic model is the topographical information, both river cross-section and flood plain. These two components rely on a suitably accurate network of bench marks. Presently FAP-18 is undertaking a second order levelling exercise in the North Central Region, totalling some 2,300 km, but the results from this will not become available before April, 1992, at the earliest.

When the above data becomes available, it will serve to validate the accuracy of the bench marks used in the topographic surveys of embankments and river cross-sections. However, the timing of the release of this data, together with the not inconsiderable task of re-adjustment of existing survey, would mean that any study, if it were to use this data, would have to be delayed to suit. This is clearly not likely to happen, since some projects are required to continue studies through to design stage.

All flood plain data originates from very old 4" and 8" to the mile irrigation maps, originally produced in 1963 from 1952 air photography. In the case of the North Central Model, the 1 Km square grid of levels was used for derivation of flood plain characteristics.

It is probable that for planning and pre-feasibility level studies, this level of detail can be tolerated, (provided that the expectations of accuracy of the results are commensurate with the level of accuracy of the data). Feasibility level studies will demand a higher degree of accuracy and reliability from the model and the quality of the topographic data should reflect this.

Since most feasibility level studies will be carried out on considerably smaller areas, the prospect of obtaining more accurate topographic data becomes realistic.

Once an area is identified as the subject of a feasibility level study, the configuration of the flood plains should be verified with sufficient transects to provide an indication of the present flood plain levels and extent. Further river section surveys should be carried out, with the cross-section locations related to the recent satellite image maps and not the old 1:50,000 maps.

The whole aspect of topographic survey, whether for modelling purposes or otherwise, will prove to be a costly and time-consuming exercise. It is therefore clear that the allocation of priorities for survey work should be addressed. This will come from the results of the pre-feasibility studies and should be

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followed up with survey at an early date, preferably to be completed during the early stages of the study.

ANNEX III

Additional Hydrodynamic Model Runs - 1988

In addition to the hydrodynamic model runs for 1989, which are discussed in Chapter 6 and the results presented in Figure 5.1.2 to 5.13.2, a number of supplementary runs were made for the extreme case of 1988. The results of these runs are presented in graphical form in this Annex.

Each planning unit is described by 2 graphs. The first of these show the flooding characteristics, (in terms of the percentage of the net cultivable area flooded, divided into notional flood phases), for the base case, or existing situation. The lower graph on each page illustrates the effect of imposing an embankment along the Jamuna from Bahadurabad to Bhuapur and thence along the left bank of the Dhaleswari and Kaliganga rivers. Changes in the resultant area of cultivable land flooded can be observed by comparing the two graphs.

Additional runs of the model were made for a number of combinations of alternative engineering interventions. These are fully described and illustrated in Preliminary Supporting Report II.5.

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Figure III.1.1

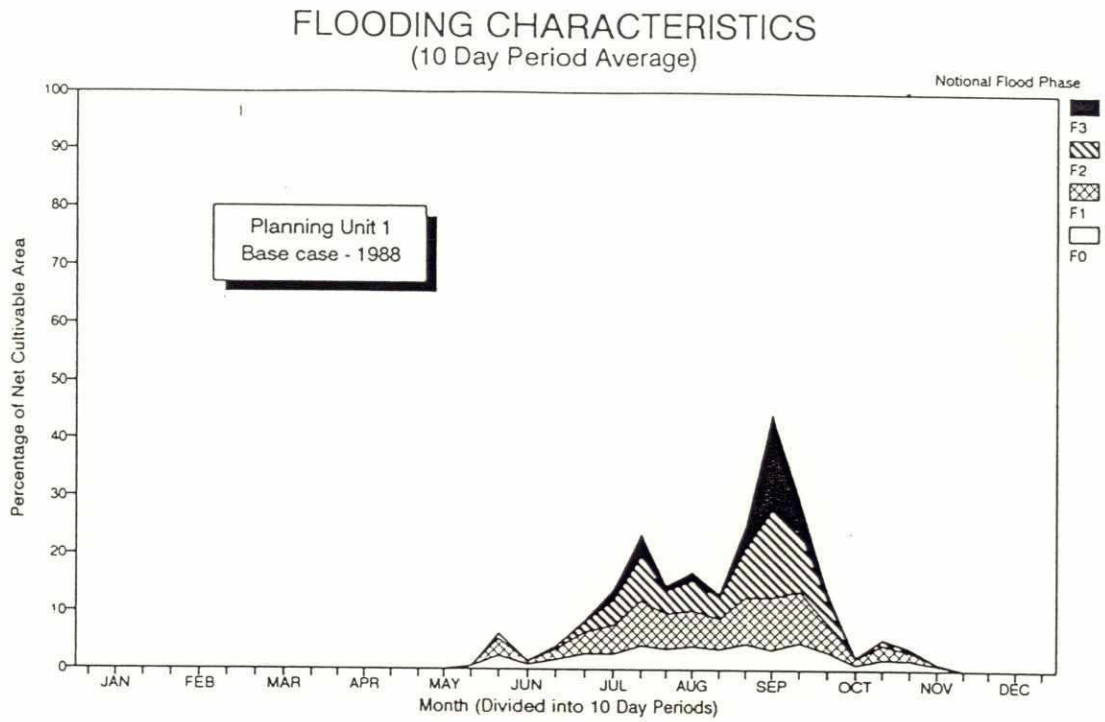
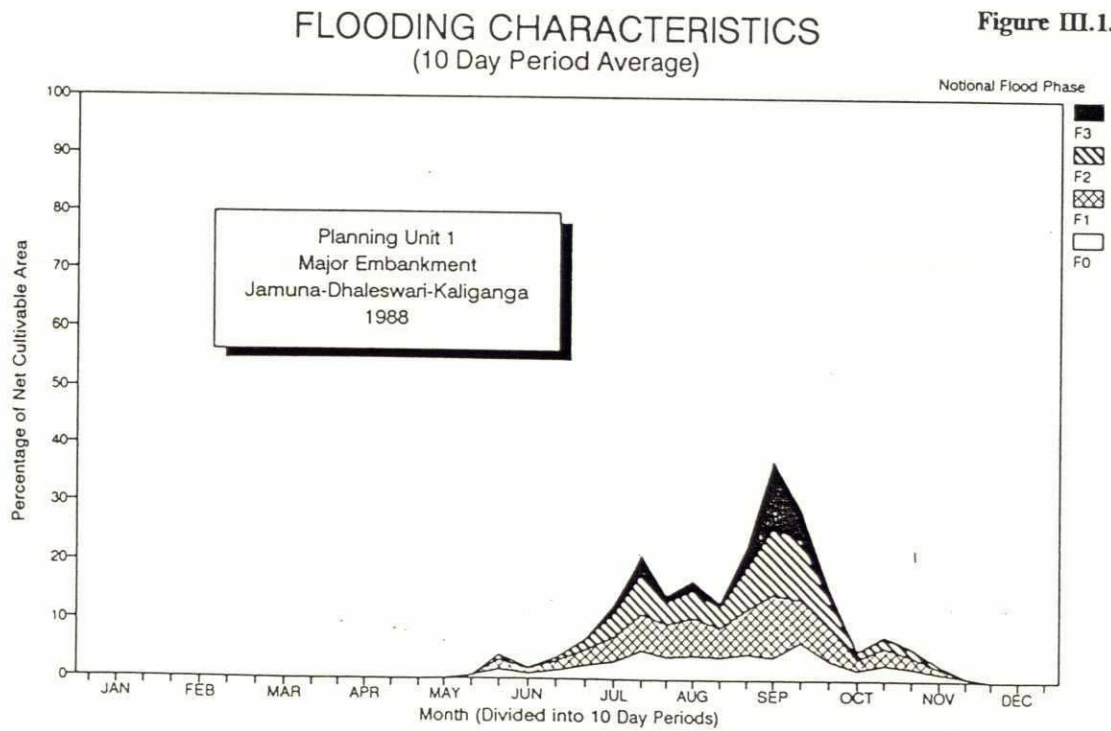


Figure III.1.2



2022

Figure III.2.1

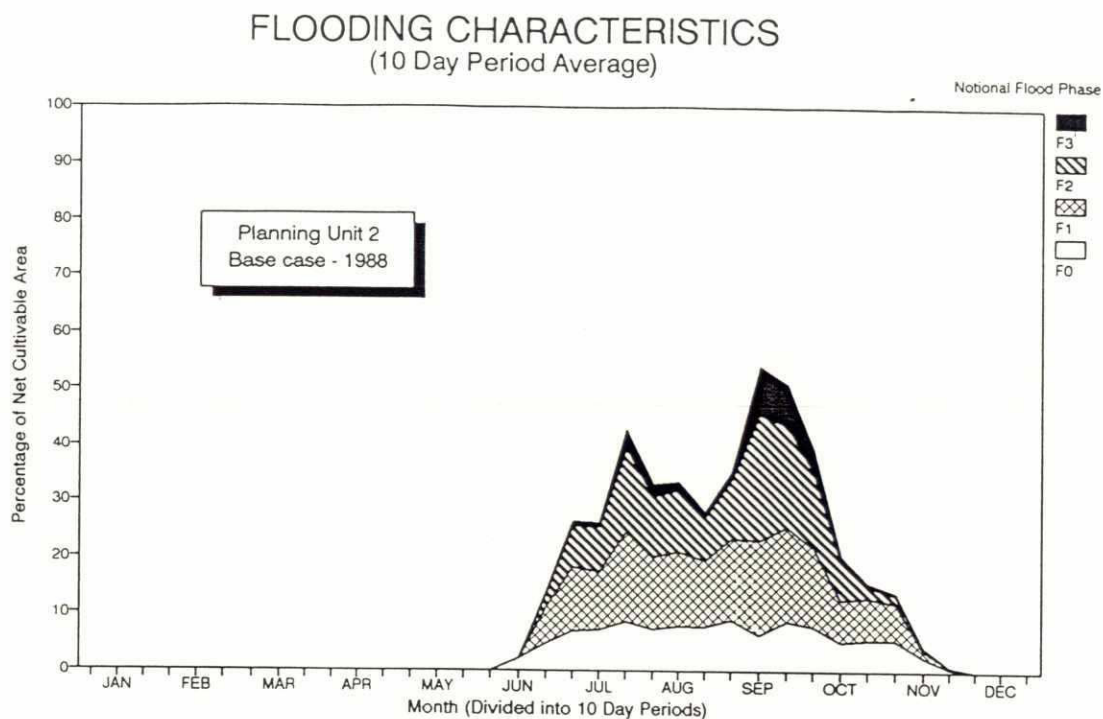
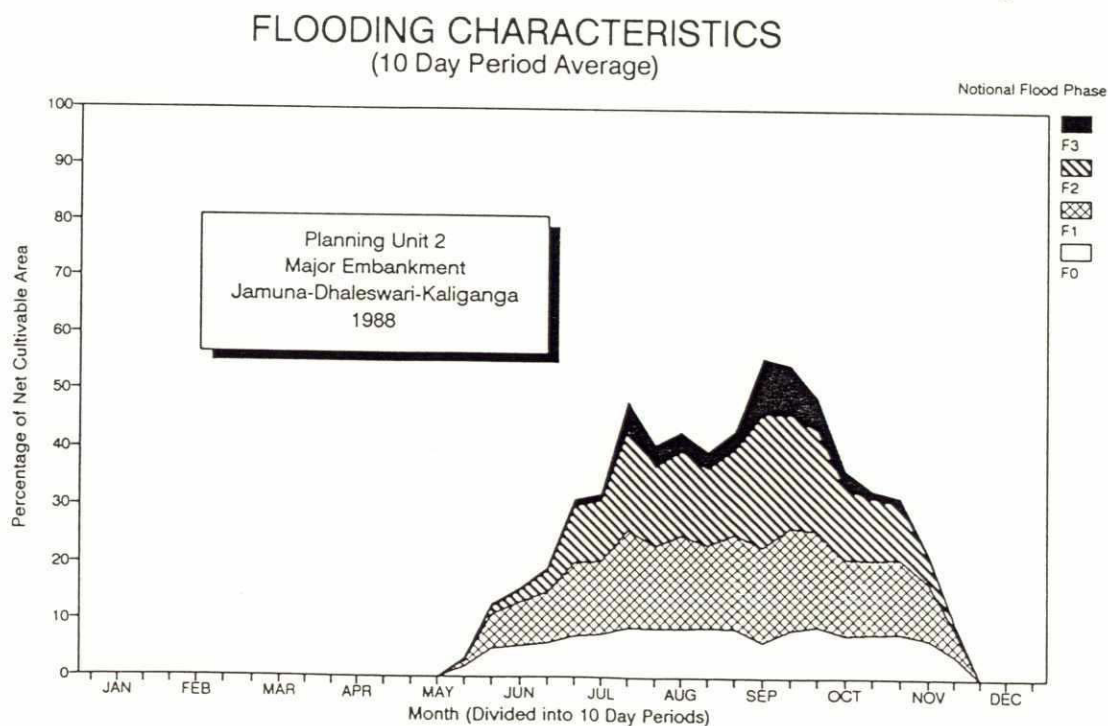


Figure III.2.2



2

Figure III.3.1

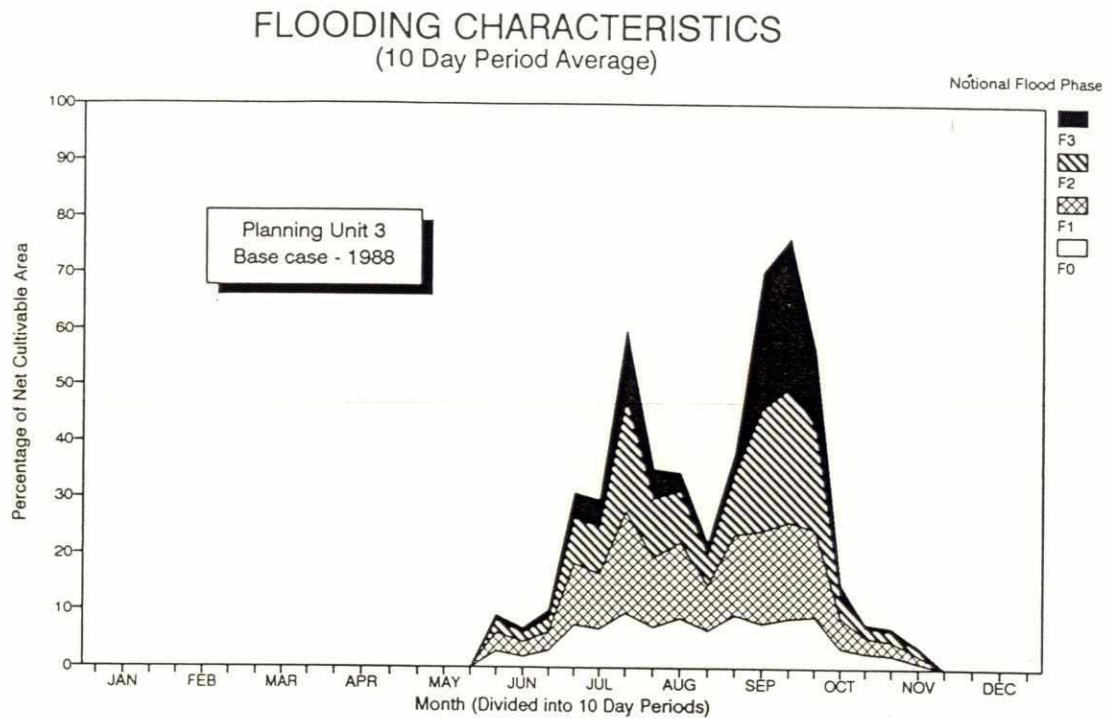
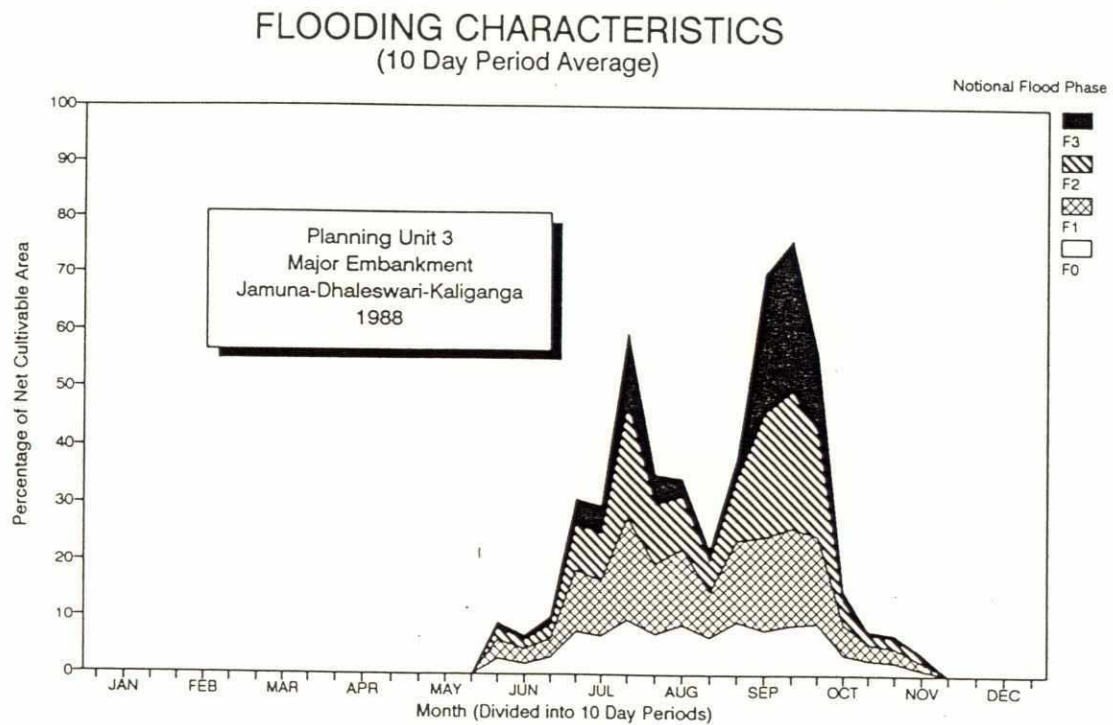


Figure III.3.2



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Figure III.4.1

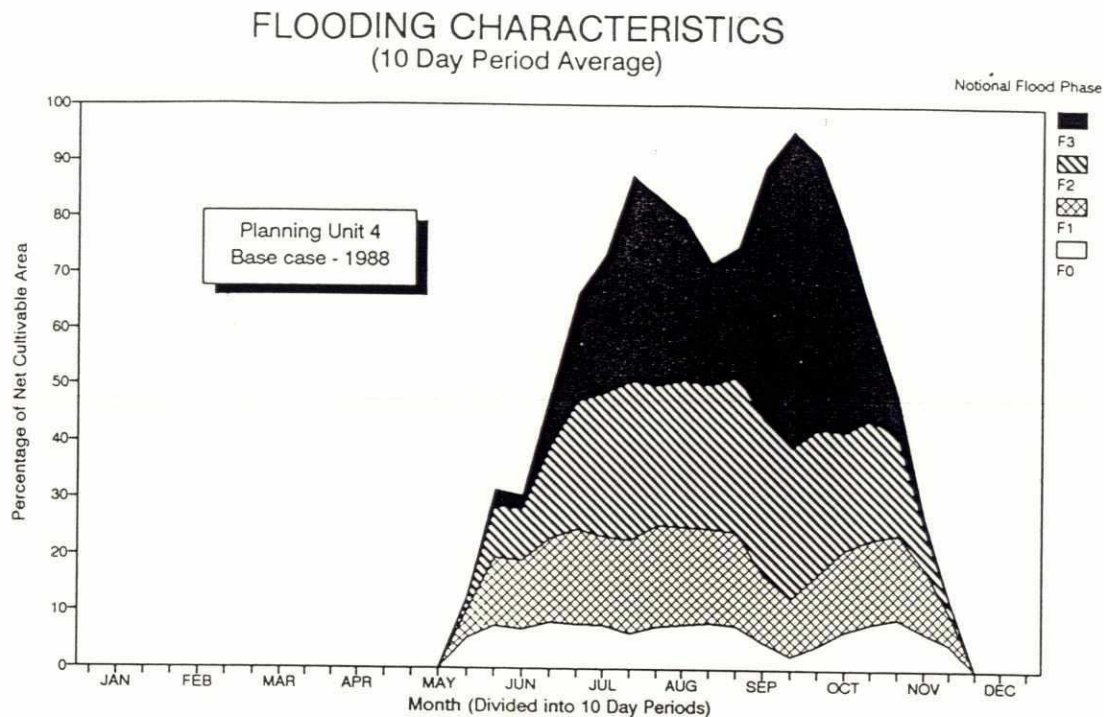


Figure III.4.2

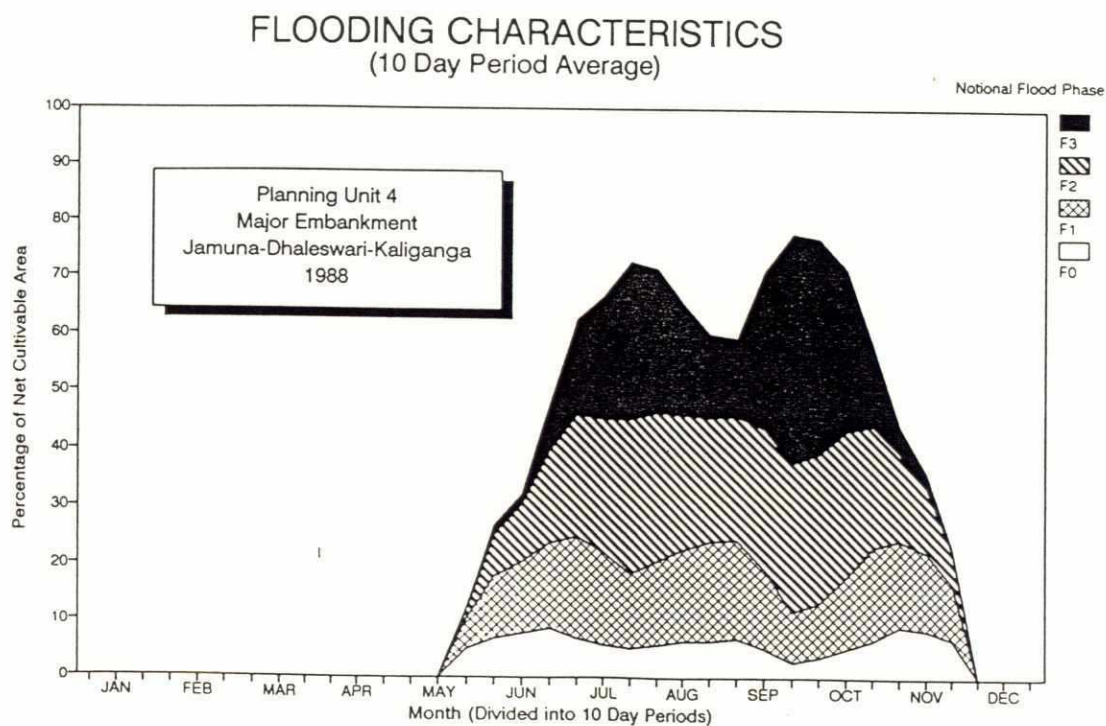


Figure III.5.1

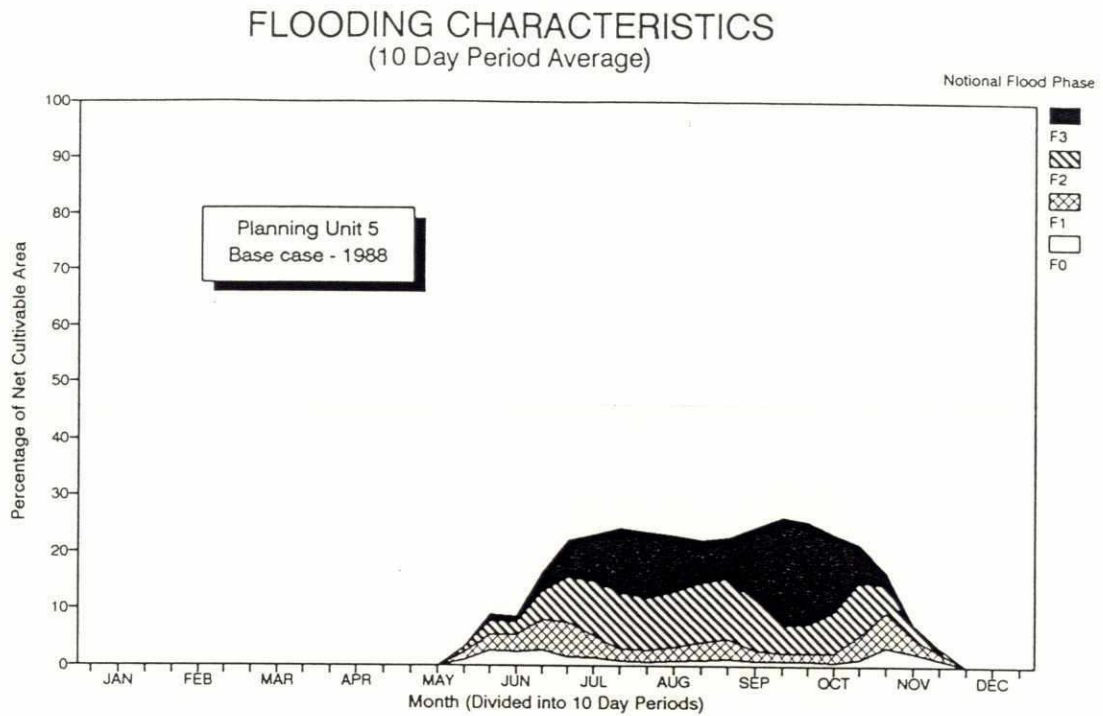
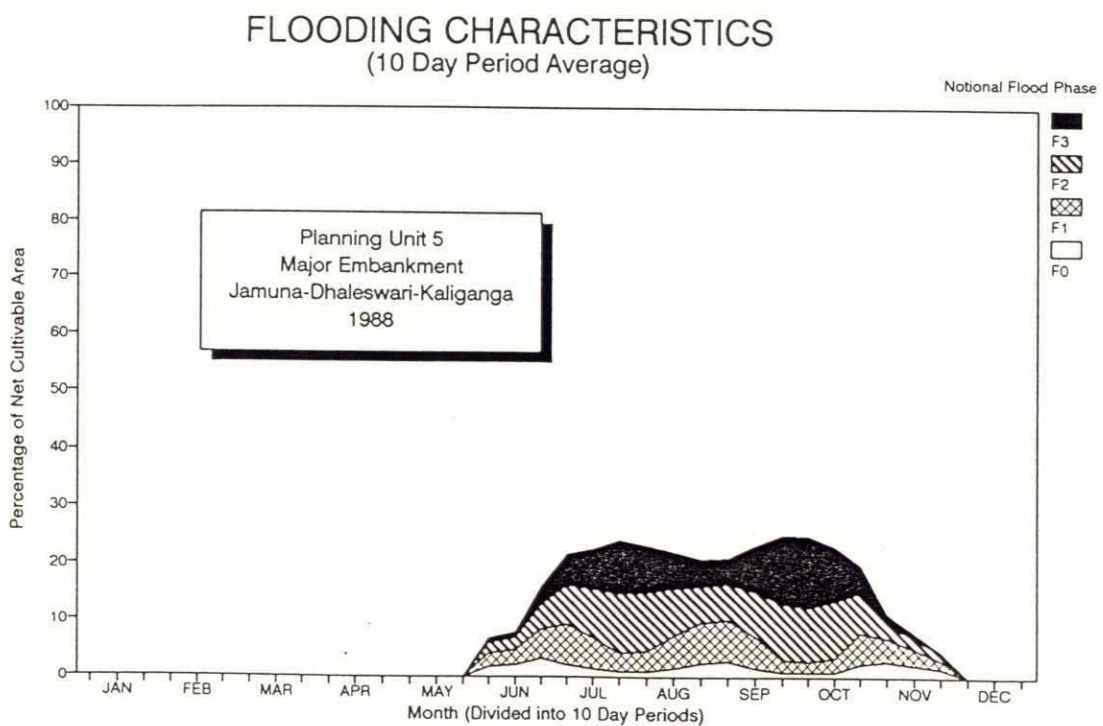


Figure III.5.2



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Figure III.6.1

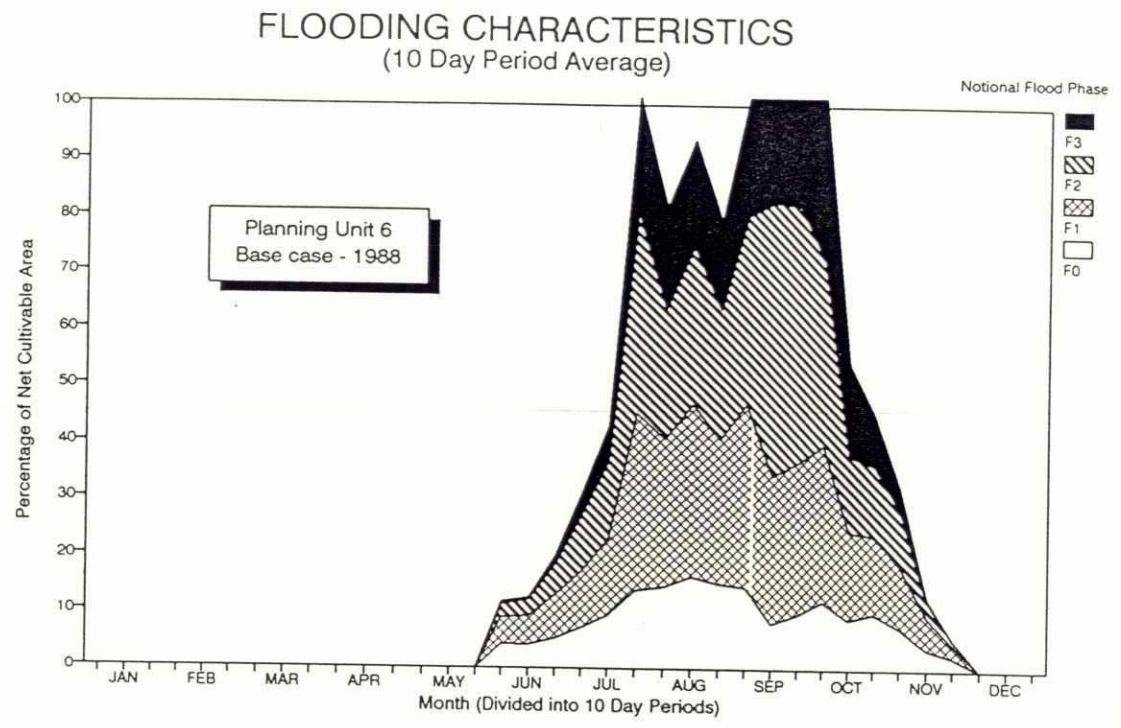


Figure III.6.2

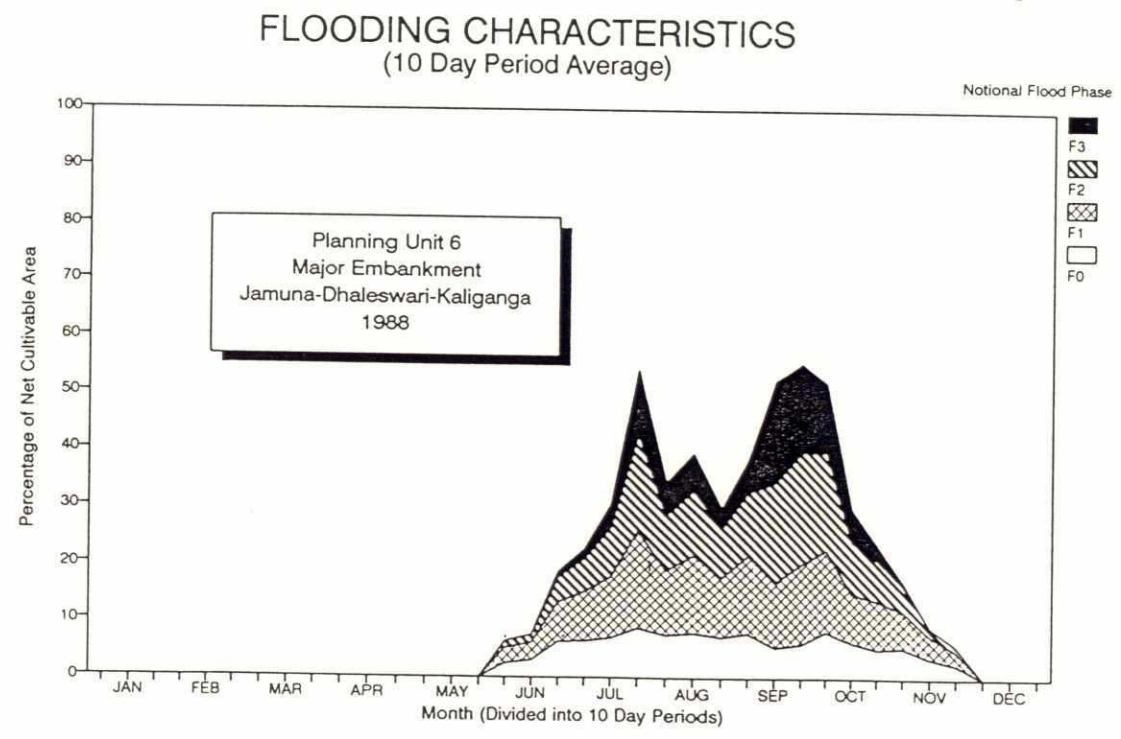


Figure III.7.1

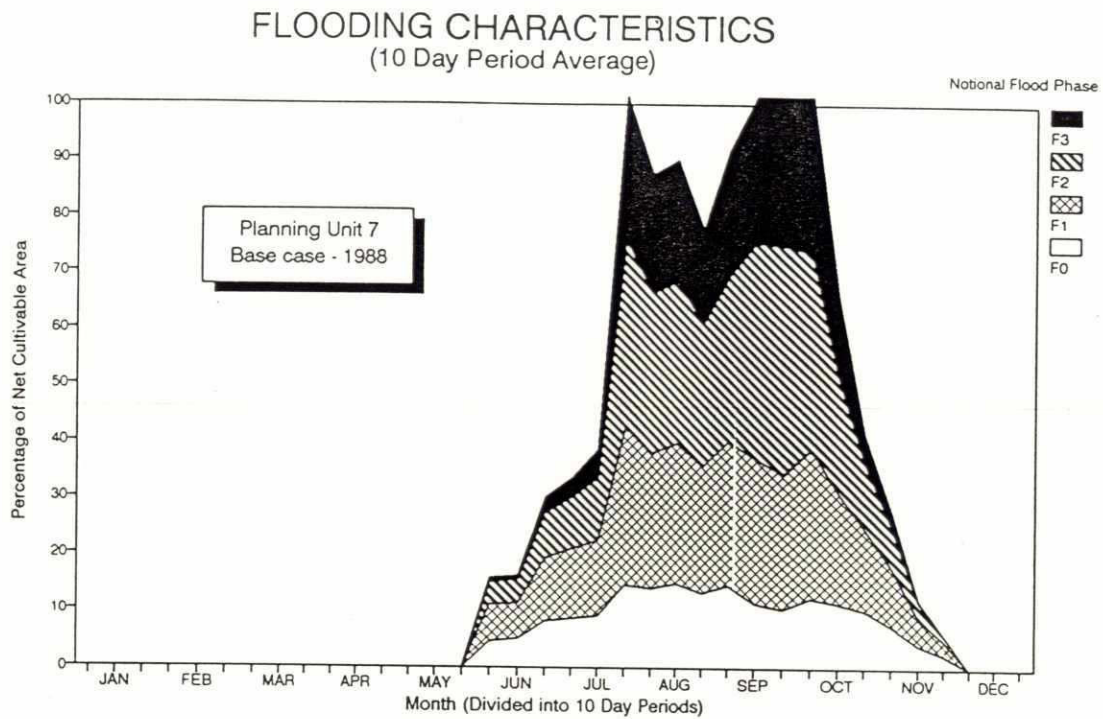


Figure III.7.2

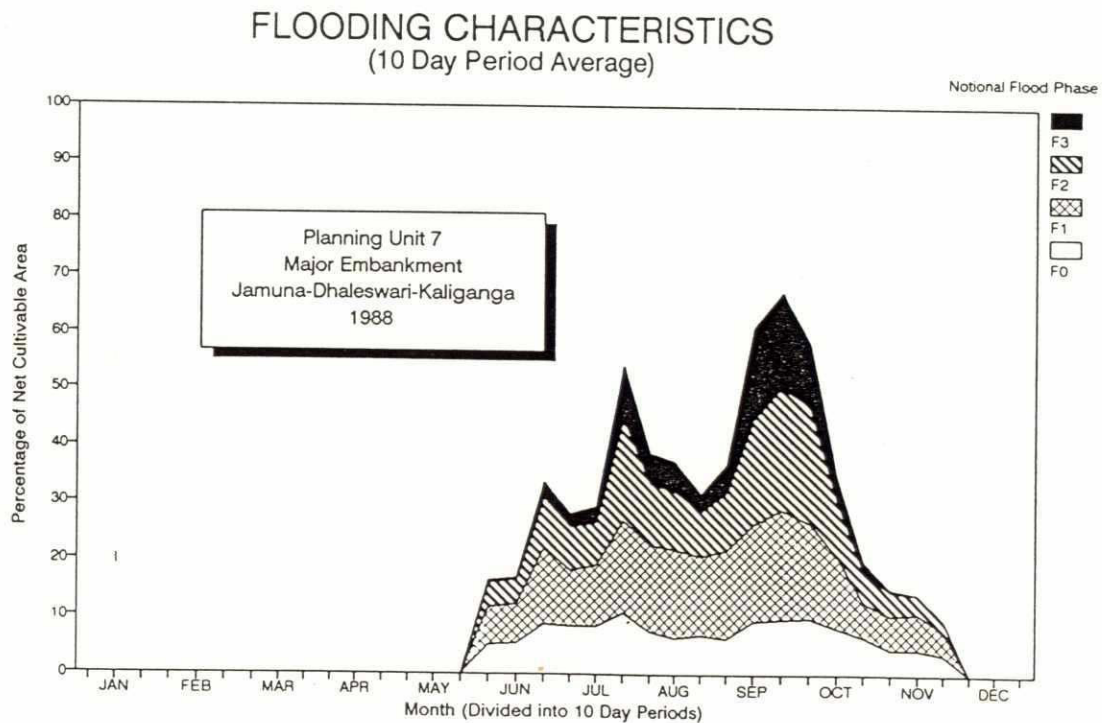


Figure III.8.1

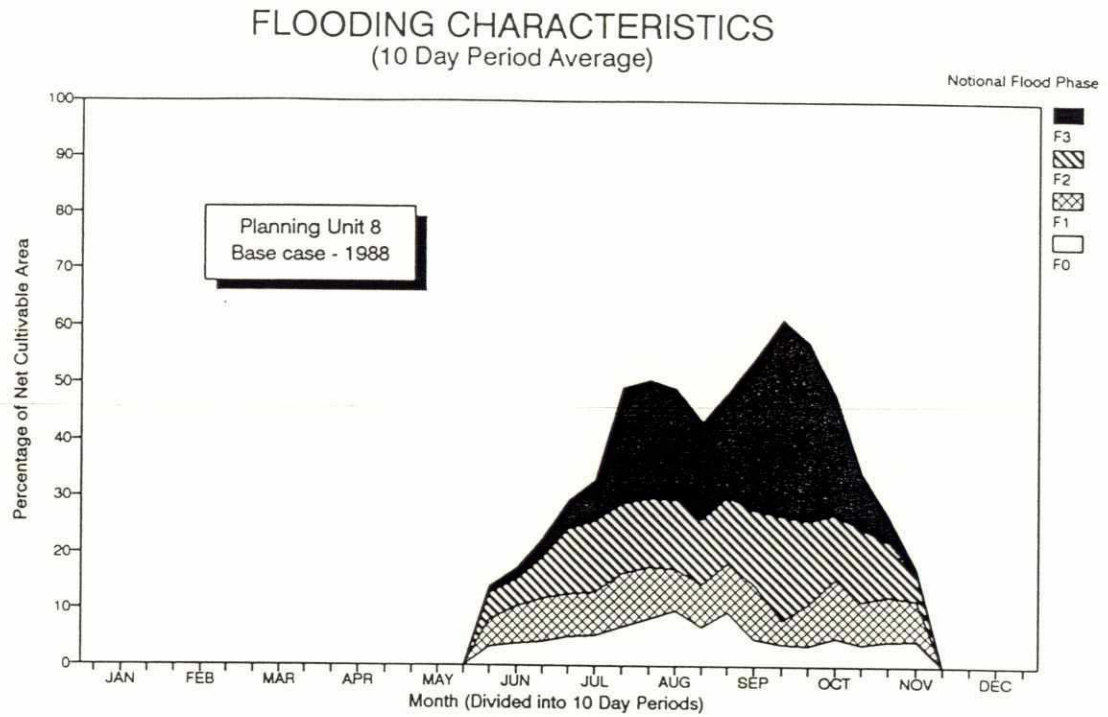
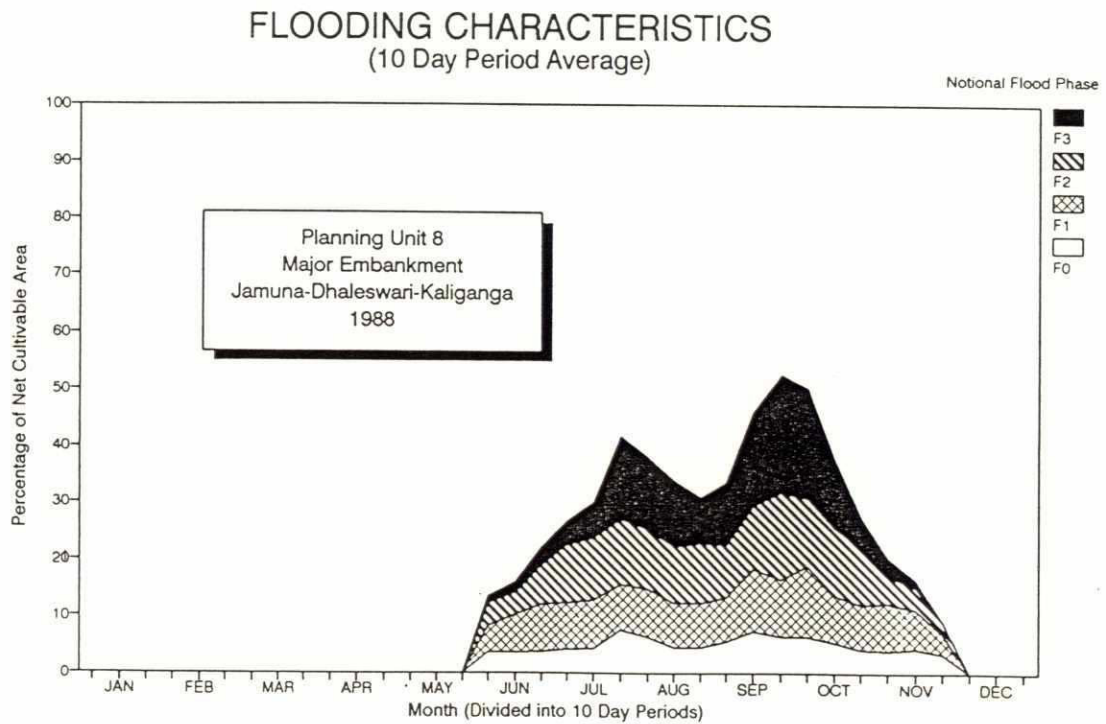


Figure III.8.2



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Figure III.9.1

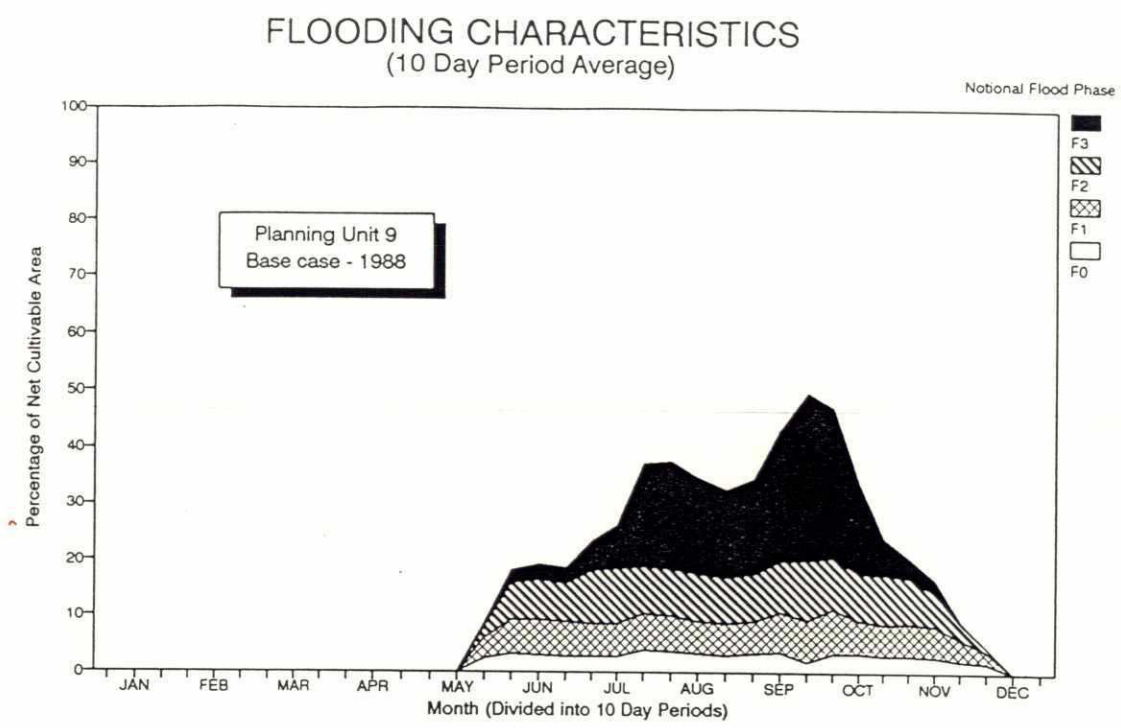
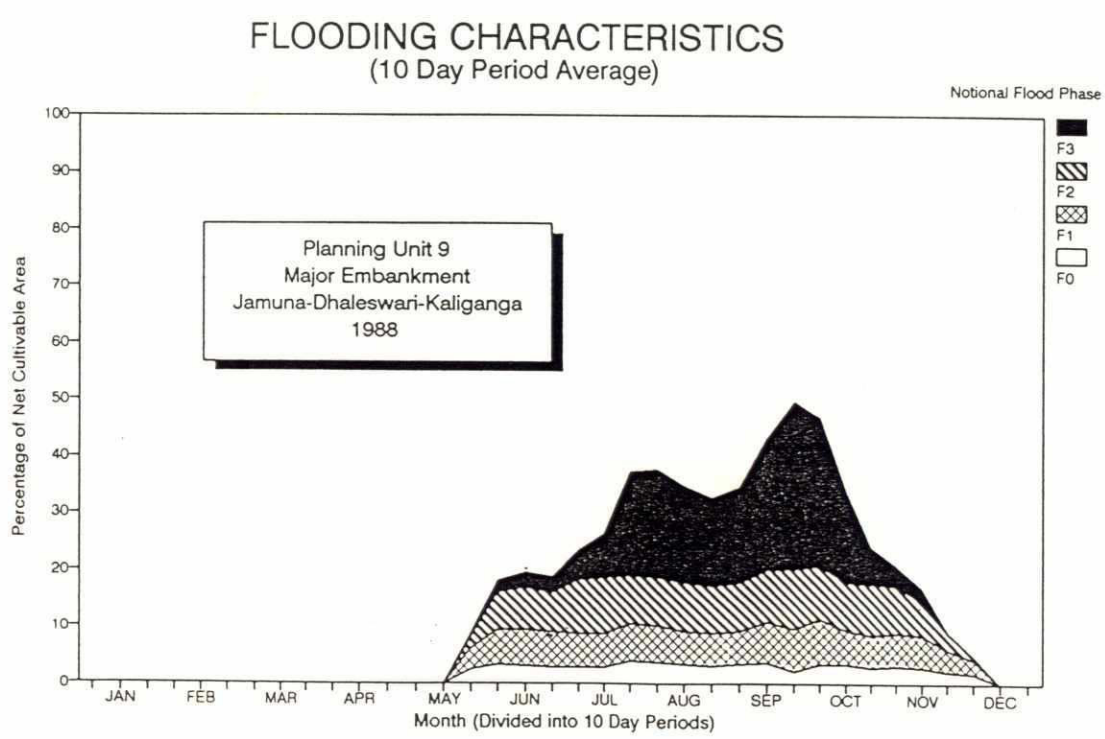


Figure III.9.2



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Figure III.10.1

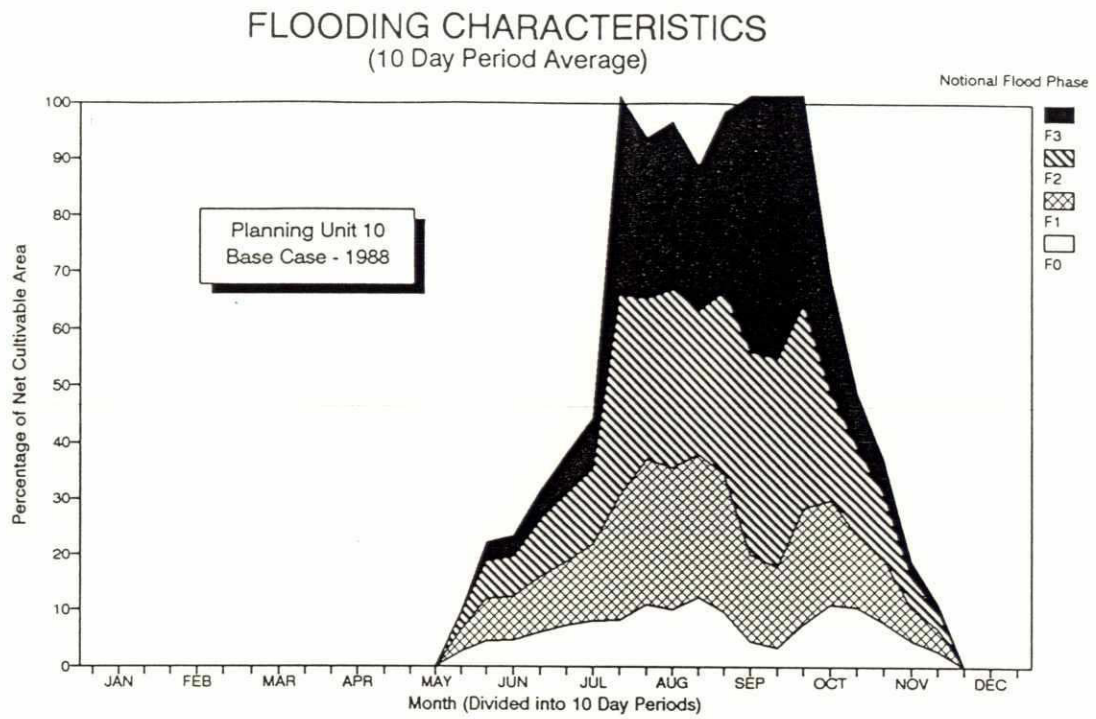


Figure III.10.2

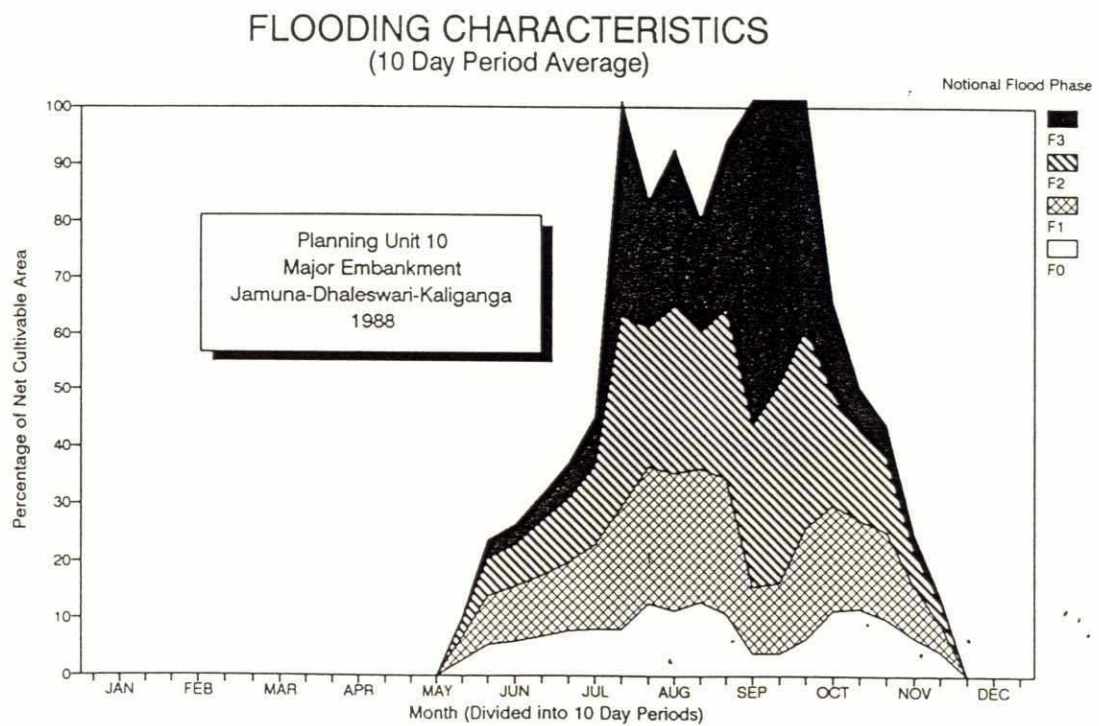


Figure III.11.1

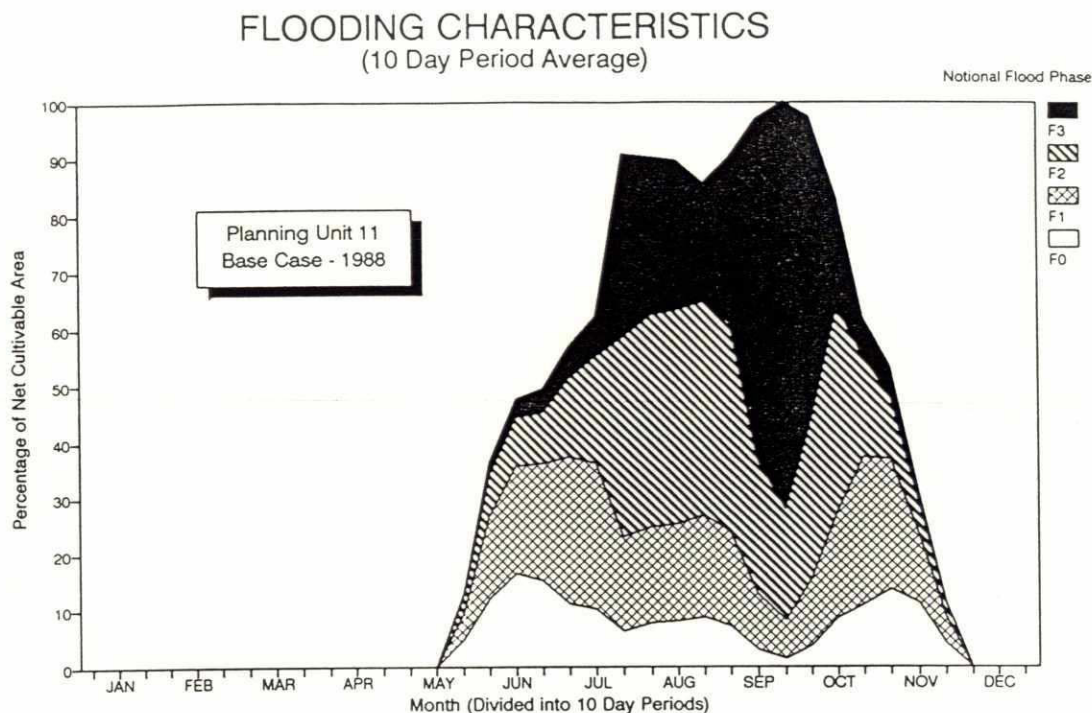


Figure III.11.2

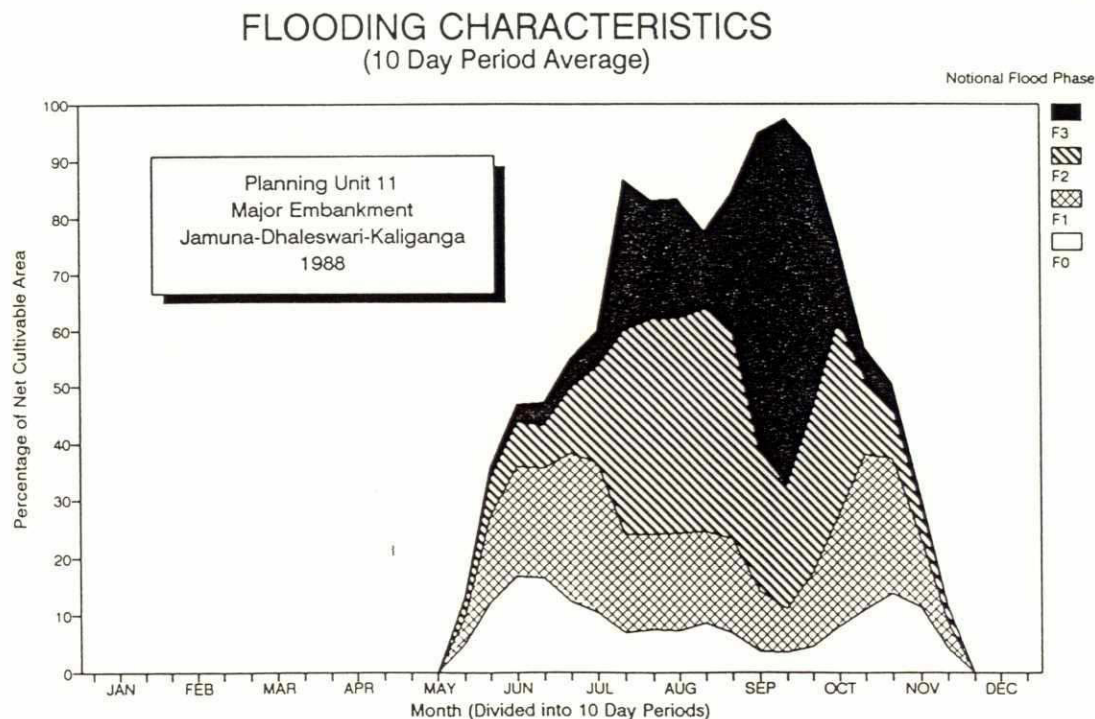


Figure III.12.1

Not Applicable - Dhaka City

Figure III.12.2

Not Applicable - Dhaka City

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Figure III.13.1

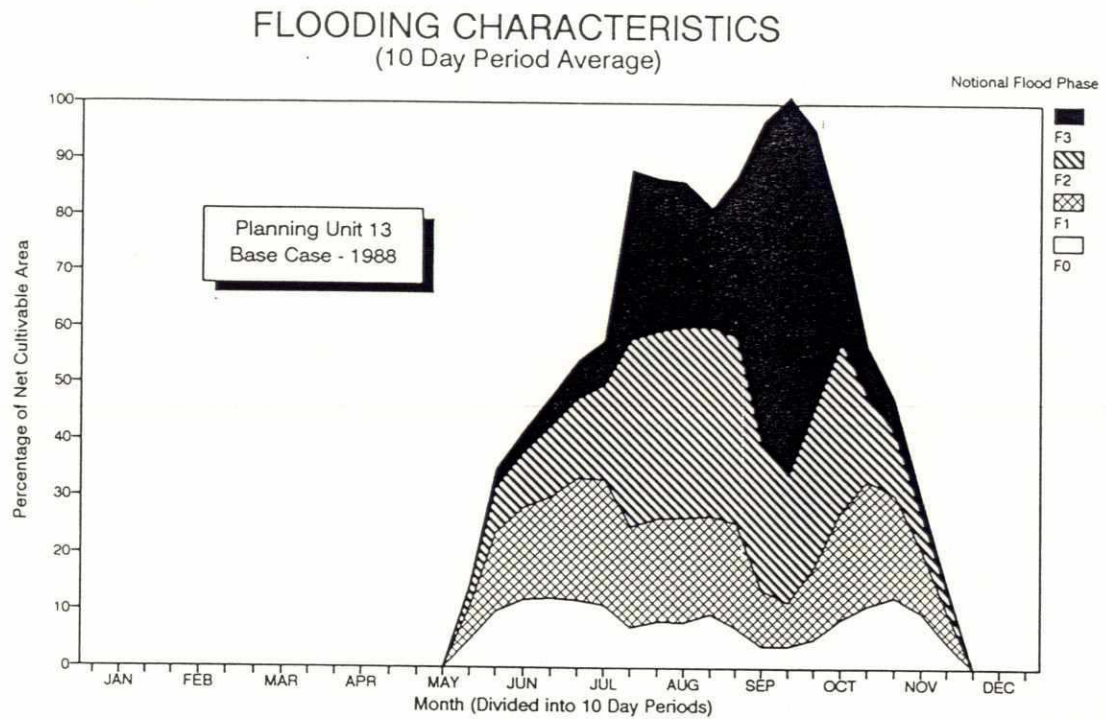


Figure III.13.2

