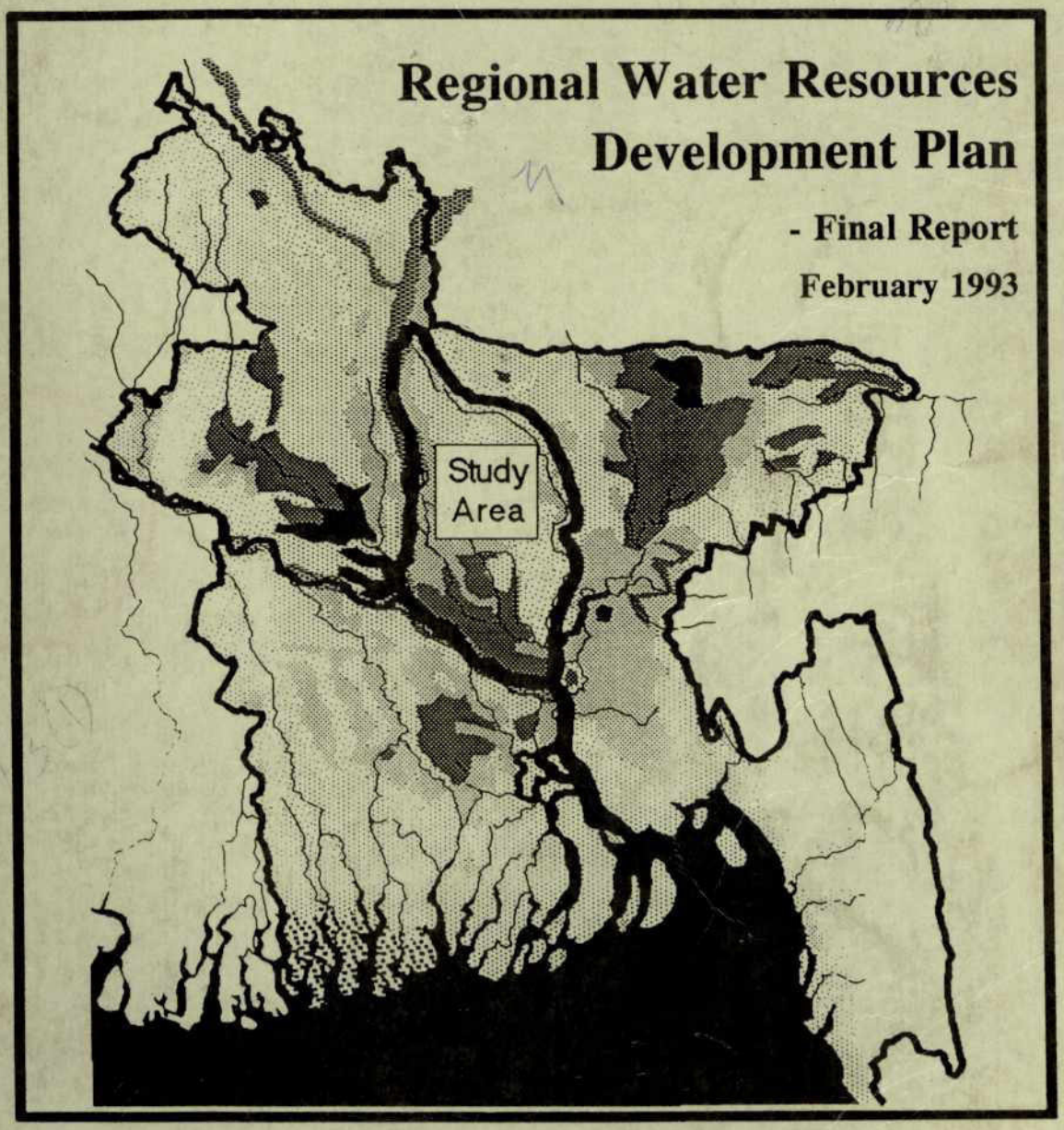
Government of the People's Republic of Bangladesh

Flood Action Plan

(2)

FAP 3

North Central Regional Study



Commission of the European Communities

and

Caisse Française de Développement

Project ALA/90/03

Consortium

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

in association with:

Desh Upodesh
BETS

The Regional Water Resources Development Plan - Final Report consists of the following:-

Main Volume	REGIONAL WATER RESOURCES DEVELOPMENT PLAN

Supporting Reports:-

SR I	LAND RESOURCES AND AGRICULTURE
SR II	WATER RESOURCES
SR III	FISHERIES
SR IV	HUMAN RESOURCES SOCIO-ECONOMICS AND INSTITUTIONS
SR V	ENVIRONMENT
SR VI	INFRASTRUCTURE AND EXISTING SCHEMES
SR VII	ENGINEERING
SR VIII	DEVELOPMENT OPTIONS
SR IX	PLANNING UNITS AND REGIONAL SCHEMES
SR X	ECONOMIC, AND MULTICRITERIA IMPACT ASSESSMENT

NORTH CENTRAL REGIONAL STUDY, FAP-3
REGIONAL WATER RESOURCES DEVELOPMENT PLAN

CONTENTS

5

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AEZ	Agro-Ecological Zone
BADC	Bangladesh Agricultural Development Corp.
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
BCAS	Bangladesh Centre for Advanced Studies
FDC	Bangladesh Fisheries Development Corp.
BIDS	Bangladesh Institute of Development Studies
BIWTA	Bangladesh Inland Water Transport Auth.
BJRI	Bangladesh Jute Research Institute
BKB	Bangladesh Krishi Bank
BNPP	Bangladesh National Physical Plan. Board
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engg.Technology
BWDB	Bangladesh Water Development Board
CA	Catchment Area
CAS	Catch Assessment Survey
CAT	Coordination Advisory Team
CCCE	Caisse Centrale de Coopération Economique
CEC	Commission of European Communities
CPM	Coarse Pilot Model
CS	Consultants' Studies
DA	Development Area
DAE	Department of Agricultural Extension
DANIDA	Danish International Development Agency
DDT	Dichlorodiphenyl-trichloroethane
DHI	Danish Hydraulics Institute
DOE	Department of Environment
DOF	Department of Fisheries
DOS	Disk Operating System
DSSTW	Deep Set Shallow Tubewell
DTW	Deep Tubewell
DUL	Desh Upodesh Ltd.
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIP	Early Implementation Programme
FAO	Food & Agricul.Organ.of the United Nations
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCDI	Flood Control,Drainage & Irrigation Project
FFYP	Fourth Five Year Plan
FHS	Flood Hydrology Study
FMM	Flood Management Modelling
FPCO	Flood Plan Co-ordination Organisation
FRI	Fisheries Research Institute
FRSS	Fisheries Resources Survey System
FSR	Farming Research System
FWP	Food for Work Programme
FY	Financial Year
GOB	Government of Bangladesh
GW	Groundwater
HTW	Hand Tubewell
HYV	High Yielding Variety
IDA	International Development Agency
IPM	Integrated Pest Management Programme
IRRI	International Rice Research Institute
JFP	Jamuna Flood Plain
JPPS	Jamalpur Priority Project Study
LGEB	Local Government Engineering Bureau
MCA	Multicriteria Analysis
ME	Ministry of Education
MF	Ministry of Finance
MIWDFC	Minist.of Irrig., Water Dev.& Flood Control
ML	Ministry of Land
MLGRDC	Minist.of Local Govt.,Rural Dev.& Coop.
MOA	Ministry of Agriculture
MOEF	Ministry of Environment and Forestry
MOFL	Ministry of Fisheries & Livestock
MOSTI	Manually Operated Shallow T/W for Irrig.
MP	Ministry of Planning
MPO	Master Plan Organisation
MTN	Madhupur Tract North
MTS	Madhupur Tract South
NCA	Net Cultivable Area
NCR	North Central Region
NCRM	North Central Regional Model
NCRMG	North Central Regional Model Group
NCRS	North Central Regional Study
NFMP	New Fisheries Management Policy
NGO	Non Government Organisation
NGR	Natural Growth Rate
NWP	National Water Plan
OBFP	Old Brahmaputra Flood Plain
O&M	Operation and Maintenance
ODA	Overseas Development Administration (UK)
PA	Planning Area
PFDS	Public Foodgrain Distribution System
POE	Panel of Experts
PU	Planning Unit
PWD	Public Works Datum
RARS	Regional Agricultural Research Station
RHD	Roads and Highways Department
RS	Regional Scheme
SES	Socio-Economic Survey
SOB	Survey of Bangladesh
SPARRSO	Space Research & Remote Sensing Organ.
SR	Supporting Report
SRP	Systems Rehabilitation Project
SRTI	Sugarcane Research and Training Institute
STW	Shallow Tube Well
SWMC	Surface Water Modelling Centre
TOR	Terms of Reference
Tk	Taka
UNDP	United Nations Development Programme
UNHCR	United Nations H.Commission for Refugees
WFP	World Food Programme

SUMMARY

S.1 North Central Regional Study

Text Reference

The North Central Region Study (NCRS) forms component three (FAP-3) of the Flood Action Plan and covers an area of 12,000 sq.km., between the Jamuna, Padma, Meghna, Old Brahmaputra and Lakhya rivers. — Chapter 1

This Final Report (FR) presents a Regional Water Resources Development Plan (RWRDP) with an emphasis on the flood control and drainage measures required to achieve a sustained development of the regional economy, taking into account social and environmental factors. The NCRS focuses on areas where flooding and impaired drainage hamper economic activity and identifies a series of measures to alleviate these adverse effects and to develop the land and water resources. The Final Report is augmented by a series of supporting reports (SRs). — Table 1.4

S.2 Regional Overview

The disastrous floods of 1987 and 1988 focused the world's attention on the problems of flooding in Bangladesh and flooding remains one of the major factors controlling food production of the North Central Region. A substantial proportion of NCR is flooded annually and in years such as 1987 and 1988 the majority of western & south-western floodplains of the Region are flood affected. — Chapter 2, Figure 2.1, Figure 2.2

Flooding in the North Central Region can originate from 3 sources: direct rainfall, direct overbank spillage from the major boundary rivers and overbank spillage from the internal regional rivers. It is possible for each phenomenon to occur separately or in combination with any other. The pattern of river levels generally experienced in the region shows a 2-peaked response, the first peak being generated by internal regional rainfall excess, normally in June/July, and the second peak resulting from high cross-boundary flows in the major rivers, normally in early September. The flood of 1988 was caused by the unusual coincidence of peak floods in both the Jamuna and the Ganges rivers whereas the floods of 1987 were caused primarily by the unusually high regional rainfall. — 2.2, 2.2.1, Figure 2.3, Figure 2.2

The river system is characterised by the major (Jamuna,Padma and the Old Brahmaputra-Lakhya-Meghna) and the interior rivers (Dhaleswari-Kaliganga, Bangshi-Turag and Banar-Lakhya systems). The rivers of the region are subject to significant morphological changes. — 2.2, Figure 2.5, Figure 2.6

Large volumes of excess rainwater accumulate in the depressions and low-lying areas, and during the pre-monsoon and monsoon seasons, (from May to October), the predominantly high water levels in the regional rivers (which convey spills from the Jamuna) prevent the outflow of excess rainfall from the internal flood plains. As long as the commanding water levels in the boundary rivers remain high, the levels in the regional rivers also remain high and the removal of water from, (or transfer through), the region is severely inhibited. The Meghna-Padma at the south-east corner is tidal influenced and causes further reduction of drainage in the Region, thus keeping flood levels high. — 2.2.3, Figure 2.4

Drainage of the North Central Region takes place at 4 levels: the boundary river system (primary), the regional river system (secondary), the khal system (tertiary), and the beel system (quaternary). The mechanism by which the region drains relates directly to this hierarchical system and its interconnections. **2.2.4**

The NCR land resources consist of four main physiographic units:- **2.3.1**

- Young Brahmaputra and Jamuna Floodplains
- Old Brahmaputra Floodplain
- Padma Floodplain
- Madhupur Tract

The soils occur in complex patterns, but consist mainly of two types - Floodplain soil type or Madhupur Tract soil type. **2.3.1**

The climate of the area is tropical monsoon, with average annual rainfall from 1400 mm in the Tangail, (south-west), region to 2200 mm in the Mymensingh, (north-east), region. The south-west monsoon winds usually begin in June and last through to October bringing heavy, persistent rains. **2.3.2**

Cropping patterns are determined by the seasonal floods with rice as the most important crop. **2.3.3**
Agriculture is the main output of the Region (excepting the industrial activities of Dhaka city). Paddy production is estimated at some 3 million tons/year. **2.3.5**

Irrigation has increased significantly in recent years and is not limited by groundwater potential except in the eastern part of the Region. **2.3.4**

Fisheries form a significant resource of the area particularly in the floodplains. **2.3.6**

Socio-economic aspects of the NCRS are summarised in the Study and problems related to the agricultural sector include the saving capacity, unemployment, women's activities, fisheries, poverty and malnutrition. Other problems are linked to high population densities, migrations, and poor infrastructures. These together can form a very constraining socio-economic framework for regional development and are taken into account in the planning process through the multicriteria analysis. **2.4**

Successful water resources development is dependent on its acceptance by the local community and public participation is important in this regard. A public meeting has been held in Mymensingh to discuss the Draft Plan which heard the views of some Members of Parliament and other representatives of the Region. This has resulted in the inclusion in the RWRDP of certain additional regional schemes which although not receiving a high priority in terms of a response to flooding problems alone, are included as they have significant irrigation and agricultural development content which makes them significant for the overall water resources development of the Region. **3.3.2** **6.2**

S.3 Methodology

The Region was initially divided into thirteen 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, soils, land use, population intensities and socio-economic characteristics. The PUs are defined to assist in the planning process, they are not development units and options may need to be implemented over more than one PU at a time.

3.1
Figure 3.1

Subsequently, the characteristics of the PUs have been compared and the results indicate that the NCR can be broadly categorised as falling into 5 characteristic sub-regions (see Figure 2.5) on the basis of biophysical and socio-economic features:-

2.5
3.1
Figure 2.13

- Jamuna Flood Plain 35% of NCR area
- Old Brahmaputra Flood Plain 20% of NCR area
- Madhupur Tract North 19% of NCR area
- Madhupur Tract South 11% of NCR area
- Padma Flood Plain 15% of NCR area

The natural and socio-economic environment is described on the basis of these sub-regions and a water development strategy developed.

3.2

S.4 Water Development Strategy

A water development strategy is proposed and the water resources characteristics, are considered along with socio-economic, environmental and national planning aspects:-

3.3.1

- identify economically viable developments
- identify areas where high agricultural value can be added from controlled flooding interventions
- priority to heavily distressed sub-regions
- develop first where socio-economic frameworks exist to sustain growth
- involve local people in the planning and management of flood control and drainage programmes
- promote local economic initiatives induced by agricultural, livestock and fisheries improvements
- allow for mitigatory measures wherever groups/persons are adversely affected by a development
- use embankments for several socio-economic purposes
- economic promotion through improved institutional measures
- sub-divide region into regional planning units to facilitate the planning process
- develop environmental management programme so as to sustain the region's resources

3.3.2

S.5 Development Options

Development options have been formulated and include:- 3.3.3

- fully controlled flooding and drainage, based on full flood control along the major rivers by embankments and fully gated structures, and major drainage improvements;
- semi-controlled flooding and drainage, where flooding depends partly on embankments with fully gated structures, and partly on natural openings or semi-regulated ones.
- compartmentalisation (water management systems including required institutional agreements and comprising peripheral inlet/outlet structures, internal water control works, channel improvement, and infrastructure improvements).
- development of unprotected or partially protected areas in terms of flood proofing (both rural and urban), flood preparedness and early flood warning systems

Within the various sub-regions of the North Central Region, compartmentalisation is expected to play a key role in all future development scenarios. The compartmentalisation of protected areas creates water management units organised by the local beneficiaries and supported technically by the local institutions. 3.3.3

S.6 Preliminary Screening of Development Options

Appropriate flood mitigation actions are summarised for each PU in the Study. After considering the main physical development constraints, PU's 1,2,4,6,7 and 10 are considered as priority development areas. Inside these PU's several planning actions are described in technical and economic terms with or without combination of regional schemes (linking together for instance PU1 and PU2, also PU2 and PU4 for which flood mitigation measures are clearly interrelated). Alternative scenarios have been taken into consideration for the above priority planning units which take include the possible implementation of Jamuna Bridge. 3.?.4 **Figure 3.6**

In addition to planning for the development of these priority planning units the Regional Water Resources Development Plan (RWRDP) also assesses the other planning units (PU's 3,5,8,9,11,12 and 13), and recommends local planning and water management measures.

S.7 Planning Process

An inventory of development alternatives and components is given, but irrigation development has not been considered as a particular option (being outside the scope of the TOR for the Study). It is assumed that irrigation will be developed by the private sector without any heavy public investment. **Chapter 4**

The planning process was multi-disciplinary and involved the use of a hydraulic model with engineering and economic analyses together with agricultural, fishery, socio-economic, institutional and environmental studies. These were incorporated into a multi-criteria analysis of the identified scheme alternatives.

S.8 Pre-feasibility Studies

A pre-selection of possible projects prioritised pre-feasibility studies on five regional schemes:- 5.1

The **Jamalpur Priority Project, scheme RS1** (also known as FAP 3.1) located at the northern upstream corner of the NCR, which was identified early in the FAP as being suited for priority development (the FAP 3.1 Feasibility Study has been carried out concurrently with this NCRS). 5.2 Figure 5.1

Both the FAP 3 and 3.1 analysis of RS1 show that a low cost engineering option (Option B) is the most viable option for the area. An alternative flood proofing and local drainage option (Option A) would provide benefits in terms of security from floods but it is difficult to justify this option on economic grounds as the assessment of costs and benefits of flood proofing have not yet been well quantified.

Option B allows for the best use to be made of the advantages of the JPPS area. An option is being developed by FAP 3.1 that will utilise the existing embankments where appropriate and keep construction costs down to a minimum. FAP 3 calculate that such an approach would give an IRR of 12% (without taking into account the costs or benefits of flood proofing). If allowances are made for indirect benefits (of damages avoided and increased agricultural benefit) then the IRR increases to more then 13%. 5.2 Table 6.3 Table 6.5

The **Jamalpur to Bhuapur Development Scheme, RS2** covers an area of 149 000 ha (116 000 ha NCA), consisting of PUs 2 and 4. The area is already partly flood protected by the Jagannathganj-Jamalpur railway embankment and the BWDB embankment from Bhuapur to Jagannathganj. 5.3 Figure 5.2

The prefeasibility analysis shows that this scheme gives a high economic return (18 % IRR, NPV of Tk. 476 million). This is largely due to the existing hydraulic infrastructure which has reduced the required investment capital. In social and environmental terms, it is also relatively attractive as fishery resources are relatively low in the area and as the embankments are already largely in position, there is a relatively small additional impact on flood levels outside the embankments resulting from the scheme. The significant initiative of the scheme is the compartmentalisation concept, and RS2 can be seen to be an extension of the FAP 20 Pilot Project which is located immediately downstream. Table 6.3 Table 6.5 Table 4.2

The **Dhaleswari - Kaliganga Development Scheme, RS3** covers an area of 150 000 ha (117 000 ha NCA), consisting of PUs 6a and 7. The area includes within it the FAP-20 Compartmentalisation Pilot Project at Tangail. Limited embankments already exist in the area, particularly in the FAP 20 area; but most of the Dhaleswari-Kaliganga remains unembanked. 5.4 Figure 5.3 Figure 5.4

The proposed development is to construct embankments for controlled flooding along the Dhaleswari-Kaliganga from Joker Char (near the Pungli offtake) down to Kalatia. The possible development has been split into two phases and should be considered as either with (RS3A) or without the Jamuna bridge (RS3B)

The prefeasibility analysis shows that this scheme with controlled structures (RS3A1C+RS3A2C) gives the highest economic return (IRR of 22%, NPV of Tk. million 1700). However it is a large scale scheme requiring substantial capital investment (Tk. million 2700, US $60 million) and the consequences of such a development need careful investigation before it can be justified. The impact on the adjacent areas of PUs 6b, and 10 plus the environmental consequences need to be fully estimated. The scheme would affect a major floodplain fishery area (one of the largest remaining unembanked fishery resources areas), and the consequences of such an interference may have far reaching effects beyond the NCR area. **Table 6.3** **Table 6.4**

It is therefore recommended that RS3 be taken through to feasibility study, but that time is allowed for preparatory studies to be made to establish fully the environmental, hydrological and socio-economic characteristics of the area and the consequences of such a development.

The **Bangshi River Improvement and Drainage Scheme, RS4** would improve the flow capacity of the main drainage channel for the western part of the region. The river would be straightened, widened and deepened for a total length of 81 km. The work would start at Kalatia (constraints downstream of this point are determined by the high water levels backing up from the Meghna/Padma confluence) and be implemented upstream to include strengthening and improvement of the Bangshi river east of Basail. 5.5 Figure 5.5

The prefeasibility studies show that this scheme on its own would not be economically viable (IRR of 6%). But RS4 is also found to be complementary to other regional schemes, and thus the scheme is recommended to be studied as a possible addition to the scope of works to both RS2 and RS3 feasibility studies. Table 6.3 Table 6.5

The **Muktagacha - Bhaluka Development, RS5,** covers an area of 172,000 ha in PU3, substantial areas are flooded annually from local rain water and runoff from the adjacent Madhupur Tract. There is little direct flooding from the adjacent Old Brahmaputra but drainage from the area is restricted at the south-eastern end by high water levels in the rivers. Groundwater conditions are unfavourable and it is estimated that only 60% of the eventual irrigation demand can be met from groundwater. The aim of development in the area would be to increase agricultural production by improving the drainage and water management. The area would benefit from improved water supply, possibly through the diversion of surface water from the Old Brahmaputra.

The **Bhuapur - Aricha Development, RS6**, forms an alternative to RS3. The upstream section is the same as RS3 (following the left bank as far as Dhula), but instead of following the Dhaleswari downstream of Dhula, another embankment would be constructed on the south side of the Dhaleswari offtake following the left bank of the Jamuna down to Aricha and finally connecting up with existing BWDB embankment works close to Harirampur. The scheme forms part of the earlier proposed Dhaka South West Project. **5.6** **Figure 5.6** **Figure 5.7**

This scheme is potentially a large scale development, but it involves major changes to the present hydraulic regime of the major rivers (Jamuna, Padma, & Dhaleswari). The prefeasibility analysis has shown the scheme to be economically marginal (IRR of 11%); and there are major potential **Table 6.3**

environmental consequences that are envisaged as a result of the scheme. The scheme is seen to be even more complicated to assess than RS3 and should have a high risk factor applied to its assessment. It is not recommended for further study in the medium term but should be reconsidered at a later date in the RWRDP. **6.5.5**

S.9 Regional Water Resources Development Plan

The Regional Water Resources Development Plan (RWRDP) has been developed using a multi-criteria approach with the economic and sensitivity analyses of engineering and agricultural/fishery benefits/disbenefits being supplemented with more qualitative assessments on socio-economic and environmental impacts. **6.1 to 6.4**

The RWRDP is presented below, but the success of the complete plan is subject to certain recommended institutional changes and to making the best use of experiences gained in the related FAP supporting studies. The priorities are based on the conclusions, described in the multicriteria analysis. **6.4** **6.5.4**

The anticipated developments have been categorised as suitable for short, medium and long term development: 6.5.6

Short Term

Short term development is considered as those schemes that could be prepared and implemented within the next 6 years (see Figure S.1). These schemes consist of priority projects that are expected to have a relatively small environmental impact on adjacent areas, and thus require only 1 to 2 year feasibility study. Figure 6.2

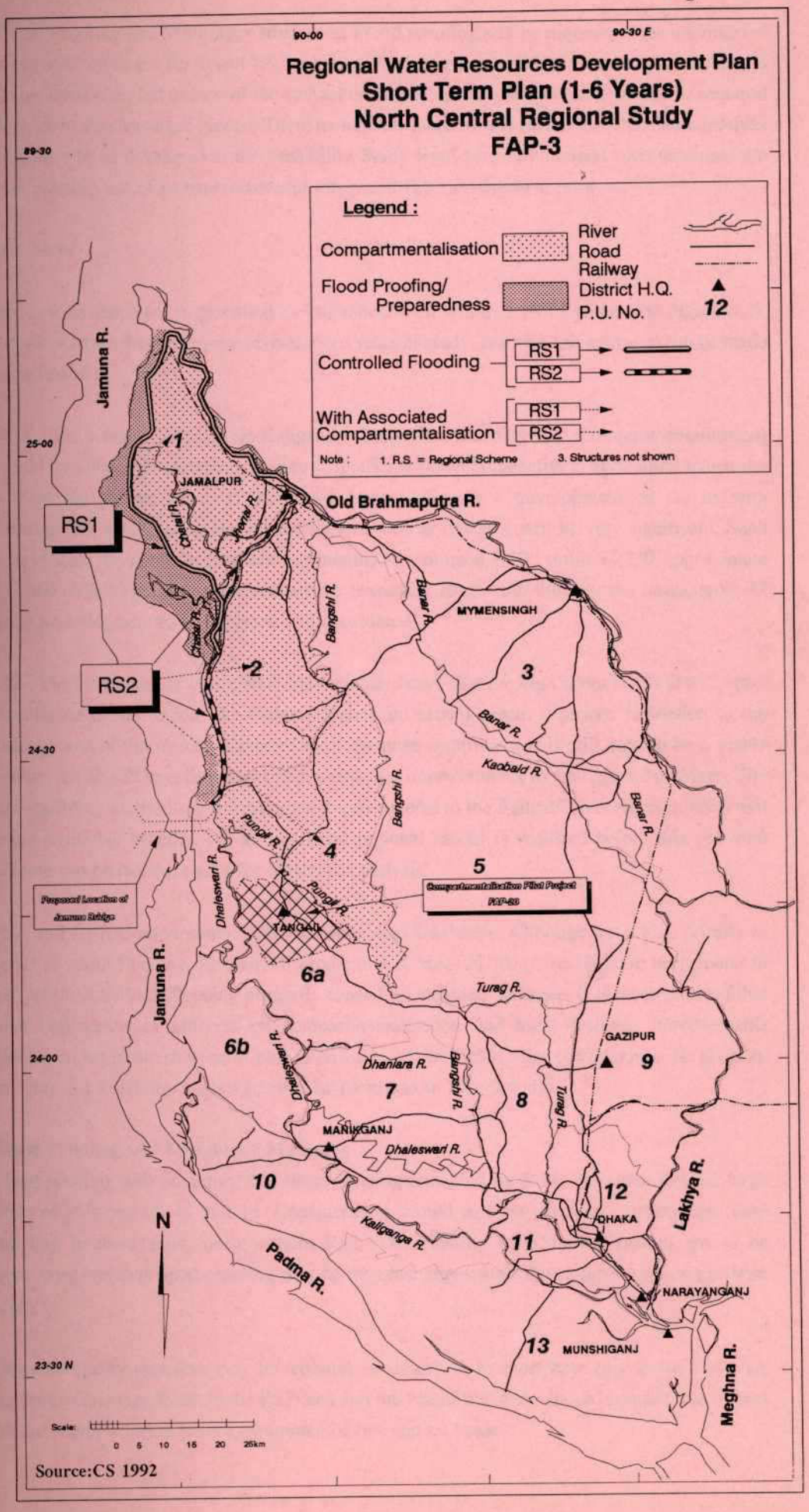
The schemes included in this category are :

(i) **RS1b (FAP 3.1).** RS1 was identified in the early stage of the FAP during 1990 as a priority project and the feasibility study for this scheme, the Jamalpur Priority Project is already under way. The FAP 3.1 schedule is to complete project preparation by 1993, thus allowing for implementation to begin in 1994 (Year 2).

(ii) **RS2.** Significant structural elements of the RS2 (Jamalpur to Bhuapur Development) are already in place. The main control embankments consisting largely of the existing railway embankment (from Jamalpur to Jagannathganj) and the existing BWDB embankment from Jagannathganj to Bhuapur. (The Jamalpur Fertilizer Co. are already funding further improvements, in 1992, to this embankment to be used as a road). The scheme complements the development of RS1b and will also benefit from control to be made under RS1b on Baushi and the Jhenai Bridges.

The significant benefits envisaged from this scheme result from the compartmentalisation that would be developed in the area. The findings of the adjacent FAP 20 Tangail compartmentalisation project will be relevant in this respect.

Figure : S.1



Source:CS 1992

(iii) **Flood Proofing and Mitigatory Measures.** Flood proofing will be required in the unprotected areas adjacent to the RS1b and RS2 schemes. This consists mainly of the char land area and active flood plain left outside of the embankments. Other mitigatory measures may be required for certain disadvantaged groups. There include the landless and fishermen. Detailed initiatives will have to be developed at the Feasibility Study level and may include such measures are multipurpose use of embankments and integrated fish development projects. Figure 6.2

Medium Term

Medium term development is classified as implementation within 7 to 15 years (see Figure S.2). These medium term schemes require several more years of study, before a fair appraisal can be made on their advisability. 6.5.6 Figure 6.3

(i) **RS3.** This scheme (Dhaleswari-Kaliganga Controlled Flooding and Compartmentalisation) would be a major development. It shows significant potential benefits to agriculture indicating a large net present value. However the impact of such a development on the existing environment, nearby areas and related sectors such as fisheries will be very significant. Such a large scale development (engineering funding is estimated at Tk. million 2730, approximate US $60 million) requires a comprehensive feasibility study, and time for the implications of such a development to be analysed and considered.

(ii) **RS4.** The investigations of regional drainage has shown that the high water levels at the south-east corner of the region (the Padma-Meghna influence) create a serious restriction to the drainage out of the region. Although local drainage improvement is still seen to be a viable option, see (iii), there is limited scope for effective improvements to the regional drainage. The pre-feasibility studies have revealed that improvements to the Bangshi river (scheme RS4) will bring justifiable benefits, but an improved regional model is required before this potential scheme can be recommended for feasibility analysis.

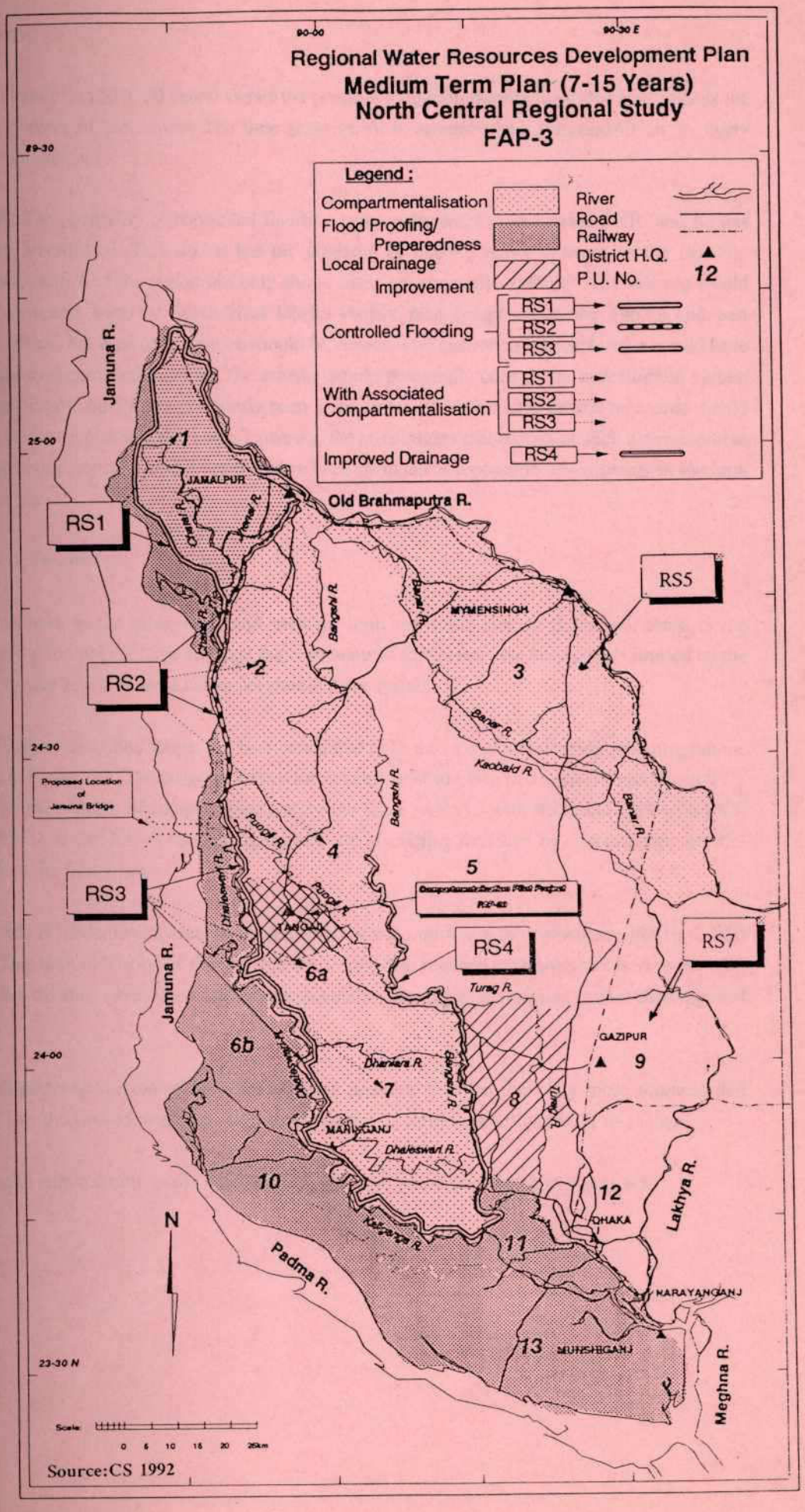
(iii) **RS5 and RS7, Compartmentalisation and Local Drainage.** Although not a high priority in terms of major flooding, agricultural production in areas of PUs 3 and 8 have been found to be hampered by local flooding primarily caused by impeded drainage. It is recommended that after observation of progress on compartmentalisation and local drainage improvements recommended in the short term plan (FAPs 20, 3.1 and RS2), that consideration be given to carrying out feasibility studies for similar programs in PUs 3 and 8.

(iv) **Flood Proofing and Mitigatory Measures**

Flood proofing will be required in those areas unprotected by RS3. This may include large areas of PUs 6b, 10, 11 and 13. Consideration should also be given to carrying out flood proofing in these areas, even without RS3. The viability of RS6 (see below) has to be questioned and thus flood proofing may be the most appropriate development option for these areas.

Other mitigatory measures may be required, as described in short term (iii) above. Fisheries are particularly significant in the RS3 area and the feasibility study should consider the impact on this sector in detail before recommendations can be made.

Figure S.2


Regional Water Resources Development Plan
Medium Term Plan (7-15 Years)
North Central Regional Study
FAP-3
Legend :
Compartmentalisation
Flood Proofing/ Preparedness
Local Drainage Improvement
River
Road
Railway
District H.Q.
P.U. No.
Controlled Flooding
With Associated Compartmentalisation
Improved Drainage
RS1
RS2
RS3
RS4
RS5
RS7
Jamuna R.
Old Brahmaputra R.
JAMALPUR
MYMENSINGH
GAZIPUR
DHAKA
NARAYANGANJ
MUNSHIGANJ
MANIKGANJ
TANGAIL
Padma R.
Lakhya R.
Meghna R.
Proposed Location of Jamuna Bridge
90-00
90-30 E
89-30
25-00
24-30
24-00
23-30 N
N
Source:CS 1992

Long Term 6.5.6

The long term plan (16 to 30 years) shows the possible long term development that best utilises the natural resources of the region. The time scale given is arbitrary being dependent on so many unpredictable factors. Figure 6.4

(i) **RS6.** The possibility of controlled flooding being extended to incorporate PU10 and 6b has been investigated. This option has the potential of making major changes to the flooding characteristics of the region but only shows marginal economic viability. The scheme would be consistent with the South-West Dhaka Project plan (proposed in the 1960's and part completed) but is an option which should be viewed with caution as if completed it would have major environmental impacts. The scheme would potentially change the hydrological system dramatically. Advice has previously been given (FAP 1990) that such drastic measures should not be contemplated at this stage. However, the possibilities still remain of such a development becoming practicable and it has therefore been included as a possible development in the long term plan.

(ii) **Other Measures**

In addition to the other short and medium term measures already described, there is the potential for making local drainage improvements to PU9. However this again is limited by the high water levels in the Lakhya-Meghna-Padma system.

The RWRDP, as described above, has been scheduled to fit into a regional development programme as shown in Figure S.3. The program allows for development to place in a logical sequence and for maximising the benefits of complementary activities (such as RS1b with RS2; and RS4 with RS3) where possible. It also allows for making the best use of existing facilities, by concentrating on RS2 and RS1b in the first years.

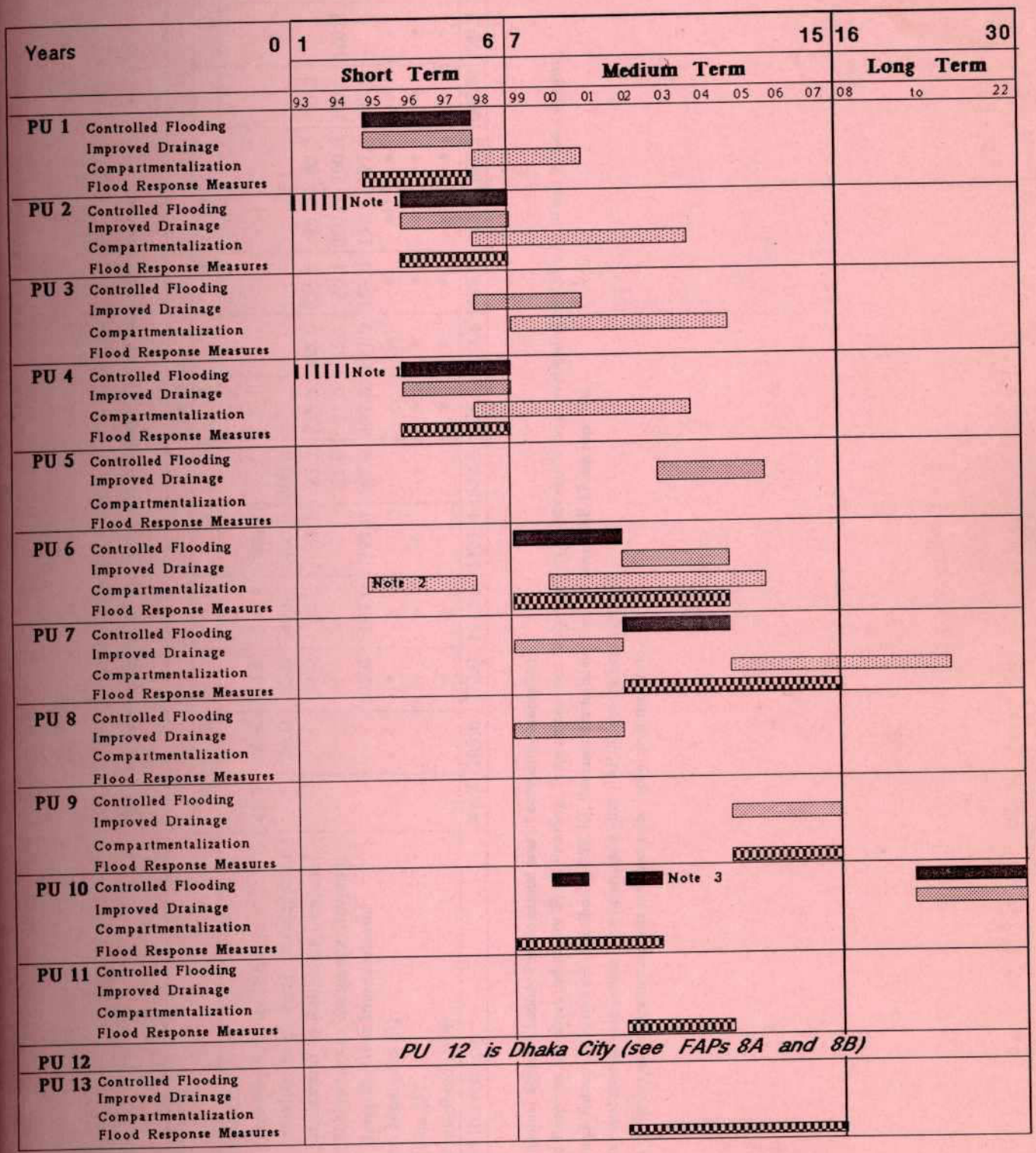
The schedule is fundamentally one of implementation from upstream to downstream (RS1b to RS2 to RS3). This is an indication of the fact that the worthwhile regional initiatives are seen to be those of controlled flooding (with associated compartmentalisation and local drainage) rather than regional drainage.

An overall planning horizon of 30 years has been used for the plan, but only those schemes that would fit into the first 15 years are considered worthy of further investigation at this stage.

The financial requirements in the medium term (first 15 years) are shown in Table S.1.

Figure : S.3

Regional Water Resources Development Plan- Programme



Controlled Flooding

Improved Drainage

Compartmentalization

Flood Response Measures (e.g. flood proofing/preparedness/early warning)

Note :

1. Existing BWDB embankment is to be improved by RHD under funding from Jamuna Fertiliser Factory in 1992/93.
2. FAP 20's compartmentalisation is expected to be implemented in PU6
3. Embankment works will be needed associated with developments on the Dhaleswari-Kaliganga in PUs 6 & 7.

Source:CS 1992

TABLE S.1

Financial Requirements of the Short and Medium Term Plans (Tk. million)

Description of Works		Plan Year															Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	(Tk.ml.)
Regional Schemes (1)																	
RS1	Jamalpur Priority Project	41.7	69.6	500.8	500.8	500.8											1613.5
RS2	Jamalpur to Bhuapur Development		36.0	60.0	400.0	400.0	400.0										1296.0
RS3-Phase 1	Dhaleswari to Kaliganga Devpmnt.			14.2	14.2	23.7	23.7	255.5	255.5	255.5	85.2	85.2	85.2				1097.8
RS3-Phase 2	Dhaleswari to Kaliganga Devpmnt.						21.6	21.6	36.1	36.1	360.6	360.6	360.6	120.2	120.2	120.2	1557.9
RS4	Bangshi River Improvement			197.0	197.0	197.0	197.0	197.0	197.0	197.0	197.0	197.0	197.0				1969.9
Flood Response Measures (2)				*	*	*	*	*	*	*	*	*	*	*	*	*	Note (2)
Fishery Initiatives (3)				*	*	*	*	*	*	*	*	*	*	*	*	*	Note (3)
Institutional Strengthening (4)				*	*	*	*	*	*	*	*	*	*	*	*	*	Note (4)
Total Financial Requirement		41.7	105.6	772.0	1112.0	1121.4	642.3	474.2	488.6	488.6	642.8	642.8	642.8	120.2	120.2	120.2	7535.3

Notes: 1. The Regional Schemes include for the capital cost of compartmentalisation

2. * Flood Response Measures include for Flood Proofing, Preparedness and Early Warning. Costs should be determined after FAPs 10,14 and 23 have reported.

3. * Although fishery initiatives are described in PSR III, the costs are to be determined after FAP 17 has reported.

4. * Institutional strengthening costs to be determined after FAP 20 and 26 have reported.

5. Annual operation and maintenance costs have not been included in the Table.

Figure : 1.1

The Study Area

Source:CS 1992

CHAPTER 1
THE NORTH CENTRAL REGIONAL STUDY

1.1 General

1.1.1 Introduction

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 shows the Study Area of the North Central Regional Study and its location within Bangladesh.

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, FPCO 1990).

1.1.2 Flood Action Plan

The NCRS forms component three (FAP-3) of the Flood Action Plan. The Flood Action Plan comprises more than twenty-six components and supporting activities (see Table 1.1) and is being coordinated 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 focuses initially on:-

- measures to control flooding and improve drainage in areas bordering the main rivers, the regional 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.

The North Central Regional Study is one of several studies which need to be undertaken during the first stage of the Flood Action Plan. The initial stages of the Plan are designed as an integrated series of studies which in the most part are self complementary. Close co-operation is essential between the various FAP studies both in terms of reporting and in terms of personal interaction to maximize the benefits to be achieved from the studies.

The outcome of the supporting studies have been used where available in the development of the North Central Region Water Resources Development Plan, see Table 1.1.

The main focus of the Flood Action Plan is that defined in the Eleven Guiding Principles which are listed in Table 1.2. These provide the framework for the development planning being undertaken.

TABLE 1.1
FAP Studies and their 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]
2	North West Regional Study	Boundary conditions, comparative analysis and riverine areas
3	North Central Regional Study	This study
3.1	Jamalpur Priority Project	Priority Project within the Study Area
4	South West Area Water Management Study	Boundary conditions, comparative analysis and riverine areas
5	South East Regional Study	Boundary conditions, comparative analysis and riverine areas
6	North East Regional Study	Boundary conditions, comparative analysis and riverine areas
7	Cyclone Protection Project	Experience from construction programme
8A	Greater Dhaka Protection Project	Flood Protection works interface on NCRS system.
8B	Dhaka Integrated Flood Protection Project	Flood Protection works on NCRS River System.
9A	Secondary Towns Protection Project	Only 3rd priority towns are within North Central study area. These are Mymensingh, Jamalpur and Manikganj.
9B	Meghna Left Bank Protection Project	Adjacent to and within NCRS area
10	Flood Forecasting & Early Warning Project	Proposals made by FAP-10 will need to be integrated with the formulation of developments in NC Region.
11	Disaster Preparedness Programme	Proposals made by FAP-11 will need to be integrated with the formulation of developments in NC Region.
12	FCD/I Agricultural Review	Indication of impact of FCD/I schemes
13	Operation & Maintenance Study	Identify constraints and give guidelines for O&M
14	Flood Response Study	Guidelines on effective flood response measures
15	Land Acquisition and Resettlement Project	Guidelines and procedures for Land Acquisition and Resettlement
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 activities to provide topographic mapping, aerial photographs and satellite imagery 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	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 Jamuna 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.

TABLE 1.2

The Eleven Guiding Principles

1. Phased implementation of a comprehensive Flood Plan aimed at:
   - protection of urban, rural, commercial, industrial and public utility centres and communication networks;
   - controlled flooding, wherever possible and appropriate, to meet the needs of agriculture, fisheries, navigation, urban flushing, soil productivity and recharging the surface water and groundwater resources with minimum dislocation of the environment.
2. Effective land and water management of protected and unprotected areas, involving compartmentalisation, drainage, irrigation, drainage decongestion, land use, cropping patterns, environment, ecology, erosion/sedimentation control etc.
3. Strengthening and equipping the disaster management machinery including building infrastructure for quick and effective communication and transmission during disasters.
4. Improvement of the flood forecasting system and establishment of a reliable and comprehensive flood warning system with adequate lead times and at the same time evolving techniques for dissemination.
5. Safe conveyance of the large cross-boundary flow to the Bay of Bengal by channelling it through the major rivers with the help of embankments on both sides.
6. Effective river training works for the protection of embankments, infrastructure and population centres, linked wherever possible with the reclamation of land in the active river flood plain.
7. Reduction or distribution of land on the main rivers through diversion of flows into major distributaries or interception of local runoff/local rivers by channelling through major tributaries or special diversions.
8. Improvement of the conveyance capacity of the river networks to ensure efficient drainage through appropriate channel improvements and ancillary structures to provide regulation and conservation.
9. Development of flood plain zoning as a flexible instrument to accommodate necessary engineering measures and allocate space for habitation patterns, economic activities and environmental assets.
10. Coordinated planning and construction of all rural roads, highways and railway embankments with provision for unimpeded drainage.
11. Encouraging maximum possible popular participation by beneficiaries in the planning, implementation, operation and maintenance of flood protection infrastructure and facilities.

1.1.3 National Planning

The North Central Regional Study and the Flood Action Plan should be viewed in the context of the national objectives for development of agriculture and water resources. These objectives are stated in the current Five Year Plan and have been developed further in the National Water Plan Project (MPO 1991).

The major national objectives defined in the Government of Bangladesh's Fourth Five Year Plan (1990-1995) are:

- Growth in national income
- Alleviation of poverty and generation of employment
- Increased self reliance.

The FFYP is a comprehensive document and emphasises community participation and decentralised planning and the need to bring women into the mainstream of the development process. It includes a firm commitment to expanding the role of the private sector in economic development. It also recognises the urgency of preserving and improving the environment. The objectives defined for agriculture, flood control and water resources development are summarised below:

Agriculture - Objectives

- Self sufficiency
- Sustained agricultural growth through more efficient and balanced use of the country's land, water and other natural resources
- Diversification of agricultural production, especially to improve nutritional standards
- Increased foreign exchange earnings through agricultural exports
- Containing areas under cereals (especially rice) within the limits of soils and ecological balance, to release land progressively for other crops, while achieving cereal production targets through increases in yields
- Reduction of rural poverty and promotion of income equality between socio-economic groups and between regions
- Promotion of economic and employment opportunities and access to resources such as credit for landless and small farmers and other disadvantaged groups.

Agriculture-Strategy

- Appropriate rehabilitation, maintenance and management of existing projects
- Efficient planning, effective implementation and appropriate operation and management of schemes
- Selection of appropriate projects and programmes
- Maximisation of crop yields
- Development of less risky areas
- Improvement of farming practices, taking account of the agro-ecological conditions
- Proper crop diversification, with less reliance on cereal crops.

Policies in support of this strategy are intended to encourage a high input/high output agriculture, as the means of generating rates of growth of agricultural production which will exceed the rate of population growth. The strategy emphasises privatisation, particularly with regard to the supply of inputs, and the need for more competitive markets both for inputs and for products.

Fisheries - Objectives

- Raise production and increase availability to improve nutrition
- Expand employment opportunities in fisheries
- Improve socio-economic conditions of those in the fisheries sector
- Increase fishery exports
- Improve general environment and public health
- Help increase GDP

Fisheries - Strategies

- Improve inland open water stocking and management
- Continue protection and conservation of fisheries resources and habitats
- Improve the leasing system
- Develop aquaculture
- Support fish seed production
- Support shrimp seed production
- Encourage production of shrimp and fish feed
- Control marine fisheries development
- Establish good access for fish landing, postharvest technology and marketing
- Encourage welfare and community development through granting fishing rights, providing required materials and implementing measures to ensure security of boats, equipment etc.
- diversify fishery exports
- allow imports for fish culture
- encourage liberalisation of the credit system
- support research, surveys and studies, education, training and extension
- improve the fisheries data base and information system
- strengthen the planning, implementation, monitoring and evaluation of the MFL,DOF,FRI & BFDC

1.1.4 Flood Control Drainage and Irrigation Schemes

Planning and implementation of Flood Control, Drainage and Irrigation Schemes (FCD/I) has been carried out over many years in the NCR. An inventory of existing schemes and previously proposed schemes is given in Table 1.3 and shown on Figure 1.2. The NCRS does not necessarily agree with the viability or practicality of implementing these schemes, but they are included as a reference.

Previous national studies have proposed water resources developments for the North Central Region. In particular the National Water Plan (MPO 1991) and the 1960's Master Plan report (IECO 1964) have been a base reference for this study. The IECO report proposed 4 major projects in the North Central Region:-

- the Old Brahmaputra Project
- the Dhaka Southwest Project
- the Dhaka North Irrigation Project
- the Dhaka-Narayaganj-Demra Project

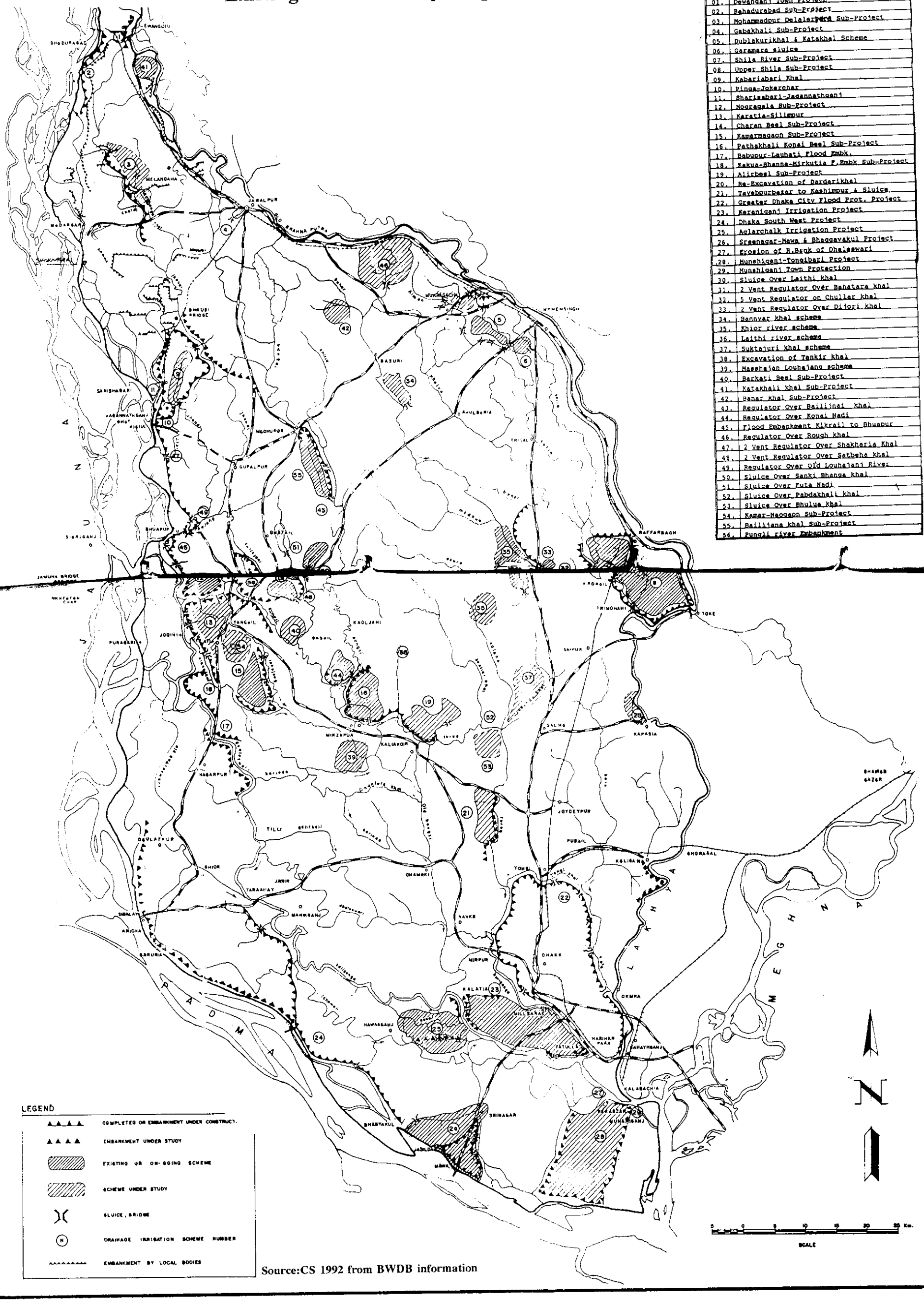
Flood Control and Water Resources - Objectives

- Rapid increase of irrigated areas to sustain technological transformation
- Provision of supplementary irrigation facilities, with complementary flood control and drainage measures and utilising other resources to improve crop yields and production, particularly in the kharif season.
- Regulation and control of floods, drainage, salinity, tidal water inundation, river erosion and other physical damages and human sufferings
- Promotion of efficient use of water resources in respect of time and spatial location, through emphasis on inter-basin water balances and optimal cropping patterns, without causing harmful environmental effects
- Generation of productive employment opportunities for rural people to ensure an equitable distribution of the benefits of development.

Flood Control and Water Resources - Strategy

- Bring shallow - and medium-flooded land under controlled flooding, through construction of dykes and polders with regulators and complementary structures, in order to permit development of environmentally desirable, integrated agriculture and aquaculture
- Construct dwarf submersible embankments in suitable deep-flooded areas to permit safe harvesting of winter crops
- Improve drainage
- Introduce comprehensive analysis of flood control and drainage or flood control drainage and irrigation (FCD/FCDI) projects, with social costs and full accounting for externalities and linkages
- Improve the quality and speed of implementation of schemes in order to achieve targeted changes in the land/water environment according to planned schedules
- Create an appropriate institutional framework for the operation and maintenance of schemes on a self-sustaining basis
- Assign the responsibility for maintenance/management of small schemes to local bodies, and correct institutional and management deficiencies at the field level
- Emphasise rehabilitation of existing projects, in the light of past experience, in order to increase their effectiveness
- Focus new projects on short-gestation, cost-effective schemes
- Emphasise implementation of existing large-scale projects through a modular approach
- Maximise local participation in projects at all stages, from formulation through to implementation and maintenance.

Existing and Previously Proposed FCD/I Schemes



Legend

Sl. No.	Name of Project
01.	Dewangani Town Project
02.	Bahadurabad Sub-Project
03.	Mohammadpur Delalerpara Sub-Project
04.	Gabakhali Sub-Project
05.	Dublakurikhal & Katakhal Scheme
06.	Garamara sluice
07.	Shila River Sub-Project
08.	Upper Shila Sub-Project
09.	Kabaribari Khal
10.	Pinga-Jokarchar
11.	Sharisabari-Jagannathganj
12.	Mogragala Sub-Project
13.	Karatia-Silimpur
14.	Charan Beel Sub-Project
15.	Kamarmagaon Sub-Project
16.	Pathakhali Konai Beel Sub-Project
17.	Babupur-Lauhati Flood Embk.
18.	Kakua-Bhanna-Mirkutia F.Embk Sub-Project
19.	Alirbeel Sub-Project
20.	Re-Excavation of Dardarikhal
21.	Tavebpurbazar to Kashimpur & Sluice
22.	Greater Dhaka City Flood Prot. Project
23.	Keraniganj Irrigation Project
24.	Dhaka South West Project
25.	Aglarchalk Irrigation Project
26.	Sreenagar-Mawa & Bhaggavakul Project
27.	Erosion of R.Bank of Dhaleswari
28.	Munshiganj-Tongibari Project
29.	Munshiganj Town Protection
30.	Sluice Over Laithi Khal
31.	2 Vent Regulator Over Bahatara Khal
32.	5 Vent Regulator on Chullar Khal
33.	2 Vent Regulator Over Dijori Khal
34.	Bannyar Khal scheme
35.	Khior river scheme
36.	Laithi river scheme
37.	Suktajuri Khal scheme
38.	Excavation of Tankir Khal
39.	Masshajan Louhajang scheme
40.	Barkati Beel Sub-Project
41.	Katakhali Khal Sub-Project
42.	Banar Khal Sub-Project
43.	Regulator Over Bailijnai Khal
44.	Regulator Over Konai Nadi
45.	Flood Embankment Kikrail to Bhuapur
46.	Regulator Over Rough Khal
47.	2 Vent Regulator Over Shakheria Khal
48.	2 Vent Regulator Over Satbeha Khal
49.	Regulator Over Old Louhajani River
50.	Sluice Over Sanki Bhanga Khal
51.	Sluice Over Futa Nadi
52.	Sluice Over Pabdakhali Khal
53.	Sluice Over Bhulua Khal
54.	Kamar-Naogaon Sub-Project
55.	Bailijana Khal Sub-Project
56.	Pungli river Embankment

LEGEND

- COMPLETED OR EMBANKMENT UNDER CONSTRUCT.
- EMBANKMENT UNDER STUDY
- EXISTING UR ON-GOING SCHEME
- SCHEME UNDER STUDY
- SLUICE, BRIDGE
- (N) DRAINAGE IRRIGATION SCHEME NUMBER
- EMBANKMENT BY LOCAL BODIES

Source:CS 1992 from BWDB information

Figure 1.2

Existing and Previously Proposed FCD/I Schemes

TABLE 1.3
List of Water Development Projects in North Central Region area FAP-3

Sl. No.	Name of Project	Type	PU No.	District	Upazila	Status	Area Bene-fited(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		1.17	21.95	3.50	4.88	Remaining parts Partly washed
02.	Bahadurabad Sub-Project	Flood Embk.	1	Jamalpur	Islampur	C		7.50		3.50		away by Jamuna River
03.	Mohammadpur Delalerpara Sub-Project	Embankment	1	Jamalpur	Melandaha	C	60.70	14.30	19.50	4.50	4.30	
04.	Gabakhali Sub-Project	Embankment	1&2	Jamalpur	Jamalpur	C	3.84	14.25	17.59			
05.	Dublakurikhal & Katakhal Scheme	FCDI	3	Mymensingh	Muktagacha	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	Sharisabari	OG	7.21	11.00				Completed 1989-1990
10.	Pigna-Jokerchar	Flood Embk.	2	Tangail	Bhuapur	C	84.00	37.00	15.30	3.25	4.25	
11.	Sharisabari-Jagannathganj	Embankment	2	Jamalpur		P						
12.	Mogragala Sub-Project	FCD	6	Tangail	Tangail	P		25.00				Postponed
13.	Karatia-Silimpur	Flood Embk.	6	Tangail		C	40.00	40.00	14.85	3.00	4.30	SSFCDI 1983-1984
14.	Charan Beel Sub-Project	FCD	4	Tangail	Kalihati	C	14.17	42.00	11.58	2.70	4.30	Completed 1983-1984
15.	Kamarmagaon Sub-Project	Flood Embk.	6	Tangail	Delduar	C	62.75	23.00	10.20	2.00	4.30	Completed 1990-1991
16.	Pathakhali Konai Beel Sub-Project	Embankment	5	Tangail	Mirzapur	C	25.00	15.00	11.40	2.50	4.30	Completed 1982-1983
17.	Babupur-Lauhati Flood Embk.	Flood Embk.	6	Tangail	Delduar	C	41.00	20.00	13.50	3.20	4.30	
18.	Kakua-Bhanna-Mirkutia F.Embk Sub-Project	Flood Embk.		Tangail	Tangail	P						Under F.C.
19.	Alirbeel Sub-Project	D	5	Gazipur,Tangail	Kaliakair,Mirzapur	OG	41.20					Dropped
20.	Re-Excavation of Dardarikhal	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 Munshiganj		OG	971.66	178.00				Completed embankment 72 km Reg. 2 Nos. Pipe sluice 9, completed
25.	Aglarchalk Irrigation Project	FCI	13	Dhaka	Nowabganj	P		19.00				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 1.3 continued
List of Water Development Projects in North Central Region area FAP–3

Sl. No.	Name of Project	Type	PU No.	District	Upazila	Status	Area Bene-fited(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.	Bannyar khal scheme	FCD	3	Mymensingh	Muktagacha	OG						
35.	Khiro river scheme	FCD	3	Mymensingh	Bhaluka	OG						
36.	Laithi river scheme	FCD	5	Mymensingh	Bhaluka	OG						
37.	Suktajuri khal scheme	FCD	5	Mymensingh	Bhaluka	OG						
38.	Excavation of Tankir khal	D	5	Tangail	Kalihati	C	7.73					Completed 1967-68
39.	Mashajan Louhajang scheme	FCD	6	Tangail	Mirzapur	C	20.23	18.32	11.28		5.48	Completed 1982-83
40.	Barkati Beel sub-project	FCD	6	Tangail	Basail/Mirzapur	C	3.73	2.53				Completed 1985-86
41.	Katakhali khal sub-project	FCD	1	Jamalpur	Islampur	C	2.83	12.90	16.77		4.87	Completed 1982-83
42.	Banar khal sub-project	FCD	3	Jamalpur	Islampur	C	2.89					Completed 1980-81
43.	Regulator Over Bailjani khal	FCD	5	Tangail	Ghatail	C	10.12					Completed 1982-83
44.	Regulator Over Konai Nadi	FCD	5	Tangail	Mirzapur	C	8.09		10.37		3.66	Completed 1983-84
45.	Flood Embankment Nikrail to Bhuapur	Embk.	4	Tangail	Bhuapur	C	35.62	35.62	15.24	15.09		Completed 1983-84
46.	Regulator Over Rouh khal	FCD	1	Jamalpur	Melandah	C	8.09					Completed 1986-87
47.	2 Vent Regulator Over Shakharia khal	FCD	2	Tangail	Gopalpur	C	28.32		16.16		4.27	Completed 1986-87
48.	2 Vent Regulator Over Satbeha khal	FCD	4	Tangail	Kalihati	C	19.42		9.76		4.27	Completed 1986-87
49.	Regulator Over Old Louhajang River	FCD	2	Tangail	Bhuapur	C	32.38					Completed 1987-88
50.	Sluice Over Sanki Bhanga khal	FCD	4	Tangail	Ghatail	C	10.52					Completed 1983-84
51.	Sluice Over Futa Nadi	FCD	4	Tangail	Ghatail	C	4.86					Completed 1980-81
52.	Sluice Over Pabdakhali khal	FCD	5	Tangail	Mirzapur	C	4.86					Completed 1981-82
53.	Sluice Over Bhulua khal	FCD	6	Tangail	Mirzapur	C	6.07					Completed 1981-82
54.	Kamar-Naogaon sub-project	FCD	6	Tangail	Delduar	C	62.75		9.76	1.70	4.27	Completed 1990-91
55.	Bailjana khal sub-project	FCD	5	Tangail	Ghatail	OG	10.12	7.50	14.00	2.50	4.26	
56.	Pungli River Embankment	Embk.	4	Tangail	Kalihati	P						

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

C:\123\INTERIM\TAB-2-19.WK1

These have been considered in the course of our studies but they are all mainly surface water irrigation projects and have been modified in subsequent plans to concentrate more on flood control and drainage as well as utilisation of the groundwater resources.

The National Water Plan (MPO 1991) is of more relevance to the present study and the contents appropriate to the North Central Region. The North Central Region as defined in the present study falls within the North East region of the National Water Plan (NWP) and covers the MPO planning areas 15,16,17 and parts of 18 and 30 (see Figure IX.2.1 in PSR IX). The NWP proposes development through increasing flood protection, improving drainage and increasing groundwater development. Some surface water development is recommended but this is minor in comparison to the proposed increase in groundwater irrigation.

The surface water developments proposed in the NWP are as follows:-

Minor irrigation
- the Keranigjanj and Aglarchalk Irrigation projects located along the Dhaleswari river and amounting to 11,000 and 8,000 ha respectively, currently being completed using LLP's
- the North Rupganj water conservancy project is completed and irrigates some 2700 ha from LLPs with water from the Lakhya river

Major irrigation
- 14,550 ha of surface irrigation using floating pumps in the left bank of the Jamuna river (this development would be considered under the feasibility studies proposed in the NCR plan).
- 21,000 ha of surface water development using floating pump irrigation from the ganges-Padma river in the area originally conceived as the Dhaka South West Project. The development would take place over 15 years with a pilot area of 4000 years in the fourth five year plan period.
- the Old Brahmaputra river valley project allows for irrigation of 62,000 ha from increased dry season inflow from the Brahmaputra river. 27,000 ha of this would be on the right bank of the Old Brahmaputra and in the North Central Region. However the NWP stresses that a detailed study of the offtaking characteristics of the Old Brahmaputra from the Brahmaputra-Jamuna (at Bhadurabad) is required and points out that the capital and recurrent costs required for ensuring that adequate offtaking flows are available may make this development recommendation not feasible.

Flood control and drainage (FCD) is the major development approach recommended for the NCR in the NWP and all of the NWP's FCD proposals have been considered in the course of preparing the present study. The NWP's proposals are described below:-

- the Brahmaputra Left Embankment and Drainage Development is planned to develop 120,900 ha (net) over the next 20 years. 23,000 ha is already identified and is being developed under the Kamarnaogan, Kabariabari and Bathuli subprojects along with the FAP 20 compartmentalisation area at Tangail. The NCRS plan (see Section 6.5.6) agrees with this recommendation and includes for FCD development in this area.
- the Greater Dhaka City Flood Protection covers some 26,000 ha and is presently being implemented with proposals as outlined by FAP's 8A and 8B.
- the NWP makes no firm recommendation about the Dhaka south west project, except to say that the FCD/I projects of Nagpur North, Kerniganj and Aglarchalk (covering 21,000 ha) should be developed as FCD/I schemes (see major irrigation above) and that a possible 70,000 ha of FCD should be considered for possible development by completing major embankments on the Padma and Dhaleswari rivers.

1.2 Phases of the NCR Study

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

Phase 2 of the North Central Regional Study commenced on March 8th, 1991, and is being jointly financed by the Commission of the European Communities (CEC) and the Government of France through Caisse Centrale de Cooperation Economique (CCCE).

The basic purpose of Phase 2 study is the preparation and evaluation of alternative water development strategies and the preparation of a regional water resources 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 resume of these are given below as applies to each report of the Study:

Inception Report

An Inception Report was prepared and submitted in May 1991 (NCRS 1991a). This was revised, at the request of the FPCO and re-submitted in July (NCRS 1991b). 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. Previous and on-going activities in the region were reviewed, including previous report of relevant studies, bridging period activities and other activities under the Flood Action Plan.

Interim Report/Draft Regional Water Resources Plan

Following the requirements of both the FPCO and the CCCE, a Draft Interim Report (DIR), (NCRS 1991c) was submitted in Mid-November, 1991, so that the preliminary findings of the Study could be promptly incorporated into the overall FAP, and in particular allow feedback relating to the priority projects.

The Comments from the FPCO and the donors on the Interim Report indicated that further clarification was required of the regional strategy and the justification of the Draft Regional Water Resources Development Plan. These comments were taken into account in the preparation of the Draft Regional Water Resources Plan (DRWRP), which was presented in March 1992 (NCRS 1992). The DRWRP report first gives an overview of development in the North Central Region and then summarises the selection of regional strategies, regional water resources planning process and presents a draft regional water resources plan.

Final Report

The final stage of this Phase 2 study elaborated and finalised the DRWRP and carried out pre-feasibility studies of the projects included in the draft plan. Draft Terms of Reference for two projects have been prepared in cooperation with the FPCO. The Final Report covers the requirements of Reports R4 and R5 of the contract. Supplementary to the DFR, there are a series of Supporting Reports SRs (see Table 1.4). These are more specialised but give supporting analysis to much of the information provided in the DFR.

TABLE 1.4

Supporting Reports

SR I	LAND RESOURCES AND AGRICULTURE
	I.1 Land Resources
	I.2 Agriculture
	I.3 Livestock and Forestry
	Annex I - Land Use
SR II	WATER RESOURCES
	II.1 Hydrometeorology
	II.2 River and Drainage System
	II.3 River Morphology
	II.4 Groundwater
	II.5 Hydraulic Model
SR III	FISHERIES
	III.1 Fishery Resources
	III.2 Fishery Initiatives
SR IV	HUMAN RESOURCES, SOCIO-ECONOMICS AND INSTITUTIONS
	IV.1 Population, Households, & Employment
	IV.2 Survey Result
	IV.3 Awareness and Project Interest
SR V	ENVIRONMENT
	V.1 Introduction
	V.2 Existing Environment
	V.3 Matrix Impact Assessment
	V.4 Impact Assessment of FCD Strategies
	V.5 Risk and Hazard Analysis
	V.6 Environmental Management Planning
SR VI	INFRASTRUCTURE AND EXISTING SCHEMES
	VI.1 General Infrastructure
	VI.2 Roads and Railways
	VI.3 Navigation
	VI.4 Hydraulic Infrastructures
	VI.5 Embankments
	VI.6 Flood Control, Drainage & Irrigation
	VI.7 Other Schemes in the NCR
SR VII	ENGINEERING
	VII.1 Earthworks and Embankments
	VII.2 Flood Control Structures
	VII.3 Topographic Survey
	VII.4 Engineering Costs
SR VIII	DEVELOPMENT OPTIONS
	VIII.1 Compartments/Embankments/Structures/Improved Drainage
	VIII.2 Flood Proofing/Fishery/Other Initiatives
SR IX	PLANNING UNITS
	IX.1 Derivation of Planning Units
	IX.2 PU Characteristics and Options
SR X	ECONOMIC AND MULTICRITERIA IMPACT ASSESSMENT
	X.1 Overview of NCR Development and Flood Control
	X.2 Economic Impact of Floods
	X.3 Agro-Economics
	X.4 Economic and Financial Analysis
	X.5 Multicriteria Analysis
	X.6 Conclusion

1.3 Other Activities of Particular Relevance to NCRS

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, see Table 1.1. The approach to planning and impact assessment also follows the guidelines on Project Assessment prepared by the FPCO (FPCO 1991b).

FAP 3.1

The Jamalpur Priority Project Study is being carried out concurrently with the latter half of the North Central Regional Study, Phase 2. The interaction between the two studies is important, and development strategies for the Jamalpur area must accord with the overall development strategies for the Region as a whole and thus 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 is being maintained between the two studies to ensure a coordinated approach to the work.

FAP 20

One of the two pilot areas for the Compartmentalisation Supporting Study (FAP 20) is located around Tangail, within the NCRS area. This study began in mid-1991 and is planned to continue for 4 years. The objective of the project is to test the compartmentalisation concept. The study addresses the complex social and environmental aspects of such local level development and carries out planning in close consultation with central and local government agencies and the public. The results of the study are critical to the future incorporation of the compartmentalisation concept within the regional plan. It is also important that FAP-3 does not negate the participatory approach. FAP-3 plans should complement rather than contradict the local planning approach.

Jamuna Bridge/Dhaleswari Mitigation Study

The go-ahead, in principle, has now been given for the construction of the Jamuna Bridge. The Jamuna Bridge Authority's (JMBA) plan to cut off the northern intake of the Dhaleswari has direct implications on the NCR and in particular the area around Tangail including the FAP 20 pilot area. The impact of the bridge on water levels and the river morphology is significant and thus the NCRS has to consider all possible development scenarios both with and without the Jamuna Bridge being implemented. The impact of the Jamuna Bridge on the environmental aspects is a complex issue and is beyond the scope of the present NCRS. The Dhaleswari Mitigation Study (JMBA 1991) has also investigated the impact of a guide bund downstream of the Jamuna Bridge. This has also been taken into consideration in the NCR planning process.

Jamuna Fertiliser Factory Road

The Jamuna Fertiliser Company (JFC) plans to facilitate access to their factory by improving the existing BWDB embankment from Bhuapur to the factory site at Tarakandi. The JFC is giving this a high priority and has started construction through the Roads and Highways Department in 1992. The road should assist with the control of flooding from the Jamuna for a 30km stretch of the river. The NCRS and the FPCO have communicated to the RHD the recommended formation level, see SR VI.6.

CHAPTER 2
REGIONAL OVERVIEW OF DEVELOPMENT AND FLOOD CONTROL

2.1 Introduction

The disastrous floods of 1987 and 1988 focused the world's attention on the problems of flooding in Bangladesh and flooding remains one of the major factors controlling food production of the North Central Region. A substantial proportion of the NCR is flooded every year (see Figure 2.1) and in years such as 1987 and 1988 the majority of the western and south-western floodplains are flood affected (see Figure 2.2).

The flooding and drainage situation is summarised in Section 2.2 below and is the primary factor to be affected by the proposed water resources development plan in Chapter 6. An overview of the other factors affecting development in the North Central Region is also given, considering related factors from land resources to socio-economics. The supporting data and analysis for this overview are given in the Supporting Reports (see Table 1.3).

Bangladesh is predominantly a flat deltaic plain which has been built up from the deltas of major river systems with quaternary sediments, alleviated in the recent Holocene era. The major rivers, namely the Ganges-Padma, Brahmaputra-Jamuna and the Meghna complex played the principal role in this process. The North Central Region (NCR) is directly affected by these three rivers. 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, this region supports many people, with the population growing fastest on the fertile land of the floodplain.

The general ground slopes in the area are from the north-west to the south-east, which is significant for the drainage in the area. The Jamuna Left Bank Floodplain (North Central Region) differs from the Right Bank Floodplain (North West Region) in that the Left Bank Floodplain slopes away from the river, thus the tendency for overbank spillage to occur onto the floodplain.

With a high population density the pressure on cultivable areas particularly on the floodplains and hydroclimatic constraints generate major socio-economic problems, see Section 3.4.

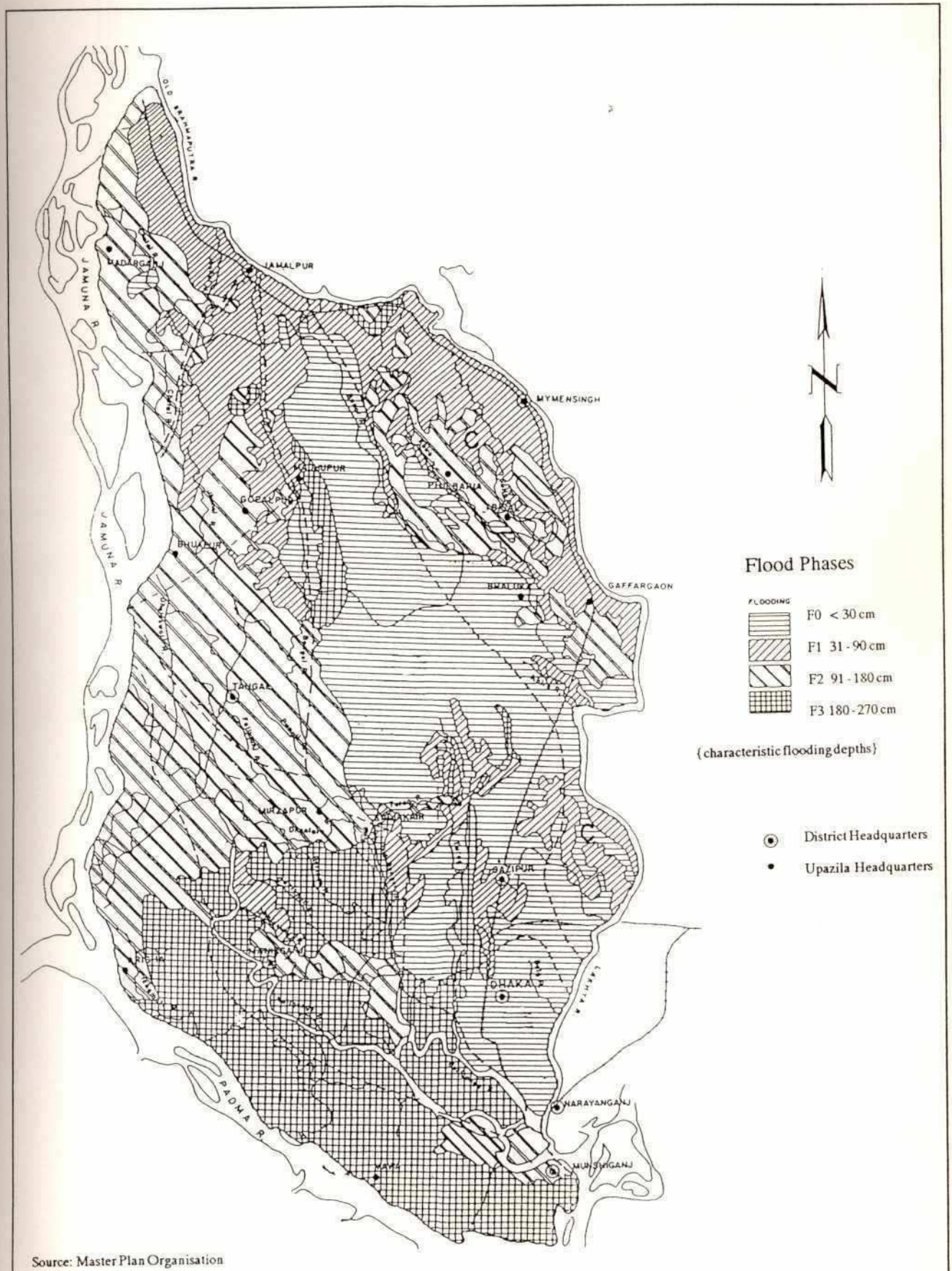
2.2 Flooding and Drainage

2.2.1 Flooding

Flooding in the North Central Region can occur from 3 sources: direct rainfall, direct overbank spillage from the major boundary rivers and overbank spillage from the internal regional rivers (see SR II.2). It is possible for each phenomenon to occur separately or in combination with any other, see Figure 2.3. The proportionate contributions of rainfall, Jamuna and local rivers varies between years and within flood seasons.

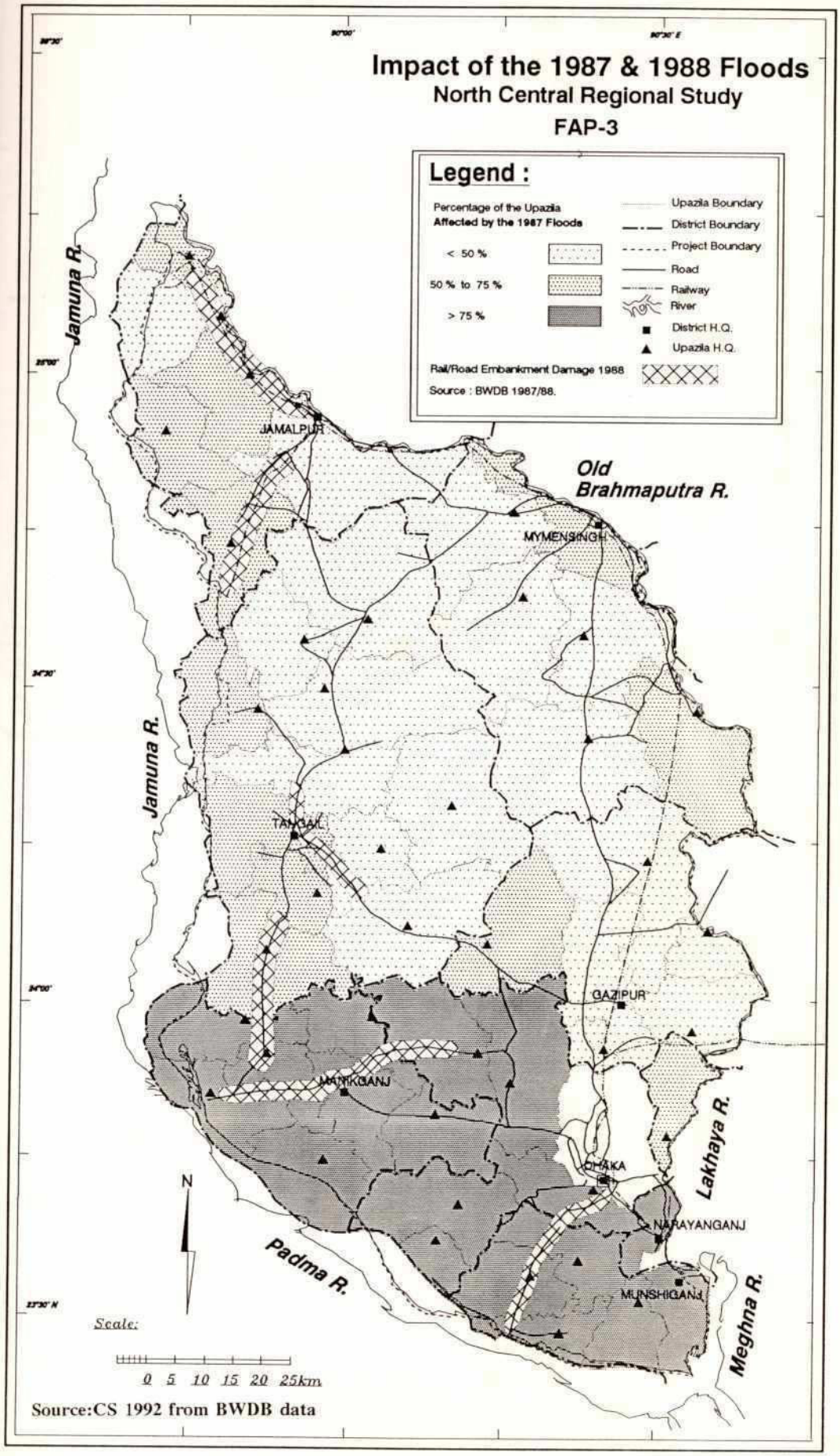
The pattern of river levels generally experienced in the region shows a 2-peaked response, the first peak being generated by internal regional rainfall excess, normally in June/July, and the second peak resulting from high cross-boundary flows in the major rivers, normally in early September (detailed hydrographs are given in SR II.3). The flood of 1988 was made worse by the unusual coincidence of peak floods in both the Jamuna and the Padma rivers whereas the 1987 floods resulted from unusually high regional rainfall together with high Jamuna/Padma river levels.

Figure : 2.1
Dominant Flood Phases



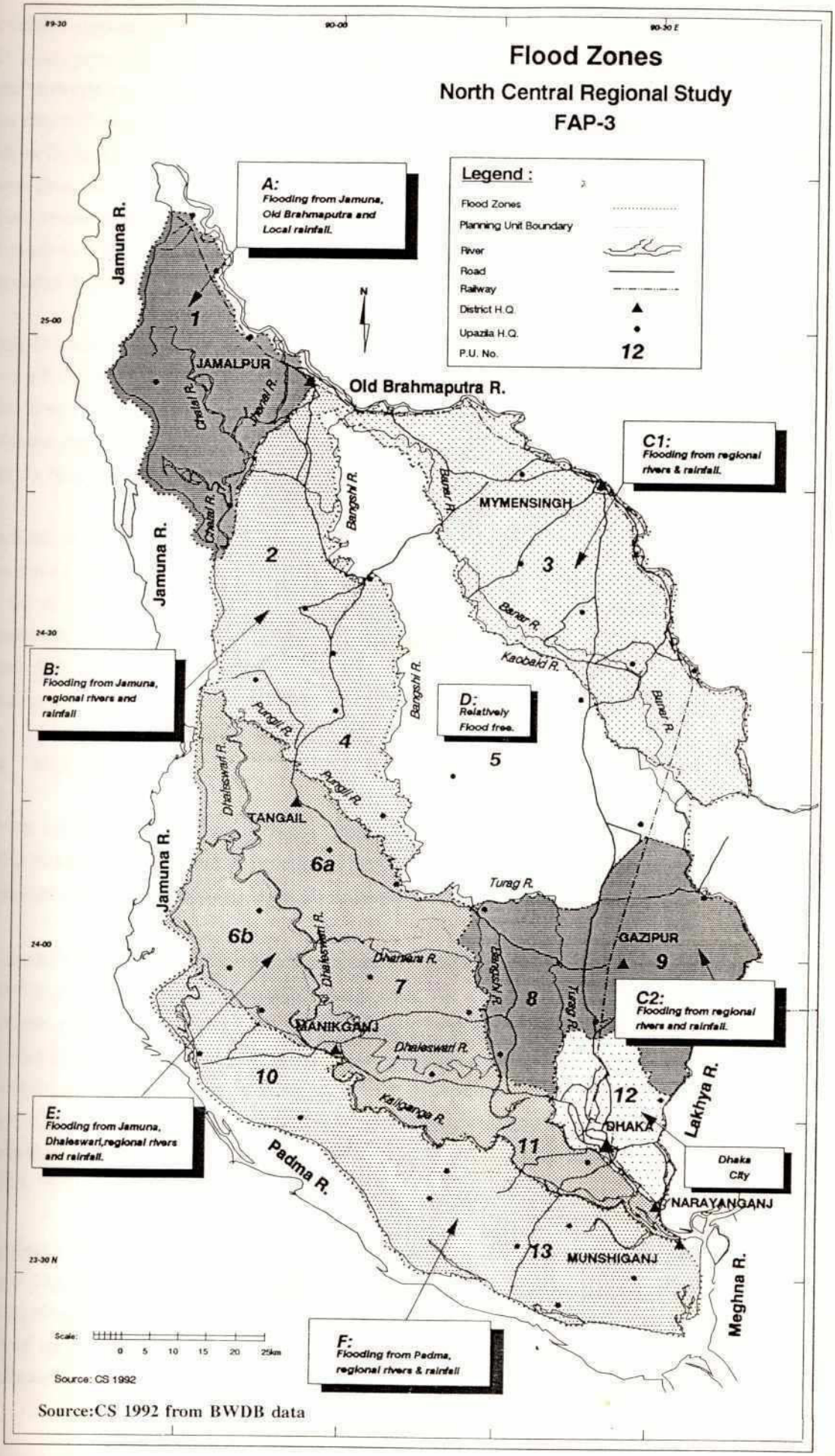
Source: Master Plan Organisation

Figure : 2.2



Source:CS 1992 from BWDB data

Figure : 2.3



Source:CS 1992 from BWDB data

The rainfall experienced within the region amounts to some 2000 mm per annum (decreasing from north-east to south-west), generally occurring over a 5-6 month period (see SR II.1). In consequence of this, large volumes of excess rainwater accumulate in the depressions and low-lying areas. During the pre-monsoon and monsoon seasons, (from May to October), the predominantly high water levels in the major boundary rivers coupled with the high water levels in the regional rivers conveying spills from the Jamuna, prevent the withdrawal of excess rainfall from the internal flood plains. As long as the commanding water levels in the boundary rivers remain high, the levels in the regional rivers also remain high and the removal of water from, (or transfer through), the region is severely inhibited. The Meghna-Padma at the south-east corner is tidal influenced, (see Figure 2.4 and SR II.2) and this causes further reduction of drainage in the Region, thus keeping flood levels high.

Ingress of floodwater from the Jamuna River can occur via direct overbank spillage, the precise location of which can vary from year to year, or through well-defined existing river channels which offtake from the Jamuna. Most of the direct overbank spill occurs between the northern intake of the Dhaleswari and the Dhaleswari offtake from the Jamuna some 30 kilometres to the south. The characteristics of this spillage will be changed by the proposed cut-off of the Northern Dhaleswari offtake for the construction of the Jamuna Bridge.

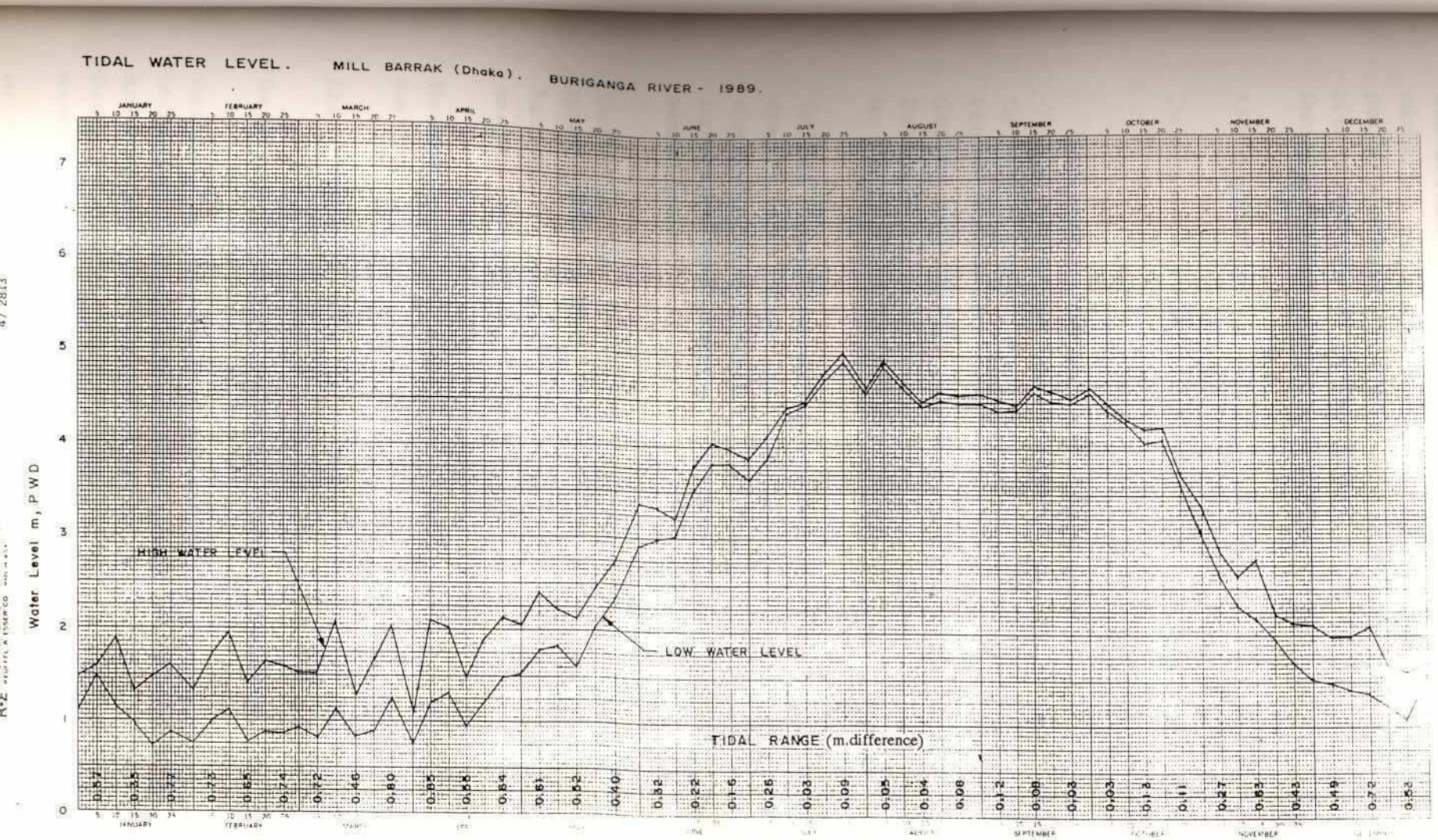
As a result of the inter-connection between the Jamuna River and the western rivers of the region, these regional rivers perform a dual function. During the monsoon season, when the water levels in the boundary rivers are high, they act as "conduits", transferring water from the Jamuna to the Meghna, with little or no spare capacity to accommodate accumulated floodwater resulting from rainfall excess. Indeed, the incapacity of some of the regional rivers to carry the required volume of overflow from the Jamuna serves only to exacerbate an already major flooding situation.

2.2.2 Major Rivers

The river and drainage system of the North Central Region is characterised and influenced by the 3 major rivers forming its boundary:- the Jamuna, Padma and the Old Brahmaputra-Lakhya-Meghna system. The hydrology and morphology of the NCR is detailed in SR II; a summary of which is given below.

The Jamuna River to the west of the project area carries runoff from the Himalayan mountain chain, passing through Nepal, Bhutan and Tibet before flowing into Bangladesh. The 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 1 kilometre in a single year. Some 200 years ago the Jamuna was a small regional river but the Brahmaputra changed its course leaving the Old Brahmaputra as a dying smaller distributary and choosing the Jamuna as its main course. The mean annual peak discharge of the Jamuna, calculated from measurements made at Bahadurabad, is approximately 67,000 cumecs, with the 1 in 100 year flood discharge estimated at 108,000 cumecs, (FAP-25, 1992).

The Padma River forms the southern boundary of the region and conveys both the waters of the Jamuna and the Ganges. The mean annual peak discharge at Baruria, (located just downstream of the confluence of the two rivers), is estimated at 88,000 cumecs and the 1 in 100 year discharge at 140,500 cumecs, (FAP-25 1992). At the south-east corner of the study area, the Padma combines with the Meghna to drain an area of some 1.55 million square kilometres in total, only a small percentage of which lies in Bangladesh.



Note: Water levels from Mid-July to end October show a tidal range of less than 15 cm in 1989. In a high flood level year (such as 1988) the tidal range is even less.

Conclusions:

1. There is little scope for improving drainage flows out of the region during the monsoon season in the south-eastern parts of the NCR (except with pumping).

2. Intra-drainage from elsewhere in the region has a limited impact on the high water levels already occurring in the SE region (the cause of high levels being mainly due to the Padma-Meghna not regional rivers) see PSR II.

Source:CS 1992 from BWDB data

Tidal Influence at SE of NCR

Figure : 2.4

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

2.2.3 Regional Rivers

The interior rivers may be categorised as falling into 3 distinct systems (see Figures 2.5 and 2.6)

- the Dhaleswari-Kaliganga system in the south-west
- the Bangshi-Turag system in the central part
- the Banar-Lakhya system in the eastern part

The Dhaleswari-Kaliganga system comprises the major distributaries of the left bank of the Jamuna, (Old Dhaleswari, Dhaleswari, and a number of un-named but significant spill channels), together with their distributaries, (Louhajang, Elangjani, Barinda). At a point some 48 kilometres downstream from its offtake from the Jamuna, the Dhaleswari bifurcates, the major channel now called the Kaliganga to the south of the diminished Dhaleswari. The two channels reunite at Kalatia, the Dhaleswari at this point having "captured" the Bangshi River.

The Bangshi-Turag system provides the central spine drainage of the region. It is fed partly by spill from the Jamuna through the Northern Dhaleswari intake via the Pungli River, partly by the accumulated runoff from the north-west of the region, (Jhenai River, Fatikjani River), and partly from the direct runoff into the Bangshi from the western slopes of the Madhupur Tract. Over recent years, the rainfall/runoff contribution from the Madhupur Tract may have increased significantly due the extensive denudation of the Madhupur Forest.

The Banar-Lakhya system to the east of the Madhupur Tract is mainly rainfall fed, with direct contribution from the Old Brahmaputra through the Lakhya River. Downstream of Toke, the Lakhya River is the main branch of the Old Brahmaputra. This system is unaffected by flows in the Jamuna, although extreme levels in the Old Brahmaputra can result in spillage at certain locations.

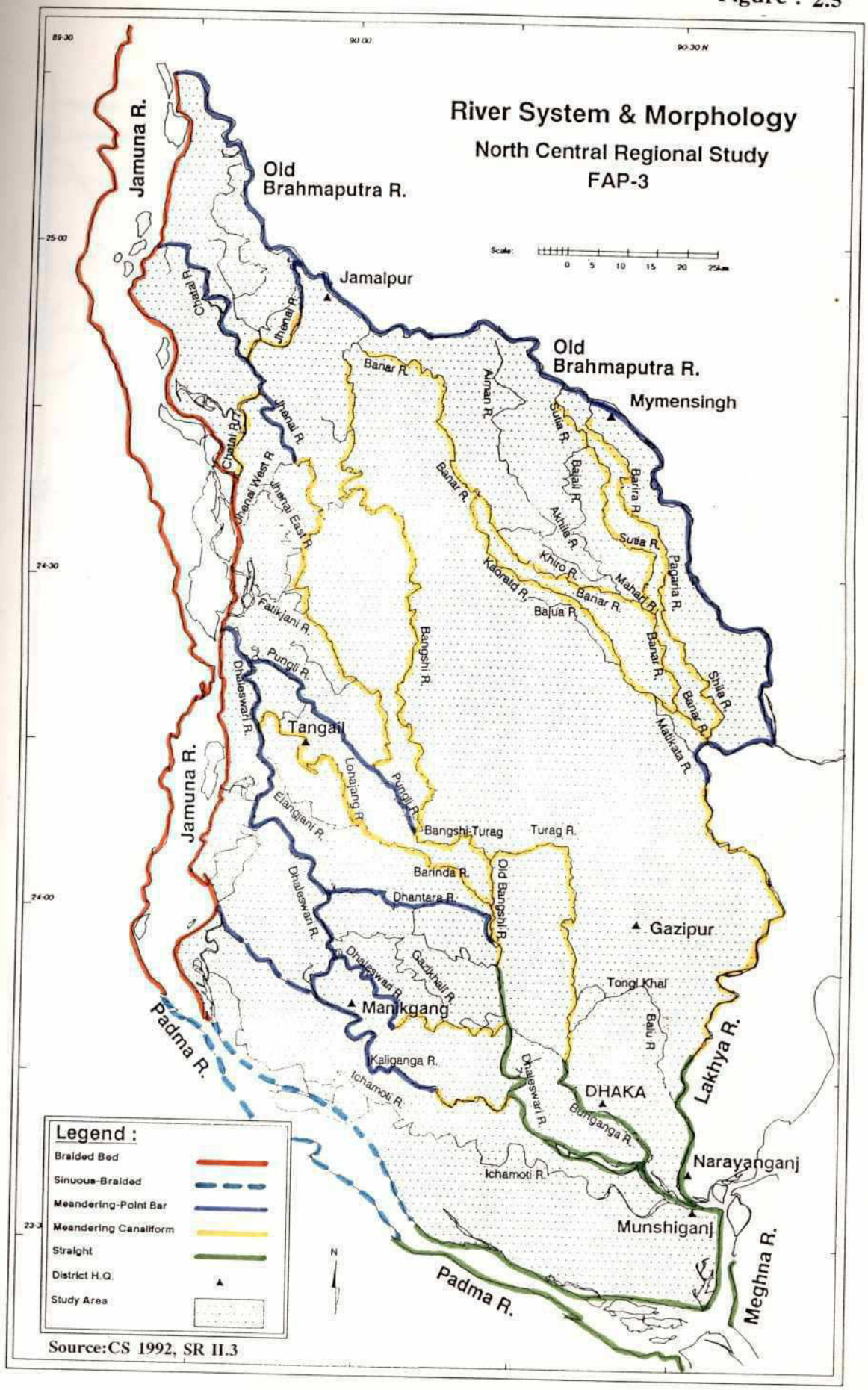
The complete internal river system is complex with peak and average discharges varying in each river considerably from year to year. More detail is given of this system, including discharge data in PSR II.2.2 and Figure II.1.5.

2.2.4 Drainage

The drainage of the NCR is detailed in SR II.2, a summary is given below.

The regional rivers in the west of the North Central Region are predominantly characterised by having river banks (levees) which are elevated above the surrounding flood plain. This is a result of either man-made intervention, in the form of embankments, or a natural phenomenon of built-up levees, typically exhibited by rivers subject to regular flooding of sediment-laden waters. The consequence of this physical characteristic serves to determine the system response to rainfall and river flooding.

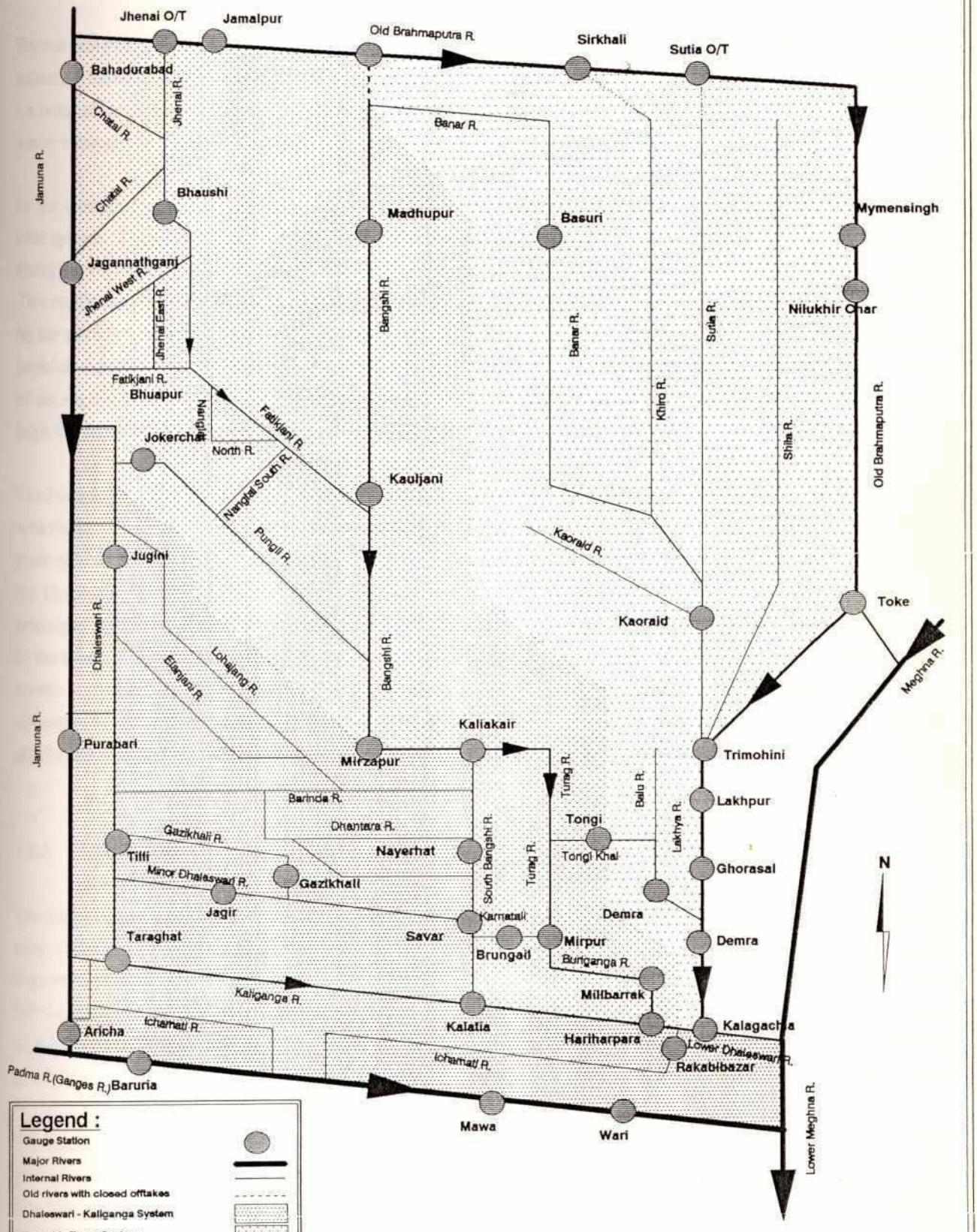
Figure : 2.5



Source:CS 1992, SR II.3

Figure : 2.6

Schematic Map of the Rivers & Drainage System of the North Central Region



Source:CS 1992, SR II.2

Drainage of the North Central Region takes place at 4 levels: the boundary river system (primary), the regional river system (secondary), the khal system (tertiary), and the beel system (quaternary). The mechanism by which the region drains relates directly to this hierarchical system and its interconnections.

Excess rainwater accumulates first in the depressions, (beels), until these have reached their capacity. Gradually the extent of inundation increases until the small khals, which link the depressions, begin to flow. These khals form an interlinking network within the internal drainage system and they are also the means by which the transfer of water between the regional rivers and the flood plain takes place.

In the western part of the study area, the regional rivers are connected to the adjacent flood plain by means of the khal system. There are a limited number of these connections and interchange of water takes place at specific points along the regional river length, rather than being uniformly distributed, as in the case of a typical drainage section. This configuration results in a restricted interchange of water between the river and flood plain which is exacerbated by the already "embanked" nature of the regional rivers. Hence, the regional rivers do not have to be even near their bankfull capacity to preclude effective drainage from the adjacent flood plain. During the monsoon season, some of the regional rivers have a limited drainage function and the accumulated rainfall excess, together with overspill from the boundary and regional rivers, remains on the flood plain.

The Jamuna river contributes water into the region through its distributary rivers, which then has to be drained along with the locally derived rainfall runoff. On recession of the boundary rivers, the regional rivers can begin to discharge more effectively and, on their recession, the internal drainage begins to function, but only at the limited locations of the khal/regional river interconnections. Hence, the key to the drainage of the North Central region lies in the prolonged influence of the high river levels in the boundary rivers over the regional river levels. Unless the levels of the lower Meghna can be reduced at times of high flow, the drainage outlet from the North Central region will remain congested. Limited improvements can be made to local drainage conditions within the region, but these will ultimately be at the expense of the downstream reaches, however restricting the inflow from the main rivers into the distributaries would decrease flooding by limiting the water entering the regional drainage network.

2.2.5 Morphology

The major rivers of the region have undergone significant morphological changes over the past centuries. An overview study of the morphological characteristics of these rivers and the possible changes resulting from adopted engineering interventions has been carried out for this phase of the study. Such detail as would be necessary for a full feasibility level study would involve a rigorous investigation of the existing conditions and further quantification of the likely behaviour patterns of the affected watercourses. The following brief notes outline the salient features of the major watercourses of the region. The subject is addressed more fully in Supporting Report II.3 to the DFR.

The qualitative classification of the regional rivers is based on four major planform properties observed on aerial photographs and satellite images: sinuosity, point bars, braiding and anabranches, see Figure 2.5. The Jamuna River is a broad braided river with large sand shoals and islands, side-channels and anabranches. High lateral migration rates take place with average rates of approximately 300 metres/year and maximum values of 800 to 1000 m/year. The river has a dominant discharge of approximately 38,000 m^3/s, with a mean surface width at bankfull of 4.5 km.

Studies carried out by FAP-1, (FAP-1, 1991), identify the Jamuna river to be in the braiding-meandering transition, as it shows, (at the macro scale), characteristics of both patterns.

The Padma River is a stable braided river which shows a meandering character at the macro scale. The erosion processes appear to be less unpredictable than the Jamuna due to its less developed braiding character. Bankfull discharge is estimated to be approximately 55,000 m^3/s with a mean water surface width of 4.3 km. Detailed studies are required to confirm the assumption of stability and to predict the maximum radius of curvature and the migration rate of a bend.

The Dhaleswari is the main left-bank distributary of the Jamuna River and is the main channel of a complex river system. The offtake of this river from the Jamuna comprises a system of watercourses subject to constant morphological changes which influence both the quantity of the flow diverted and the location at which it takes place. The northern offtake, near Bhuapur, is presently becoming smaller, while the lower, near Porabari, is showing signs of further development. Between these two major offtakes lie a number of smaller spill channels which convey additional flood flows into the Old Dhaleswari channel.

There is evidence from old maps 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.The upper and middle course of the Dhaleswari are near the threshold between wide-bend point-bar streams, (very sensitive to slight changes with equi-width meandering) and stable streams. Other rivers are more stable.

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

The rivers of the Banar-Lakhya system, (to the east of the Madhupur Tract), are composed of stable meandering canaliform rivers. The reduction in the sinuosity of the Lakhya near its downstream end indicates that the water and sediment charges are in balance with the channel's capacity for transport.

The Old Brahmaputra river offtakes the Jamuna at the northern limit of the North Central region. The mouth is presently heavily silted and discharges into this river are accordingly restricted at low to medium flows. The process of bend migration is active in the upper course but decreases with slope downstream of Jamalpur. In common with the Dhaleswari, the sediment load is controlled by the relatively high level of the intake from the Jamuna and its behaviour is very sensitive to variation in dominant discharge or sediment load. The Old Brahmaputra flows within a former braided channel and its alignment has been controlled by the presence of the Madhupur Tract. The Bangshi and Banar offtakes were closed (under instructions from the President) in the early 1970's,but significant flows still divert down the Jhenai offtake.

2.3 Physical Resources

2.3.1 Land Resources

Figure 2.7 shows the agro-ecological zones in the North Central Region. Four physiographic units occupy the greater part of the North Central Region:

- The Young Brahmaputra and Jamuna floodplains (AEZ 7 and 8)
- The Old Brahmaputra floodplain (AEZ 9);
- The Padma river floodplain (AEZ 10 and 12b);
- The Madhupur Tract (AEZ 28);

Arial beel, the Middle Meghna River floodplain and the Old Meghna estuarine floodplain occupy small areas in the south.

The agro-ecological zones can be grouped into 2 distinct areas:

i) The Madhupur Tract (AEZ 28), an old alluvium outcrop situated in the centre of the NCR is raised 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 alluvial plains of the main rivers surrounding the NCR:

- the Jamuna Floodplain, both Active (AEZ.7) and Young (AEZ.8), which occur in the North Western and Southern areas,
- the Old Brahmaputra Floodplain, (AEZ.9) in the Northern and Eastern areas with a small area bordering the Western side of the Madhupur Tract,
- the Old Padma River Floodplain, the Old Meghna Estuarine Floodplain and the Active Ganges Floodplain covering small areas in the South.

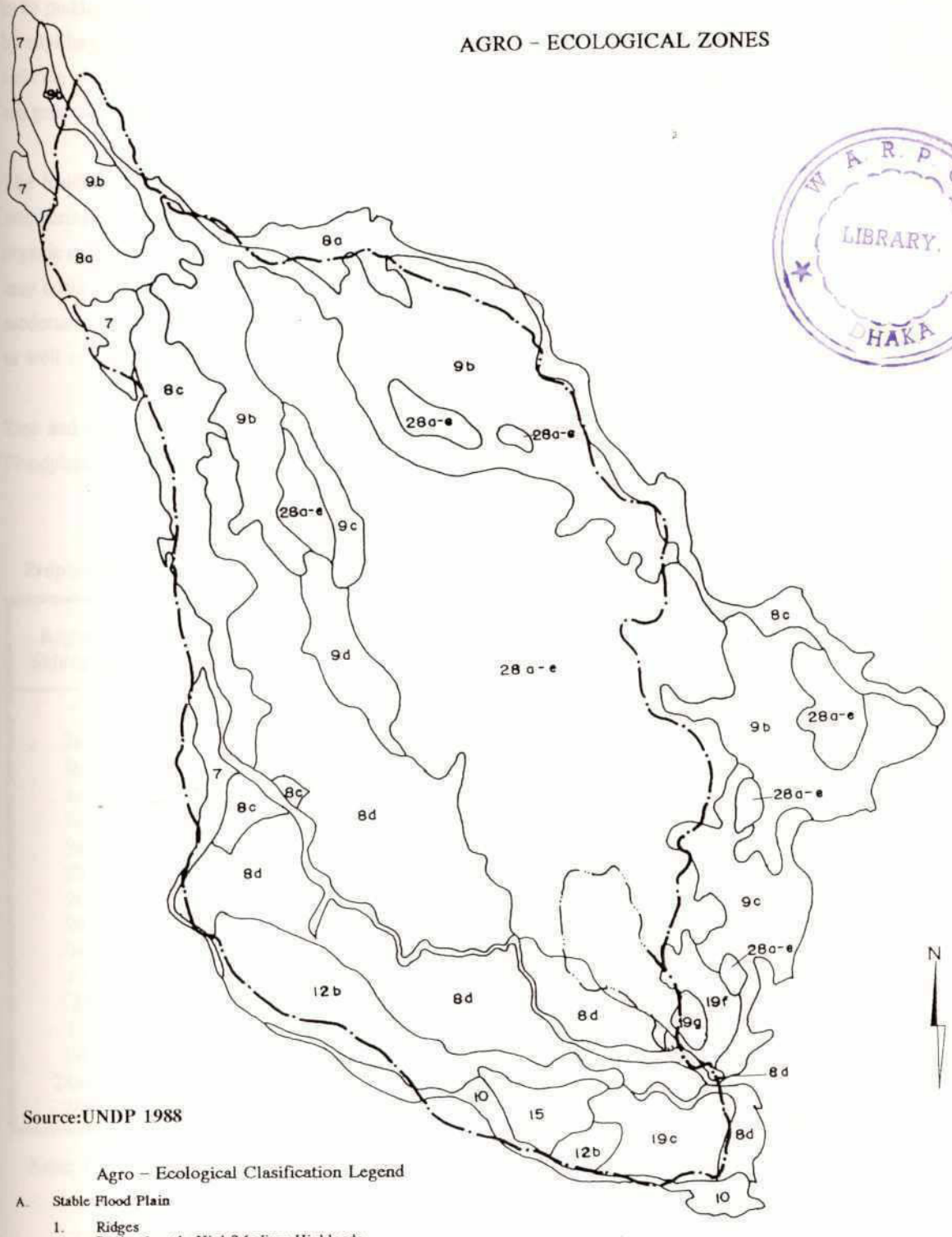
The Floodplains have a very gently undulating relief comprising broad and narrow ridges and depressions. Differences in elevation between adjoining sides and depressions range from 1-3 meters. The relief generally is more irregular on active floodplains and on young floodplains close to river channels.

Soils

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

Floodplain soil types are closely related to their position on the relief. 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 floodplains 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, and are not puddled for transplanted rice crops. Basin soils generally have a low permeability.

Figure : 2.7



Source:UNDP 1988

Agro – Ecological Clasification Legend

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 Depresions

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

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, 28c, 28f

The moisture retention capacity is moderate in most loamy soils, low in sandy and clayey soils and most soils need to be 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. Floodplains are generally classified as good agricultural land.

The Madhupur Tract Soils are underlain by Madhupur clay with variations 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, mostly 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.

TABLE 2.1

Proportions (%) of Depth-of-flooding Land Types and Soil Textural Families in Agro-Ecological Zones

Region/ Subregion	Depth-of-Flooding land type[1/]				Settlement+Water[2/]	Soil Textural family[3/]		
	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

Note: 1. F0 includes Highland (above normal flood level) and Medium Highland flooded up to 30 cm.
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.

2. % Figures related to land under settlements or permanently flooded.

3. 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

2.3.2 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.

Climatological data and analysis are detailed in SR II.1.

2.3.3 Agriculture

In the floodplains 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 have increased and rice production has risen considerably.

In 1990-91 an estimated 829,000 Ha of the study area has been cultivated, (net cultivated area, NCA). This is 73% of the gross area. Out of this NCA 323,800 Ha (39% of the NCA) has been irrigated. The total area planted to crops amounts to 1,576,350 Ha which is equivalent to a cropping intensity of 188%, but ranging from 109% to 218%, see Section 3.2. The main crop in the study area is rice. An estimated 1,070,625 Ha were harvested in 1990-91, being 129% of the NCA or 68% of all crops planted. The total rice production is 2,919,600 Tons of paddy (1,950,000 Tons of rice).

The farmers grow a wide variety of crops, which are broadly classified according to the growing seasons into 3 groups:

- Kharif-I and Kharif-II crops grown during the kharif season, which is the main cropping season. Kharif starts in March and ends in October. It is characterized by a monsoon climate with high rainfall and high temperatures. The crop environment during this season is less favourable for high yields because of the uneven distribution of rainfall, variable flooding depths, low solar radiation, high temperatures and high humidity. Rice is the predominant crop during the kharif season. Based on crop adaptability and crop culture this season has been divided into Kharif-I (March-June) and Kharif-II (July-October);

- Rabi crops grown during the rabi season, a dry season which covers the period from November to February and which is characterized by scanty or no rainfall, low temperatures and clear skies. Crop environment during this season is very favourable for high yields, because of high solar radiation, low humidity and wide variations between day and night temperatures. However crops are restricted to areas with adequate soil moisture.

Rice

In the study area rice is the most important crop and is grown throughout the year. Special adapted varieties have been developed for each growing season under rainfed, irrigated or flooded conditions by the Bangladesh Rice Research Institute (BRRI) in close co-operation with the International Rice Research Institute (IRRI). The varieties are also adapted to the preference of the rice growers and the consumers.

Among the different groups of rice "aus" is grown during the Kharif-I season, "T Aman" (transplanted aman) during the Kharif-II season and "B Aman" (deep water aman) requires both Kharif seasons to mature. All three groups of rice are rainfed cultivated. During the rabi-season irrigated "Boro" rice is grown. Estimated total production of paddy is given in Table 2.2. 23% of the Aus area is planted to HYV's, 56% of T.Aman and 94% of Boro. Although HYV B.Aman has not yet been released. 4 improved varieties have been tested, so far, with promising results. The release of these varieties can be expected in the very near future.

TABLE 2.2
Estimated Production of Paddy in the North Central Region(1986/87-1990/91)

Crop	1986-87 (t)	1987-88 (t)	1988-89 (t)	1989-90 (t)	1990-91 (t)
Aus	499,500	460,800	478,900	437,300	443,600
T.Aman	681,600	627,800	410,200	809,400	868,200
Deep Water Aman	312,900	222,600	21,400	228,400	216,500
Boro	1,137,200	1,239,400	1,469,500	1,550,600	1,369,300
Total	**2,631,200**	**2,550,600**	**2,380,000**	**3,025,700**	**2,897,600**

Source : CS 1992

Other Crops

Crops other than rice cover 59% 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 and as some parts of the Old Brahmaputra Floodplain. Further details are given in SR I.

Yield Projections

During the last 15 years rice production has steadily increased. National trends show annual rice production increases in the order of 2% (MOA 1991). The NCR production figures also show an average annual production increase from 1987 to 1991 of 2% (see Table 2.2). This increased production is almost entirely due to increases in yields through the expansion of HYVs, with little increase of area of rice grown (MOA 1991). Similar yield increases have been experienced in pulses, oilseeds and jute whereas the yields of sugarcane, vegetables and fruits have been gradually declining (MOA 1991).

2.3.4 Irrigation

The use of irrigation has increased significantly in recent years, allowing in particular for boro rice to be grown. This increase has been achieved mainly through abstraction of groundwater, see Section 3.2.

The irrigation demand for the majority of the NCR is not limited by groundwater potential (see Figure 2.8, and SR II.4 for more detail). Although presently not limited, parts of the Madhupur Tract and the Old Brahmaputra do show a potential groundwater deficit which will become limiting if the present trends in irrigation demand continue.

2.3.5 Livestock and Forestry

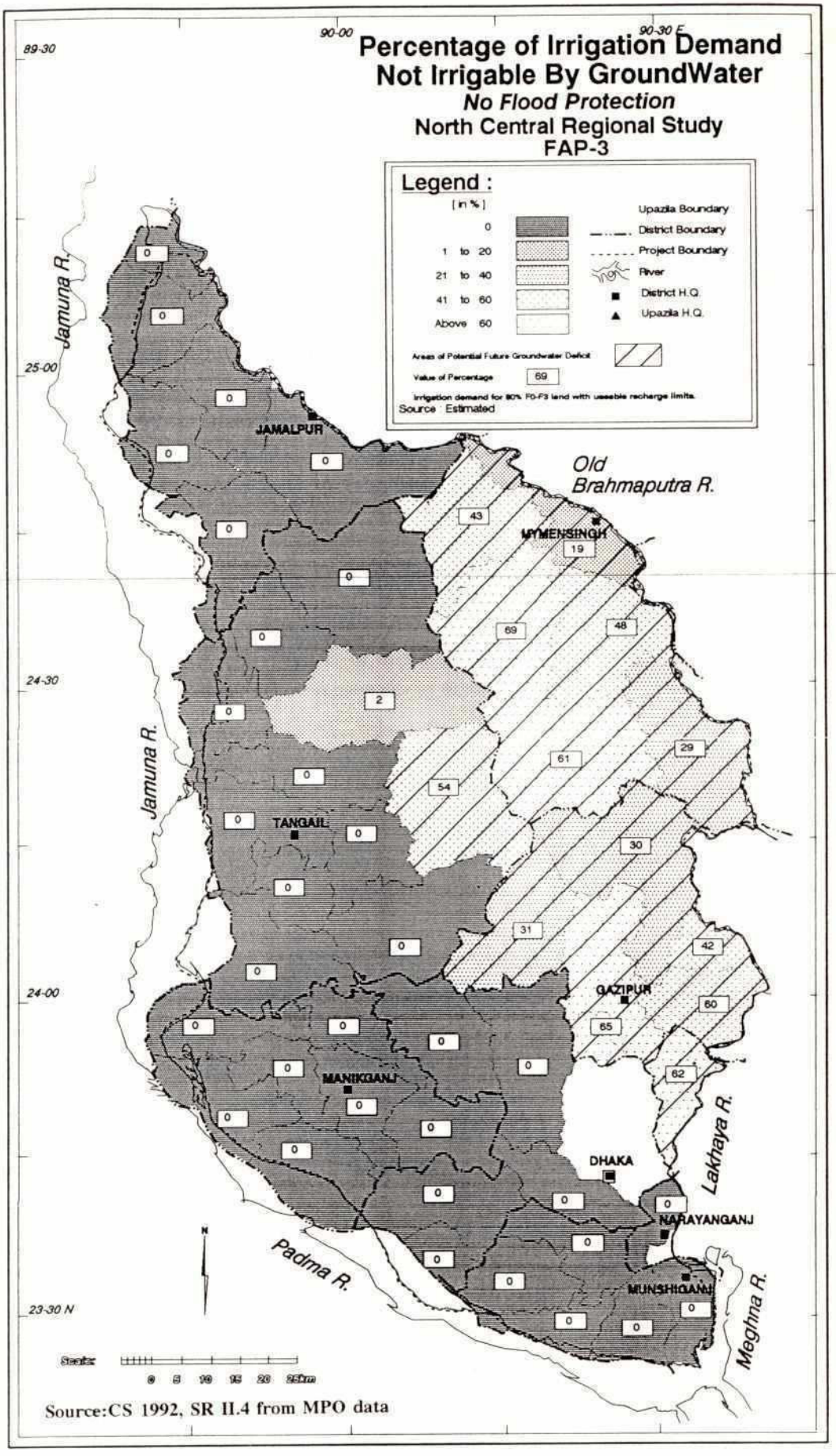
Livestock in the NCR are an integral part of the farming system, in spite of the fact that land is not available for grazing and scarcity of animal feed. The animals live almost entirely on the by-products of crops grown for human consumption. Cattle assist with the vital task of land preparation. The quality and stamina of animals used in the farm for land preparation and threshing are very poor especially on smaller farms. Availability of draught animals in the NCR is not adequate, with the exception of some areas in Tangail district. The estimated number of draught animals is 1,350,000, (675,000 draught animal pairs).

Sheep, goats and poultry are raised by most rural households. These animals live off farm residues and on scavenging, providing meat,skins and eggs. Mutton and chicken meat fetch higher market prices compared to beef. The total number of poultry is estimated at more than 9 (nine) million birds, and the number of poultry farms in the NCR is on the increase.

Forestry

The parts of Madhupur Tract that extend in Savar (Dhaka District), Kaliganj and Kapasia (Gazipur District) and Muktagacha (Mymensingh District) have reserve forests, but, due to the increasing population pressure along with the expansion of habitat and industry, the forest land in the NCR is diminishing very fast. Forest trees are felled randomly and the programme of afforestation is meagre.

Figure : 2.8



Source:CS 1992, SR II.4 from MPO data

2.3.6 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 (although some floodplain fisheries have fallen into a poor condition). A large number of fish species migrate from rivers to reproduce, feed and grow on the floodplains.

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 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 2.3). 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.

Estimates have been made of the financial value of the total catch from both capture and culture fisheries in the NCR using the most recent data (1988/89) presently available (Table 2.3). The estimates were based on average current fish prices obtained by fishermen and farmers in the NCR (see SR III). Taken together, the capture and culture fisheries of the NCR produced an estimated 35,000 tonnes with a value to fishermen and farmers of about 1,109 million Taka.

Fish is an extremely important component of the diet of people in Bangladesh, providing about 70-80% of the total animal protein intake (BBS 1988). Although data from nutritional and household expenditure surveys are somewhat conflicting, certain trends are apparent:

- a decline in per capita consumption of fish from 33g per day in the 1960's to 21g per day in the 1980's;
- a widening of the gap between urban and rural fish consumption (urban increasing faster than rural)
- marked inequality between rural consumers with landless households averaging only 16g/person/day and farmholders with more than 3 acres of land consuming twice that amount.

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 levels of per capita availability i.e. 7.5 kg per annum (WB 1991), 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 people. This number is well below the total population of the region, provisionally estimated at about 16 million for 1991 (11.5 million excluding Dhaka), which implies 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 north east and from the fisheries of the Meghna river.

TABLE 2.3

Total Catch and its Value from the Capture and Culture Fisheries of the NCR, 1988-1989

Type	Catch (tonnes)	Value (million Tk)
Capture Fisheries:		
Rivers	7222	288.9
Beels	4501	134.9
Floodplain	14866	371.8
Total Capture Fisheries	**26589**	**795.6**
Culture Fisheries:		
Cultured ponds	6197	247.8
Culturable ponds	1550	38.8
Derelict ponds	1078	27.1
Total Culture Fisheries	**8825**	**313.7**
Total Capture and Culture	**35414**	**1109.3**

Note: Value of catch based on estimates of average current (1991) fish prices in the NCR: Rivers Tk.40.00; Beels Tk.30.00; Floodplain Tk.25.00; Cultured ponds Tk.45.00; Culturable and Derelict ponds Tk.25.00.

Source : DOF 1988-1989.

2.3.7 Infrastructure

Industry

Excluding Dhaka, the NCR's regional industry and non-agricultural major activities employment is about the national average (at about 10% of the national labour force), however Dhaka itself accounts for a further 10% of the national labour force. The principal manufacturing activities are the fibre industry, chemicals and food industry. More than 21% of the national cottage industry units are located in the NCR.

Communications

The regional railway mileage constitutes less than 10% of the national network. Although there is a relatively high proportion of the national highways inside the NCR (some 15% of the national highway), the minor unmetalled road mileage is not well developed, see Figure 2.9. The region has a well developed navigational network with 242 km of perennial (class 1&2) routes and more than 505 km of seasonal routes (class 3&4) see Figure 2.10.

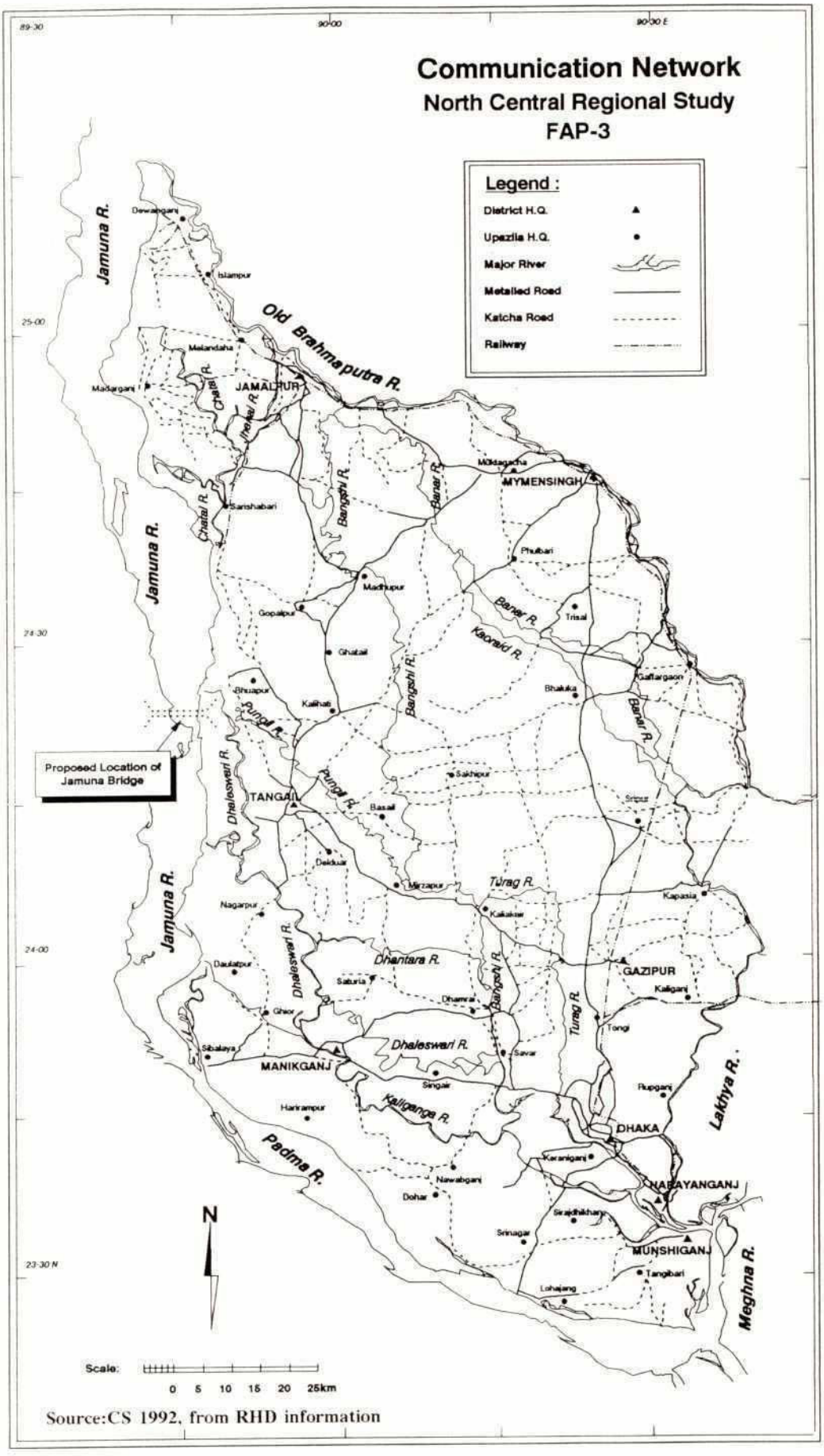
2.4 Socio-Economic Characteristics of the North Central Region

2.4.1 Demographic profile of the region

Demographic Parameters

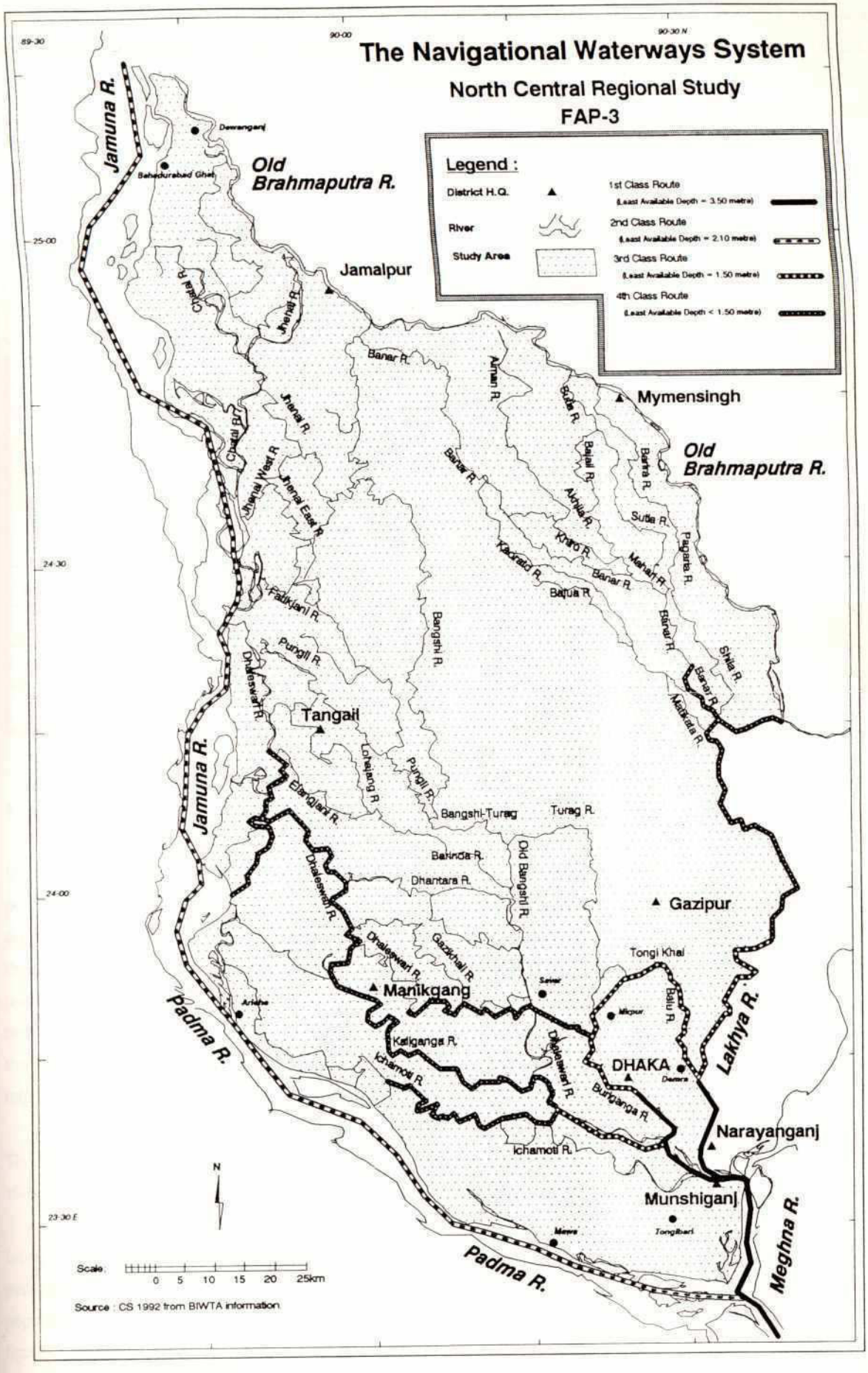
The NCR comprises of 8 districts with 8 municipalities and 1 metropolitan city. The region covers about 9 per cent of the country's total land area and constitutes some 15 per cent of the country's population. According to the preliminary results of the 1991 Population Census (BBS 1992) the total population of the area is about 16 million with 21 per cent (3.4 million) of this population living within the Dhaka metropolitan area.

Figure : 2.9



Source:CS 1992, from RHD information

Figure : 2.10


The Navigational Waterways System
North Central Regional Study
FAP-3
Legend :
District H.Q.
River
Study Area
1st Class Route
(Least Available Depth = 3.50 metre)
2nd Class Route
(Least Available Depth = 2.10 metre)
3rd Class Route
(Least Available Depth = 1.50 metre)
4th Class Route
(Least Available Depth < 1.50 metre)
Jamuna R.
Old Brahmaputra R.
Dewanganj
Bahadurabad Ghat
Jamalpur
Mymensingh
Old Brahmaputra R.
Tangail
Jamuna R.
Padma R.
Manikganj
Gazipur
DHAKA
Narayanganj
Munshiganj
Lakhya R.
Meghna R.
Padma R.
Banar R.
Bangshi R.
Turag R.
Bangshi-Turag
Dhaleswari R.
Kaliganga R.
Ichamoti R.
Buriganga R.
Tongi Khal
Scale
0 5 10 15 20 25km
Source : CS 1992 from BIWTA information

The population density for the region (BBS 1992) stands at some 1200 inhabitants/km2 (820 inhabitants/km2 excluding Dhaka) compared to the national average of 760 inhabitants/km2. The annual population growth rate for the region is currently (1981 to 1991) higher than the national average. The respective population growth figures for different districts under the North Central Region however vary widely (from 1.1 per cent in Manikganj to 4.6 per cent in Jamalpur), see Table 2.4.

TABLE 2.4

Variation in Population Characteristics in the North Central Region Districts

District	Population (% of NCR total)	Area (% of NCR total)	Population Density (persons/ km2)	Annual Growth Rate (%)	Average Size of Households
Jamalpur	9.2	14.9	730	4.6	4.79
Tangail	18.9	25.9	890	1.9	5.10
Gazipur	7.7	13.4	678	3.3	5.00
Mymensingh	12.8	16.4	915	2.3	4.99
Dhaka	31.3	10.6	3452	4.0	5.53
Munshiganj	7.4	6.3	1369	1.1	5.56
Manikganj	8.3	10.1	965	1.0	5.06
Narayanganj	4.4	2.4	2146	3.8	5.32
Total NCR	100.0	100.0	1200	2.9	

Source: BBS 1992

Factors Influencing Changes in Demographic Parameters

In interpreting the demographic figures it should be borne in mind that migration is an important component of the population dynamics of the region. The North Central Region with cities like Dhaka, Narayanganj, Mymensingh accounts for a major part of rural-urban migration. This leads to spatial redistribution of population and influences the demographic and socio-economic conditions of North Central Region as well as of the country. Figures of annual population growth rate by district, indicate that Jamalpur, Dhaka, Narayanganj and Gazipur are areas of high population growth while Manikganj and Munshiganj show a relatively lower rate of population increase. It is notable that the population density figures for these two districts are higher than the other districts in the region. Net urban migration is high in the region and contributes to a yearly urban population increase of around 3 per cent per year.

The average size of households in the region ranges between 4.99 to 5.56 and shows a marginal decrease from the 1981 figures. No significant difference in the corresponding figures for rural and urban areas is observed.

Information on rural-urban population and growth therein are given in Table 2.5 which shows that the share of urban population is increasing. This is mainly due to the high net migration to urban areas. About half of the total population in the North Central Region districts are below 15 years age which corresponds with the average national figures.

TABLE 2.5

Urban and Rural Population and Growth Rates during 1981 - 1991

Year	Urban (% of total)	Annual growth: 1981-1991 (%)	Rural (% of total)	Annual growth: 1981-1991 (%)
1981	30		70	
1991	36	4.93	64	1.76

Source: BBS 1981 and BBS 1991

2.4.2 Land Ownership and Land Tenure

Despite the recent trend of a gradual decline of the role of agriculture in the national economy, agriculture will remain the most important sector for years to come. Despite the big industrial cities within the North Central Region as in other parts of the country, control over land remains to be single most important factor, and this control will continue to determine the nature and effectiveness of all development interventions in the country.

As in the rest of the country, the land ownership in the North Central Region is highly skewed with high percentage of rural households being landless and marginal (owning below 0.4 ha). The latest official statistics (CAL 1984) indicate that in all the North Central Region districts more than 50 per cent of the rural households are landless and marginal farm households, see Figure 2.11 and Table 2.6.

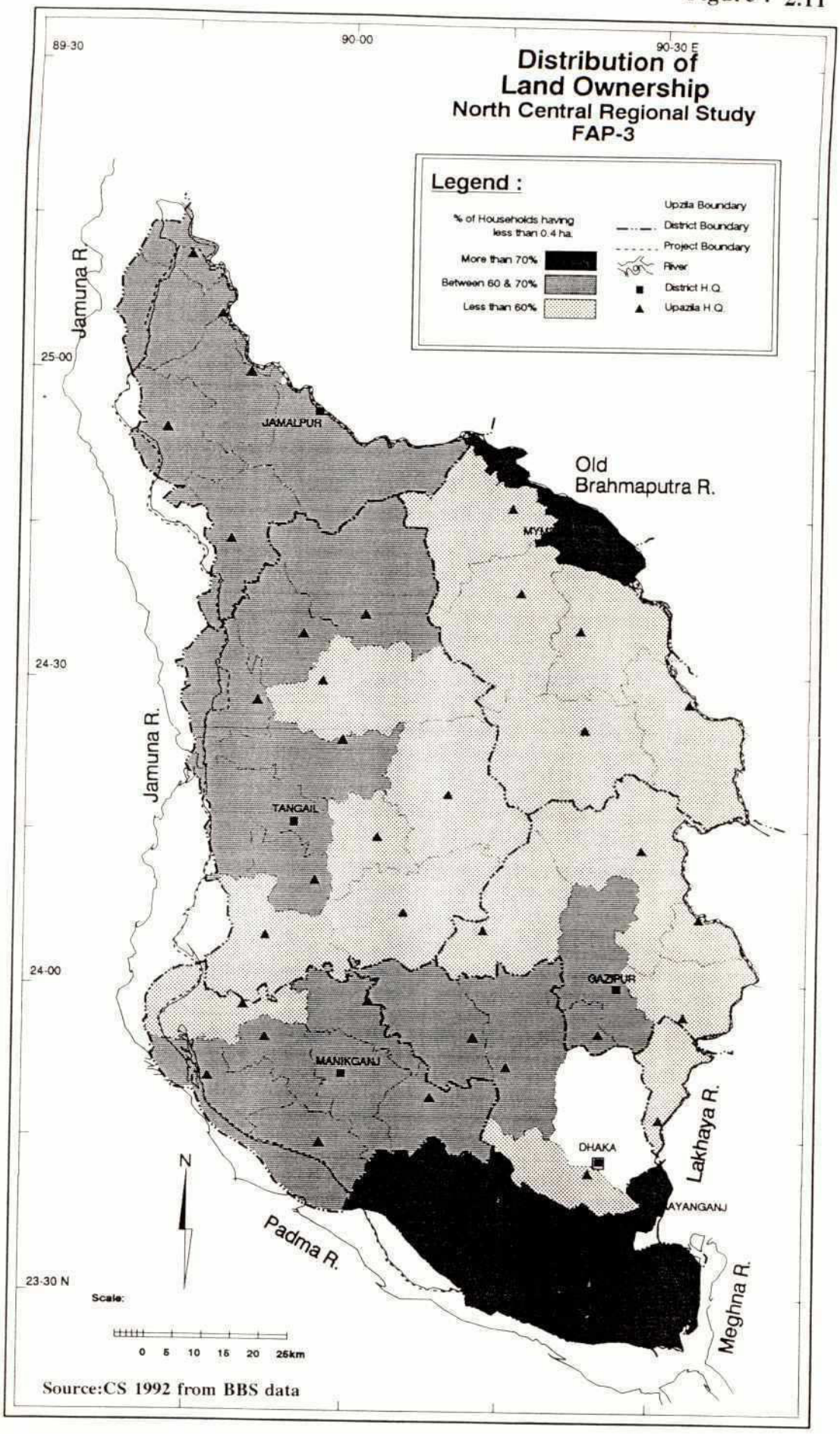
TABLE 2.6

Landless and Marginal Farm Households in the NCR

District	House-hold with no land	House-hold with home stead but no owned land	House-hold with home stead and owned area upto 0.2 ha	House-hold with home stead and owned area upto 0.4 ha	Total
Jamalpur	12.9	23.2	27.1	12.0	75.2
Tangail	9.8	13.9	29.9	13.7	67.3
Gazipur	11.6	16.3	22.5	15.2	65.6
Mymensingh	11.1	20.1	25.2	12.3	68.7
Dhaka	15.9	37.3	27.1	9.0	89.3
Munshiganj	6.5	25.6	33.5	13.7	79.3
Manikganj	6.5	24.1	27.6	11.4	69.6
Bangladesh	**8.7**	**19.6**	**28.2**	**12.3**	**68.8**

Source: CAL 1983-84

Figure : 2.11



Source:CS 1992 from BBS data

Farming households in the North Central Region (see Table 2.6) are predominantly small and marginal owning land area up to 0.4 ha. These farms, however, account for not more than 30 per cent of the land area, and the concentration of land with a small group of land-owners is continuing with increasing incidence of land-mortgage and resulting distressed selling of land by poorer land-owners.

Households owning no land or small areas tend to increase their operated area by entering into different types of tenurial arrangements with land-owners controlling/owning larger land areas. The most common tenancy practice is share-cropping where produce is shared between the operator and the owner. Prevailing law on share-cropping provides for operator getting 1/3 of the crop, the owners getting 1/3 and the reminder 1/3 to the party supplying the inputs. However, in the North Central Region, like in other areas of the country, the operator usually gets half of the produce and provides all required inputs. In case of the land owner providing the input, the operator gets only 1/3 of the produce. The prevailing practice goes against the established Tenancy Law but acute competition for the scarce land makes it possible for the land-owners to dictate their conditions on the share-cropper. In some cases land is rented against a fixed amount of rent.

With respect to the form of access to land operation, farming households can be grouped as owner-operators, owner-tenant operators and tenant operators. Corresponding figures for different North Central Region districts are presented in Table 2.7, which generally show a similar distribution to that of the national figures. These figures are important in ascertaining which groups should be addressed and consulted in planning development interventions aimed at agricultural growth.

TABLE 2.7

Tenancy and Operated Area by Districts

Districts	Owner		Owner-tenant		Tenant	
	% of total holdings	% of total area	% of total holdings	% of total area	% of total holdings	% of total area
Dhaka	64.2	58.2	34.4	41.2	1.4	0.6
Jamalpur	61.9	63.2	36.4	36.1	1.7	0.7
Mymensingh	67.3	65.2	31.7	34.4	1.0	0.4
Tangail	58.1	56.0	38.8	42.9	3.1	1.1
Bangladesh	52.6	58.5	36.0	41.0	1.4	0.6

Source:- CAL 1983-84

2.4.3 Access to Income Earning Opportunities

Occupational Structure

About 60 per cent of the civilian labour force remains employed in agriculture. Manufacturing is the second largest employer providing employment to 41 per cent of all industrial and non-farm employment in the North Central Region. Trade, hotels and financial services employ about 32 per cent of all employment in the North Central Region. This distribution slightly differs from the national figures where trade, hotels and financial services employ the largest number of labourers followed by the manufacturing sector (UNDP 1992). In general there has been a rapid increase in urban labour force which is supplemented by a significant positive trend in the relative share of women participating in the labour force. Growing landlessness, uncertainty of agricultural production due to vagaries in nature, increased poverty and an increasing incidence of the break-up of families are forcing women to enter into the labour market. Currently females account for 10 per cent of the total workers.

The higher population growth rates in Dhaka, Gazipur and Narayanganj (see Table 2.5) are possibly due to rural-urban migration meeting the additional demands generated in the urban industrial sector. These 3 districts provide employment opportunities with 75 per cent of the labour force engaged in different industry and non-farm sectors in the North Central Region.

Agricultural Sector

With the recent intensive diffusion of seed-fertilizer-water technology an increased demand for non-farm goods and services has been generated. The population pressure on scarce land is leading to landlessness in the rural areas, and it is mostly the landless and the marginal farmers who constitute the rural labour force. The rural sector has limited capacity to absorb the rapidly growing labour force. However the potential of agriculture for creating employment cannot be exploited fully due to backward technology and lack of investment in modern agricultural technology.

Though modern water-seed-fertilizer technology is quite labour-intensive only a limited amount of land in each sub-region is under irrigation (SR II.4). The Jamuna Floodplain (particularly the central and southern part) and the Madhupur Tract South sub-regions have a higher percentage of net irrigated to total cultivated area than other areas in the North Central Region, and there is a greater employment requirement in these areas. In general arable employment is not equitably distributed as the need for labour varies depending on the crop type and agricultural operations used. Agricultural operations requiring significant labour include harvesting, threshing, transplanting and sowing. Many farmers report a shortage of labour for such activities.

Wage Rates

Significant difference is observed in the wage rates in different regions of the country and between the urban and rural sectors. Table 2.8 provides information on the general trend, and indicates that wage rates (both in monetary and rice equivalent terms) are higher in the industrial sector. These rates to a great extent explain the trend of rapidly increasing urban population as a result of influx of rural/urban migrants mostly consisting of landless and near landless households.

TABLE 2.8

Wage Rates of Agricultural Wage Labourers and Unskilled Industrial workers

Regions	Agricultural wage rates				Wage rate for unskilled industrial workers	
	Nominal wage rate (Tk/day)		Rice equivalent (Kg/day)		Nominal wage rate (Tk/day)	Rice equivalent (kg/day
	Normal Season	Slack season	Normal season	slack season		
Chittagong	44	35	3.57	2.84		
Dhaka	34	23	2.76	1.87		
Rajshahi	33	21	2.92	1.86		
Khulna	36	25	2.90	2.02		
Bangladesh	**37**	**26**	**2.98**	**2.15**	**43**	**4.60**

Source:- CAL 1983-84

Despite the above-reported lower wage rates, with the current level of development in the urban sectors, the population increase rate and the decrease in available land for cultivation (due to urbanisation and increased housing needs), additional employment opportunities will still have to be generated in the agricultural sector for years to come. The creation of additional employment in the crop sector will depend on changes in cultivated area, cropping intensity and cropping pattern.

Diversification

Emphasis may have to shift towards development of livestock and fisheries, see Table 2.9, for generating additional income. The issue of fisheries development merits special attention in developing flood control and drainage interventions. The National Water Plan explicitly states that implementation of its programme will reduce the output of inland fisheries by an estimated 30 per cent (UNDP 1992). The natural resource base for fisheries is gradually being depleted as floodplains are reclaimed for irrigation and drainage, and embankments affect the movement and breeding of fish.

The high population numbers and the unemployment situation are such that whatever initiatives are taken in the agricultural sector, there will still be surplus labour for whom employment opportunities will have to be created in the non-crop sector. As mentioned above, in the rural areas non-crop activities would include fisheries, livestock, rural infrastructure and rural industries, specially cottage industries. However, lack of institutional credit means limited expansion of rural industries and thus a limited labour absorption capacity. The development of rural infrastructure is dependent on external resources and its labour absorption ability will depend on external factors.

Table 2.9

Brief Regional Description - Agriculture, Livestock and Fisheries

Districts		Jamalpur	Tangail	Gazipur	Mymensingh	Dhaka	Munshiganj	Manikganj	Narayanganj	Total NCR	
Predominant Sub-Region		JFP	JFP	MTS	MTN/OBFP	PJFP					
A) Agriculture - Cropping (with Proportional Production)											
Total Cultivated area	(ha)	116,760.0	246,000.0	162,020.0	105,800.0	112,640.0	63,500.0	91,040.0	21,000.0	918,760.0	ha
NCA/NCR area	(%)	78.0	57.0	75.0	73.0	63.0	76.0	72.0	-	68.3	%
Cropping Intensity	(%)	211.0	168.0	189.0	177.0	140.0	183.0	188.0	-	192	%
Irrigation Intensity	(%)	58.0	35.0	32.0	39.0	38.0	24.0	27.0	-	36	%
Rice	(%)	17.9	27.1	24.2	13.7	6.4	3.3	5.8	1.6	100	%
Rice Production Index 2/		141.0	100.0	137.0	119.0	52.0	48.0	59.0	70	100	%
Jute	(%)	22.1	34.3	11.5	6.4	7.7	8.4	6.9	2.7	100	%
Wheat	(%)	14.5	33.9	9.6	3.9	11.6	4.3	21.5	0.7	100	%
Mustard	(%)	10.4	42.3	2.5	5.4	11.3	17.5	6.8	3.8	100	%
Sugar Cane	(%)	32.0	18.0	14.4	13.1	3.2	2.1	16.4	0.8	100	%
B) Agriculture - Livestock											
Cattle	(%)	11.6	32.5	11.3	15.6	10.3	8	8.1	2.6	2,696,509.0	Nr
Poultry	(%)	15.2	19.7	13.9	17.2	9.2	9.6	12	3.2	9,097,189.0	
C) Fisheries - Capture	(%)										
River		21.8	26.6	4.1	12.5	17.4	13.7	3.9	-	7,222.0	T
Beel		4.9	24.1	1.4	56.7	1.3	9.8	1.8	-	4,501.0	T
Floodplain		10.6	43.3	5.4	19.5	6.2	10.1	4.9	-	14,866.0	T
Culture	(%)	5.3	41.3	5.6	17.1	11.5	12	7.2	-	8,140.0	T

Note : 1. JFP = Jamuna Flood Plain; MTS = Madhupur Tract South; MTN = Madhupur Tract North; OBFP = Old Brahmaputra Flood Plain; PJFP = Padma/Jamuna Flood Plain

2. Based on rice production per cultivated area using the NCR average as a reference of 100

Source : CS 1992

C:\DFR\MAIN\LOTUS\BRIF-242.WK1

2.4.4 Social Infrastructure and Access to Basic Services

Communication

In the North Central Region, the railway adequately serves the eastern and the northern areas. Marketed crops are carried to the inland markets and sea-port mainly by water transport although the railway system carries a substantial portion of the raw jute and jute goods trade, as well as cereals. The development in the road communication infrastructure between the major urban centres in the region has triggered a rapidly increasing share of road communication in transporting goods from and to the region.

The regional railway mileage constitutes less than 10% of the national network. Although there is a relatively high proportion of the national highways inside the NCR (some 15% of the national highway), the minor unmetalled road mileage is not well developed, see Figure 2.10. The region has a well developed navigational network with 242 km of perennial (class 1&2) routes and more than 505 km of seasonal routes (class 3&4) see Figure 2.11.

People living in the flood plain are generally dependent on water transport, see SR VI.3, in the rainy season. Even in dry season it is often easier to carry goods by boats than by bullock carts to the market. From May to November the waterways are busier than all other forms of communications. Any adverse changes to the water transport system would obviously have a considerable negative impact on the overall transport system, although increasingly road transport is taking over from water transport, which may lead to water transport eventually only serving local needs and the transport of bulk goods. Information on physical infrastructure along with the information on access to social infrastructure and services in the region are presented in Table 2.10.

Industry

Excluding Dhaka, the NCR's regional industry and non-agricultural major activities employment is about the national average (at about 10% of the national labour force), however Dhaka itself accounts for a further 10% of the national labour force. The principal manufacturing activities are the fibre industry, chemicals and food industry. More than 21% of the national cottage industry units are located in the NCR.

Education

The literacy rate in the country in 1981 was 23.8 per cent (BBS 1981) and is estimated in 1991 to be 44.2 per cent. In 1981, Jamalpur (14.9 per cent), Mymensingh (17.6 per cent) and Tangail (20.2 per cent) were much below the national average; whereas the literacy rate for Dhaka district was higher than the national figure. Gender-wise segregated literacy data shows a relatively lower literacy rate for the female.

The number of primary schools in the region is about 9000 of which about 87% are government schools. About 90% of all primary schools are in urban areas where 36% of the total population is located. The number of teachers per school varies from district to district. For greater Dhaka district the number of teachers per school is about 4.9. Corresponding numbers for Jamalpur, Mymensingh and Tangail districts are 4.5, 3.9 and 4.6 respectively. Drop-out rates remain high and in 1988 the rate was 66.0 and 69.3 for boys and girls respectively (BES 1991).

TABLE 2.10

Brief Regional Description - Social Infrastructure; Transport and Communications

Districts		Jamalpur	Tangail	Gazipur	Mymensingh	Dhaka	Munshiganj	Manikganj	Narayanganj
Predominant sub-region 1/		JFP	JFP	MTS	MTN/OBFP	PJFP			
A) Social Infrastructure									
Hospital Beds/1000 pers		0.09	0.29	0.23	0.07	0.04	0.15	0.14	0.12
Doctors/1000 pers		0.015	0.06	0.06	0.01	0	0.04	0.06	0.15
Hats/Bazars Nr.pers/Bazar		12629	10524	6255	97095	53602	13245	7686	9346
Attending School	(%)	14	20	24	10	21	23	18	56
Households with Access to Tubewe	(%)	47	35	54	57	77	70	63	74
Village with electricity	(%)	4	9	32	11	14	25	4	56
B) Transport and Communications		JFP	MTN	OBFP	MTS	PJFP	Total(km)		
Area km²/Road km		12822	27581	7098	11138	30396			
Railway	% of NCR total	25	-	-	20	55	110		
Roads NHW	% of NCR total	35	9	27	18	11	417		
Roads RHW	% of NCR total	62				38	37		
Feeder Roads	% of NCR total	67		16	17	1	163		
Upazila Roads	% of NCR total	30	14	35	10	11	527		
Waterways-Class 1&2	% of NCR total	39	-	-	-	61	242		
Class 3&4	% of NCR total	42	0	4	14	40	505		

Notes : 1. JFP = Jamuna Flood Plain; MTS = Madhupur Tract South; MTN = Madhupur Tract North; OBFP = Old Brahmaputra Flood Plain; PJFP = Padma/Jamuna Flood Plain

2. Small : < 1 ha Medium : ≥ 1 ha - < 3 ha large : ≥ 3 ha

Source : CS 1992

C:\DFR\MAIN\LOTUS\BRIF-243.WK1

74 per cent of existing secondary schools are in urban areas. Unlike the primary education sector, most of the secondary schools are non-governmental. Colleges where pre-graduate general education is provided after completion of secondary schools are mostly located in Dhaka district. The North Central Region has the best facilities for provision of pre and post graduate general and professional education in the country.

Health and Sanitation

Acute shortage of health facilities are characteristic even for relatively developed area like Dhaka and Narayanganj (see Table 2.10). About half of all available hospitals, dispensaries, hospital beds and family welfare centres are in Dhaka district. Tangail and Jamalpur have relatively poorer infrastructure for providing medical assistance.

In recent years significant improvement has been achieved in the field of sanitation, and the number of households having access to potable water in the NCR districts is reported to be very high. Corresponding figures for Dhaka, Jamalpur, Mymensingh and Tangail districts are 98 per cent, 93 per cent, 87 per cent and 89 per cent respectively (BPC 1990). Table 2.10 shows the percentage of households having access to tubewells, and the variation between district is quite significant, with Tangail and Jamalpur Districts having rather poor access.

In terms of use of sanitary latrines figures for all NCR Districts, except Dhaka, show the need for immediate action to improve the situation. Only 5 to 10% of households in the NCR Districts use sanitary latrine (BOC 1990). Some strong action is being carried on health and sanitation improvement activities in some NCR Districts such as Dhaka, Manikganj, Mymensingh, both with governmental efforts and NGO activities.

2.4.5 Incidence of Poverty

Traditionally, there are two periods of seasonal food deficits, the first one from late September to early November, the second one being from late March to early May. The expansion of Boro crops has improved the situation in the summer months but the autumn lean season (coming after the planting of Aman) still affects the rural population severely as harvest is still more than a month away. The worst affected are the agricultural labour households, consisting of the landless and the marginal farmers. This is also the time of low job availability, and low wage rates with a decline in wages in the order of 30 to 40%. As wages decline, consumption of food by households also declines, with the most affected group being the daily labourers.

The NCR socio-economic survey (see SR IV) studied budgets of different household categories. The analysis shows that the landless households have a deficit budget and, with 74-84 per cent of total expenditure being on food, any fall in total income leads to a fall in expenditure available for food.

In the case of small farmers the socio-economic survey (SR IV), shows that food constitutes 42-60 per cent of total expenditure whereas for medium and large farmers, food expenditure is 29-46% and 27-45% of the total, respectively. The dependency on hired labour income of the landless is thereby indicated. Previous studies (BBS 1988 and BIDS 1988) have defined the first poverty line as a minimum of daily intake per capita of 2,122 calories and put the hard core poverty level at a minimum of 1805 calories (1535 calories in the BIDS study, equivalent to 437 gams of rice or wheat). Using these criteria, it has been estimated (IFPRI 1991) that around 80 per cent of agricultural labour households were below the poverty line in 1990.

Besides the agricultural households, some low income non-agricultural households may also be sufferers of malnutrition (these households may be daily labourers involved in non-agricultural activities, rickshaw pullers, petty traders etc.), as are some households of individuals working in the urban informal sector (the urban poor) who are expected to suffer from malnutrition.

Nutrition levels, see Table 2.11, show the intensity of food intake shortage during the slack period in the agricultural calendar (October 1991). This information together with the more general findings of the WFP Dhaka on the Thana Distress Level see Figure 2.12, suggest that the sub-region defined as the Jamuna Flood Plains is the area where the level of malnutrition is highest in the NCR.

TABLE 2.11

Distressed Households by District

Name of Greater Districts	No.of Sample Households	Distress Households % of household on 1 meal a day for 1-3 days a week
Dhaka	65	31
Tangail	19	39
Jamalpur	60	35
Mymensingh	37	32

Source : BIDS 1991

2.5 Subregions

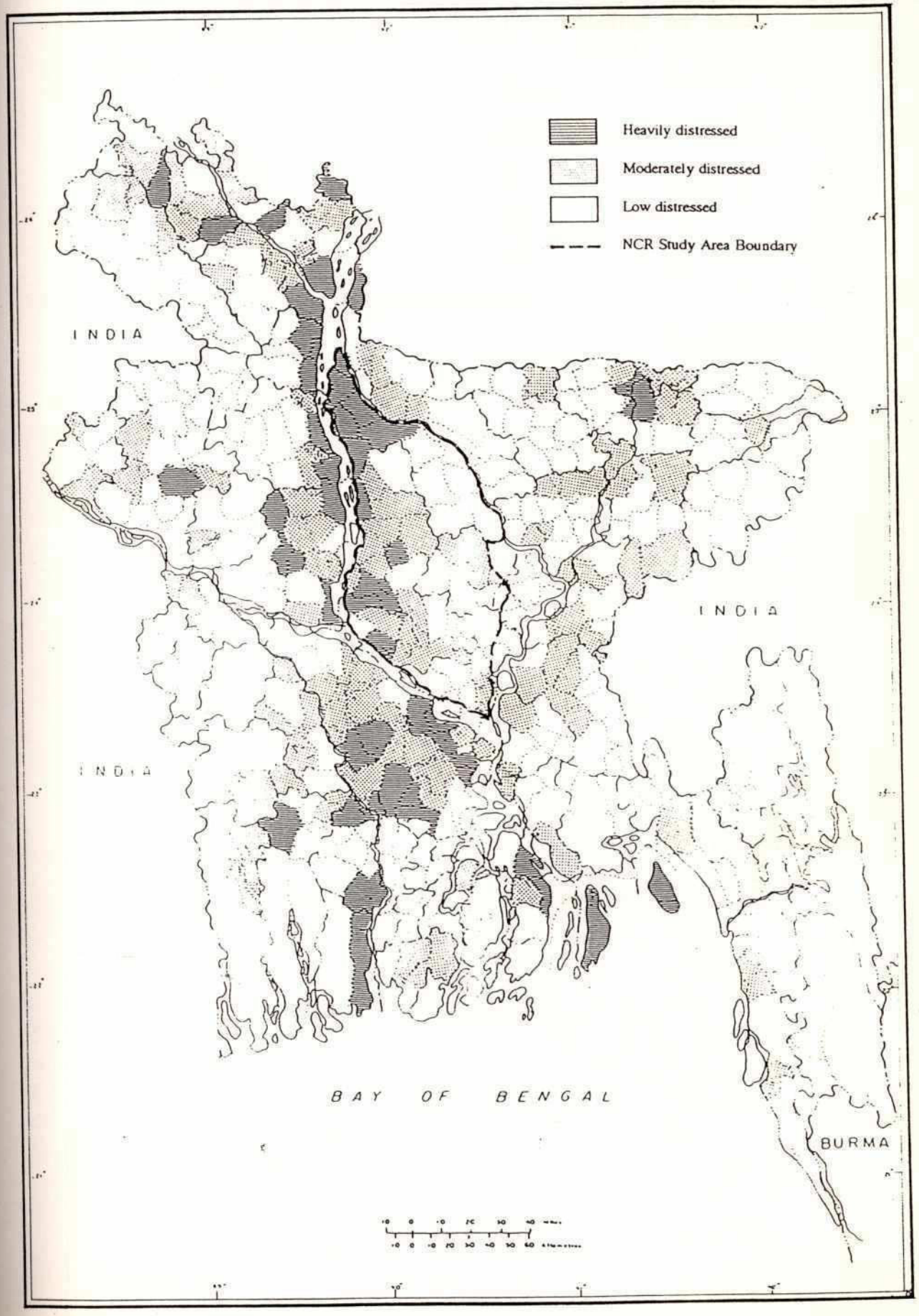
Within the NCR there is considerable variability in biophysical features and socio-economic conditions, both aspects being interdependent. The North Central Region has been influenced by the three major rivers forming its boundary, which have determined its physical characteristics.

Five subregions can be outlined in the NCR (see Figure 2.13) on the basis of biophysical and socio-economic features (which have important incidence on socio-economic aspects):-

- Jamuna Flood Plain 35% of NCR area
- Old Brahmaputra Flood Plain 20% of NCR area
- Madhupur Tract North 19% of NCR area
- Madhupur Tract South 11% of NCR area
- Padma Flood Plain 15% of NCR area

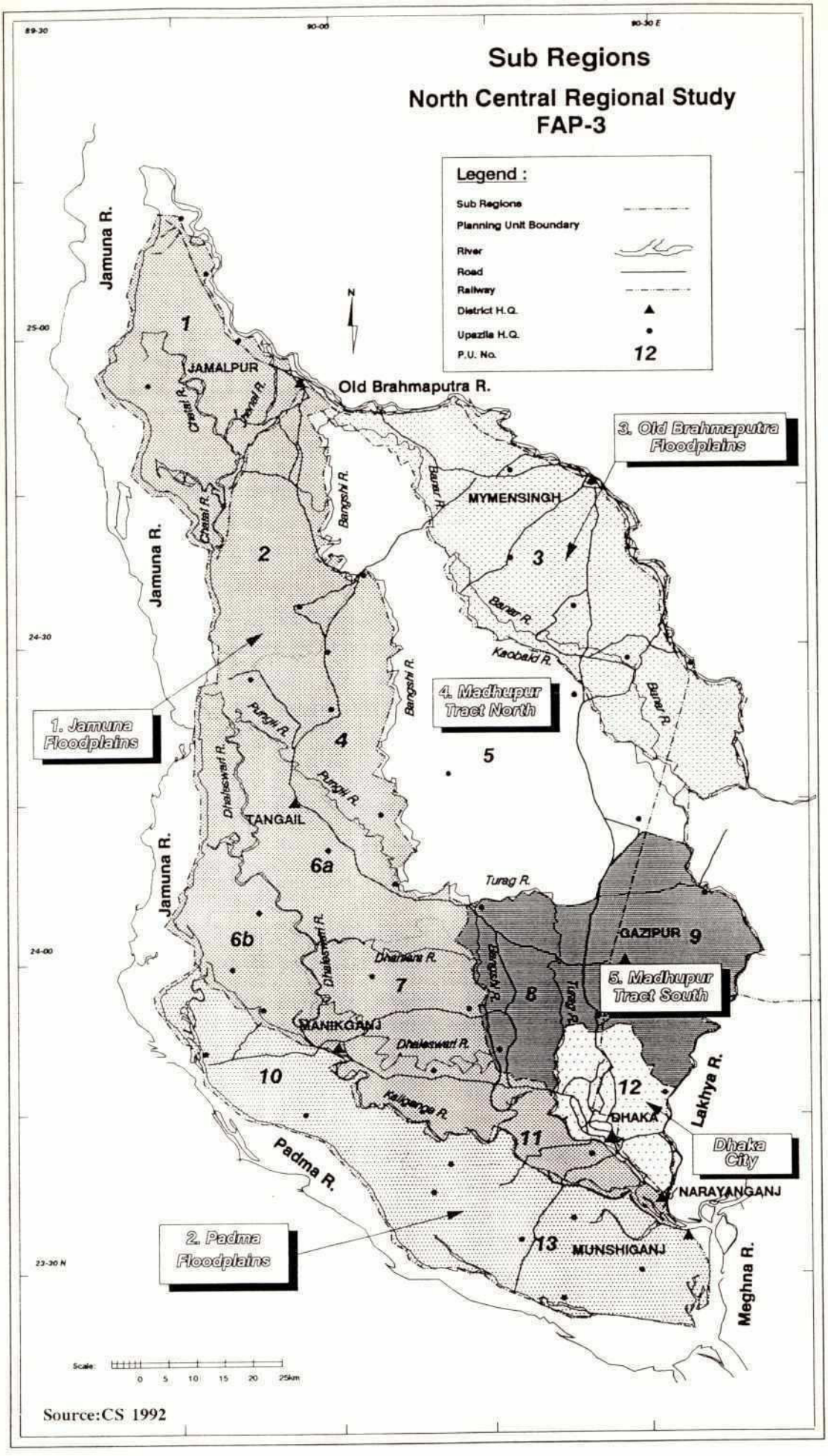
Figure : 2.12

Thana Distress Level - 1991



Source : WFP Dhaka

Figure : 2.13



Source:CS 1992

Jamuna Floodplain (Sub-regions 1)

The Jamuna Floodplain is extensively flooded (between 60 to 90% of total area) during the monsoon season. There are problems of drainage at the end of the monsoon season (depending on the variability in local relief) and of supplemental irrigation (on ridges and swales) during the dry season. The regular river flooding has resulted in locally thick layers of silt deposits which impacts on agriculture at a local level. Groundwater recharge is generally good.

The Jamuna floodplain is partly an active flood plain and is made up predominantly of sands and silts, with mainly loams on the ridges but with clays in the basins. On most of the soils a plough pan impedes internal drainage. The Jamuna is a major river and during the monsoon extends to more than five kilometres width. Flooding can occur from three sources, direct rainfall, direct overbank spillage from the Jamuna and overbank spillage from the internal regional rivers or tributaries.

The percentage of net cultivated area (more than 70%) and cropping intensity are comparatively high, particularly in the Jamalpur area (cropping intensity of 211%). This may be partly due to a recent increase in irrigation development. Besides this agricultural development, fishing activities are relatively important. The Jamuna production including rivers, beels and flood plain catches reach around 37% of the regional production.

The demographic pressure on land is generally not so high in the Jamuna flood plain as it is in the Padma flood plain. However in the eastern part of the Jamuna floodplain (near to Dhaka) a very significant growth of the industrial factories has occurred, similarly higher population densities occur near to Jamalpur, and Tangail. Near Dhaka more than 30% of the total population is engaged in the industrial sector and more than 15% in the wholesale and trade sectors whereas the other districts of the region have less than 5% and 3% respectively in these sectors. The road and railway network are generally hampered by the nature of the land, but the Jamuna flood plain is comparatively well covered. Navigational routes are well used in the sub-region, see Figure 2.10.

Padma Floodplain (Sub-region 2)

The Padma Floodplain forms the south west and south of the NCR and receives flood water from both the Padma and the Jamuna through their tributaries. Seasonal flooding occurs from either direct rainfall or direct overbank spillage from the Padma and/or the Dhaleswari/Kaliganga. The flooding reaches around 0.6-1.5 metres on the highest ridge and more than 3 metres in the lower basins for four to six months. Calcareous dark grey flood plain soils occupy most of the Padma flood plain usually in association with calcareous Brown flood plain soils. Basin soils crack widely when dry. Groundwater recharge is generally good.

The Padma Floodplain is extensively flooded during the monsoon season (up to 90%) and has problems of drainage due to the high water levels experienced in the Padma and at the confluence with the Meghna. Arial Beel is the largest beel in the North Central Region and is located in the middle of this sub-region. It remains deeply flooded for most of the monsoon season, but is now subsequently drained and allows for substantial rice production.

There is relatively intensive production of potatoes and vegetables in the south-east part of the Region, close to Dhaka and fishing activities are relatively important in the sub-region. The Padma production including rivers, beels and flood plain catches reach around 21% of the regional production.

Old Brahmaputra (Sub-Region 3)

In average years, less than 50% of the Old Brahmaputra flood plain area is flooded during the monsoon season. The Old Brahmaputra flows to the north east and passes by Jamalpur and Mymensingh towns. Before the 19th century the river carried more water than at present and had built up high levees. At that time there was a major bifurcation of flows so that now the majority of the Brahmaputra discharge flows down the Jamuna, and the Old Brahmaputra takes only a small proportion of total Brahmaputra flows so that the river rarely overtops. However spillage did still occur upstream of Jamalpur during the 1988 flood.

In the south of the sub-region there is a depression between the Old Brahmaputra river and the Madhupur Tract. Recent deposits of the Old Brahmaputra are non-calcareous alluvium. These soils are mainly grey silts or sands and are neutral to moderately alkaline after long submergence but become moderately to strongly acidic on drying out.

This Old Brahmaputra subregion has a relief of irregular ridges and depressions. Waterlogging and drainage problems occur in the depressions during the monsoon season whereas drought conditions frequently occurs on the ridges and high areas. Most of the flooding is from rainfall runoff and the possibilities of improved drainage are limited downstream by the Padma-Dhaleswari-Meghna system which is affected by tides.

The percentage of net cultivated area is high (around 75%), as are the cropping intensities (about 189%), but the aquifer conditions are relatively unfavourable and irrigation meets some 34% of the estimated eventual potential irrigation demand. The dry season water levels in the aquifer are generally too deep for shallow tubewell (STWs) development and irrigation, being mainly dependent on deep tubewells (DTWs), is only used on about 30% of the cultivated area.

Around 57% of the NCR's beel capture fishery is found in the Old Brahmaputra floodplain. It is nearly 20% of the NCR's floodplain fish production, more or less the average value of all sub-regions.

The sub-region is well connected by highway and railway to Dhaka and there is a significant trading activity with a high level of persons engaged in the cottage industry sector (the highest outside Dhaka).

Madhupur Tract North and South (Sub-Region 4 and 5)

The Madhupur Tract is generally elevated consisting of an extensive Pleistocene Formation. Its fringe areas have merged with the recent floodplain (to the east and west), while the area as a whole has been dissected by innumerable creeks and channels. The northern part is a plateau, flanking narrow valleys (mostly flattened and terraced for rice cultivation). Less than 25% of this subregion is flooded during the monsoon season only by local runoff and face local drainage problems.

Most of the upland of the Madhupur Tract has thick layers of moderately well drained permeable silty clays with heavy clays in the valleys. But some of the level uplands have impervious clay subsoils. Soil erosion is often observed after deforestation.

The northern part, of the Tract has a relatively low density of population (between 400 and 600 inhab./sq.km). The soils are clayey and generally deficient in nitrogen, phosphorus, potassium and lime. The percentage of cultivated area is less than 60% and the cropping intensity less than 170%. Irrigation is only used on about 35% of the cultivated area due to unfavourable relief, soils and aquifer conditions. The capture fishery is low and constitutes here about 11% of the regional production. The non-farm activity level is comparatively low; 20% of the total number of households are non-farm households against a regional average of 30%.

The southern part however, has a different topography. Most of the terrace is almost flat in relief, except where streams have cut across it. The terrace presents a marked elevation because of the entrenched drainage pattern and the dissected nature of the Tract. Between 30 to 40% of the sub-region is flooded during the monsoon season, which is much less than in the Padma flood plain to the south.

The southern part has a slightly higher density of population but is still low for the region (between 600 and 1000 inhab./sq.km). The percentage of cultivated area is between 60 and 70% of the subregion area, and the cropping intensity is about 175%. The irrigated area is 45% of the cultivated area also with unfavourable aquifer conditions. Only 7% of the regional capture fishery are met in this subregion.

The southern Madhupur Tract is well served by roads and benefits from non-agricultural activities (trading, cottage industry, and petty services) related to the vicinity of Dhaka city. They are more important than in the northern sub-region.

Characteristics of the five sub-regions are summarised in Table 2.12. The general view about the North Central Region indicates that the hydrological conditions are the most significant environmental factors that determine the cropping patterns, cultivating practices and productivity; in particular the annual rainfall frequency, depth of flooding and drainage. Flooding and land drainage conditions especially affect the fertile and densely inhabited Jamuna and Padma floodplains. These plains form around 50% of the NCR area. These factors are described further in Section 2.3 and SR II.

TABLE 2.12
Brief Regional Description – Physical Systems

Sub Region 1/	JFP	MTN	MTS	OBFP	PFP
A) **Physiographic Subregions**					
Physiographic Units	Jamuna Flood Plain	Madhupur Tract North	Madhupur Tract South	Old Brahmaputra Flood Plain	Padma Flood Plain
Districts Concerned	Jamalpur W.+Tangail W.	Tangail E + Mymensingh S.W.		Mymensingh N.W.	Manikganj + Munshiganj
Area as % of NCR	35%	19%	11%	20%	15%
B) **Groundwater System**					
% of potential resource already exploited by shallow tubewells	37 to 52%	12%	10%	5%	14 to 36%
SWL (m)	6.5 to 7.5	>10	>11	>11.5	3.5 to 6.5
Storage Coef.(%)	7 to 12.5	3.5	1 to 3	2	2 to 6
DTW Specific capacity 1/s/m	10 to 17	7	6	6.5	8 to 12.5
C) **Soils**					
Principal Type	Grey Flood Plain soils, non-saline phase	Red-brown Terrace soils	Red-brown Terrace soils & Dark Grey Flood Plain Soils	Dark Grey F.S. & Acid Basin Clays	Dark Grey F.S.
Texture of Ridge	Sandy & Sandy loams	-	-	Sandy	Sandy loams
Texture of Swales	Loams	-	-	Loams	Loams
Texture of Basin	Clays	Heavy Clays	Clays	Clays	Heavy Clays
Upland	-	Clays	Clays	-	-
Permeability	Variable	Moderate to low	Moderate to low	Moderate to low	Variable
D) **Hydrological Conditions**					
Climate	Mean rainfall : < 200cm Vegetative growth throughout the year	Mean rainfall:175-200cm alternation of drought and wetness	Mean rainfall:175-200cm alternation of drought and wetness	Mean rainfall:>200cm vegetative growth throughout the year. Except locally during the dry season	Mean rainfall:<175cm Vegetative growth throughout the year
Mean Annual Flooded Area (% gross area)	60% (annual ecological changes with flooding and erosion)	<25% (ecological changes very locally)	30 - 40% (ecological changes very locally)	< 50% (ecological changes locally)	90% Annual ecological change with flooding)
Demographic Pressure & land suitability index (Cultivated area % gross area)	79%	57% (deforestation and erosion)	60%	75%	72% (water pollution near Dhaka)

Note : 1. JFP = Jamuna Flood Plain, MTN = Madhupur Tract North, MTS = Madhupur Tract South, OBFP = Old Brahmaputra Flood Plain, PFP = Padma Flood Plain.

CHAPTER 3
REGIONAL STRATEGY

3.1 Methodology

The preparation of the Regional Water Resources Development Plan (RWRDP) has involved much field work, data collection, analysis, gathering of views and the coordination of many disciplines. The NCRS has been 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, see Table 1.1, and other activities of particular relevance to FAP 3 are described in Section 1.1.3 above.

The approach to planning and impact assessment follows the Guidelines on Project Assessment prepared by the FPCO (FPCO 1991), with information from MPO/WARPO being utilised where appropriate.

The main stages in the preparation of the RWRDP have been first to develop a water development strategy, identify priority areas for development, carry out pre-feasibility studies of priority regional schemes and then to prepare and present a regional water resources development plan. The NCRS has also prepared supporting reports which are submitted along with the RWRDP(see Table 1.2).

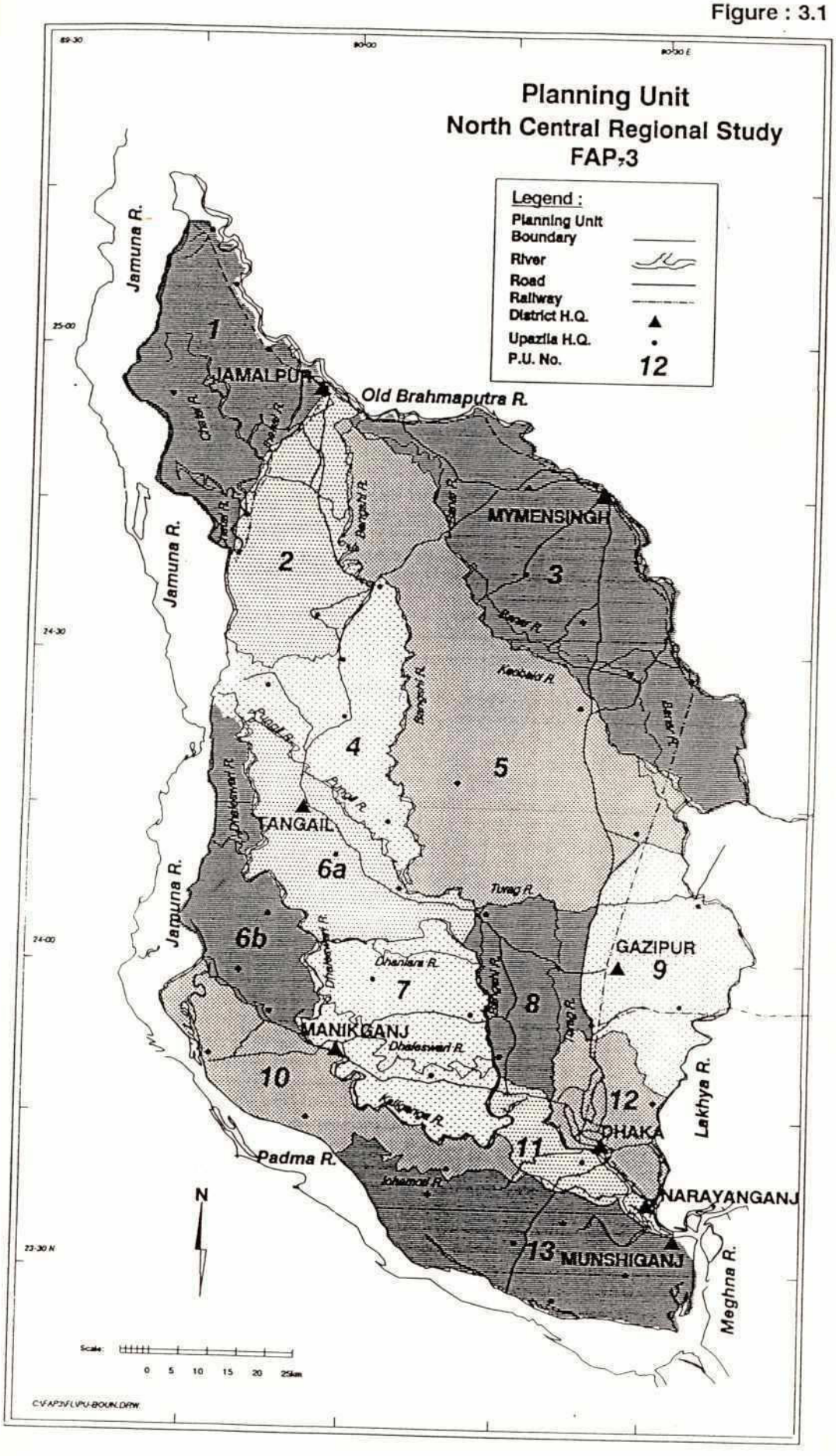
The Region has been divided into Planning Units (PUs) to assist in classifying the characteristics of the region, and to allow alternative development strategies to be prepared for different PUs. These PUs have been delineated using hydrological characteristics, but also allowing for resource characteristics such as soils, land use, population intensities and considering administrative boundaries where significant. Thirteen PUs have been designated (see Figure 3.1). Consideration was given to using the MPO planning areas for this purpose (see SR IX and Figure IX.2.1), however it was found that the MPO planning areas were delineated along catchment boundaries which is not well suited for defining regional scheme boundaries as these schemes are generally bounded by rivers (not catchments). 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.

Subsequently, the characteristics of the PUs have been compared and the results indicate that the NCR can be broadly categorised as falling into 5 characteristic sub-regions (see Figure 2.13). This categorisation has allowed for priority areas to be identified as is described in Section 3.3 below. The development strategies and options identified are seen to apply to more than one Planning Unit, and thus the PUs can be regrouped into Development Areas (DAs), see Figure 3.2. The primary analysis, however, has been carried out on a Planning Units basis with PUs being analysed using a multi-disciplinary approach. The results of this analysis are presented in SR IX.

3.2 Natural and Socio-economic Environment

The descriptions given in Sections 2.3 and 2.4 enable a summary of the major problems relating to the sub-regions and their planning units to be given, see Table 3.1. A high level of malnutrition has developed in parts of the Jamuna and Padma Flood Plains where significant flooding occurs. Population pressure in the southern parts of these areas worsens this situation. In the northern Madhupur Tract, population pressure, even though not very high, has detrimental consequences to the poor natural resources (however this is linked with the poor land quality and limited water resources, and not the flooding).

Figure : 3.1


Planning Unit
North Central Regional Study
FAP-3
Legend :
Planning Unit Boundary
River
Road
Railway
District H.Q.
Upazila H.Q.
P.U. No.
12
Jamuna R.
JAMALPUR
Old Brahmaputra R.
MYMENSINGH
TANGAIL
GAZIPUR
MANIKGANJ
DHAKA
NARAYANGANJ
MUNSHIGANJ
Padma R.
Lakhya R.
Meghna R.
Dhaleswari R.
Turag R.
Kaliganga R.
Johanna R.
N
Scale:
0 5 10 15 20 25km

Generating Process of Development Options

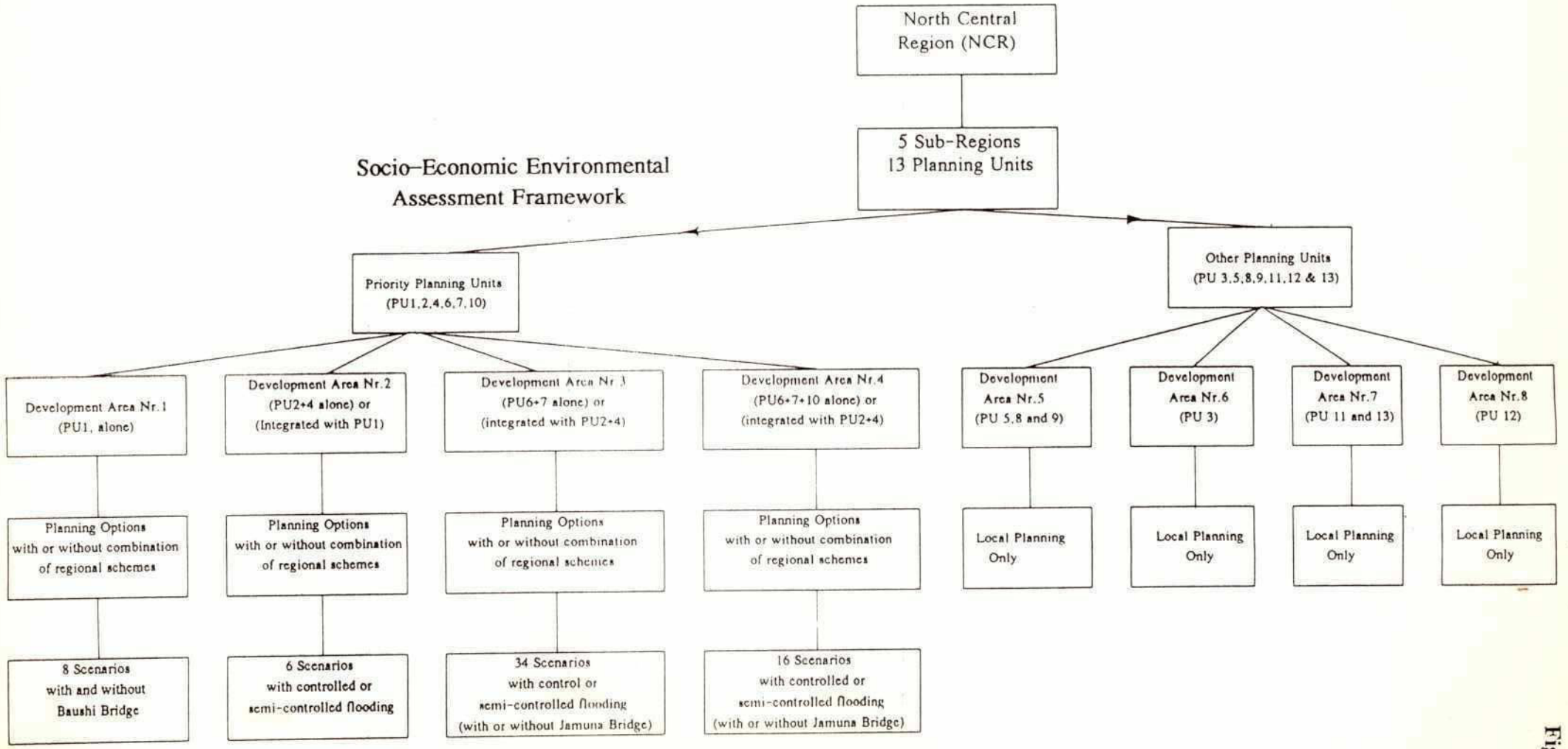


Figure 3.2

TABLE 3.1
Major Problems
Relating to the Sub-Regions and their Planning Units

Major Problems	Jamuna Flood Plain	Madhupur Tract		Padma Flood Plain	Old Brahmaputra Flood Plain
		North	South		
	PU1,PU2+PU4, PU6+PU7	PU5	PU8, PU9	PU10+PU11,PU13	PU3
A. Physical Aspects					
Vulnerability to River Flooding	xxx	x	x	xxx	x
Drainage constraints	xx (Basins)	x (Valleys)	x (Valley & Basins)	xxx (Basins)	xx
Vulnerability to Dry season	xx (Ridge, Swales)	xxx (Uplands)	x (Swales, Uplands)	x (Ridge, Swales)	xx (Ridges, Swales)
B. Socio-Economic/Environmental Aspects					
Impacts of Demographic Pressure on:					
- Malnutrition	xx	x	x	xxx	x *
- Cultivable land	x	x	x	xxx	xx
- Biomass resources (national growth)	x	xxx	x	x	x
- Fishery resources	x	x	x	xxx	x
- Groundwater resources		xxx	xx		x
Employment	xx	x	x	xxx	x

Note : xxx Significant xx Moderate x Minor

* : xxx for Mymensingh area

Increasing cropping intensity and the use of high yielding varieties may lead to a decrease in the existing biological diversity in the Region, see SR V - Section 3.5. The situation is worsened by deforestation in the Madhupur sub-regions and by increased agricultural productivity and the drying up of wetlands for winter rice cultivation in the flood plains. The extent of pollution due to an increase of pesticide and fertilizer use threatens areas of fisheries, wild life, and water bodies used for domestic purpose. The quantifiable evidence on these phenomena are not currently available and they are not presently determining factors when differentiating sub-regions as planning units for planning purposes. However, there is a high degree of variability concerning both biophysical and socio-economic features in the North Central Region, and they will have to be seriously considered when preparing more detailed studies.

Regional development should reduce the internal imbalance and raise the income of the whole region to avoid over concentration of population around some urban centres. Increasing attention is being paid to sub-region growth by planners because it has been observed that some areas are progressing satisfactorily while most other areas are lagging far behind.

The quality of life is very poor for the vast majority in NCR. There is one medical practitioner for more than 4,500 persons and one hospital bed for more than 3,500 persons. Calorific intake is four fifths of the estimated requirement of 2,300 calories per day.

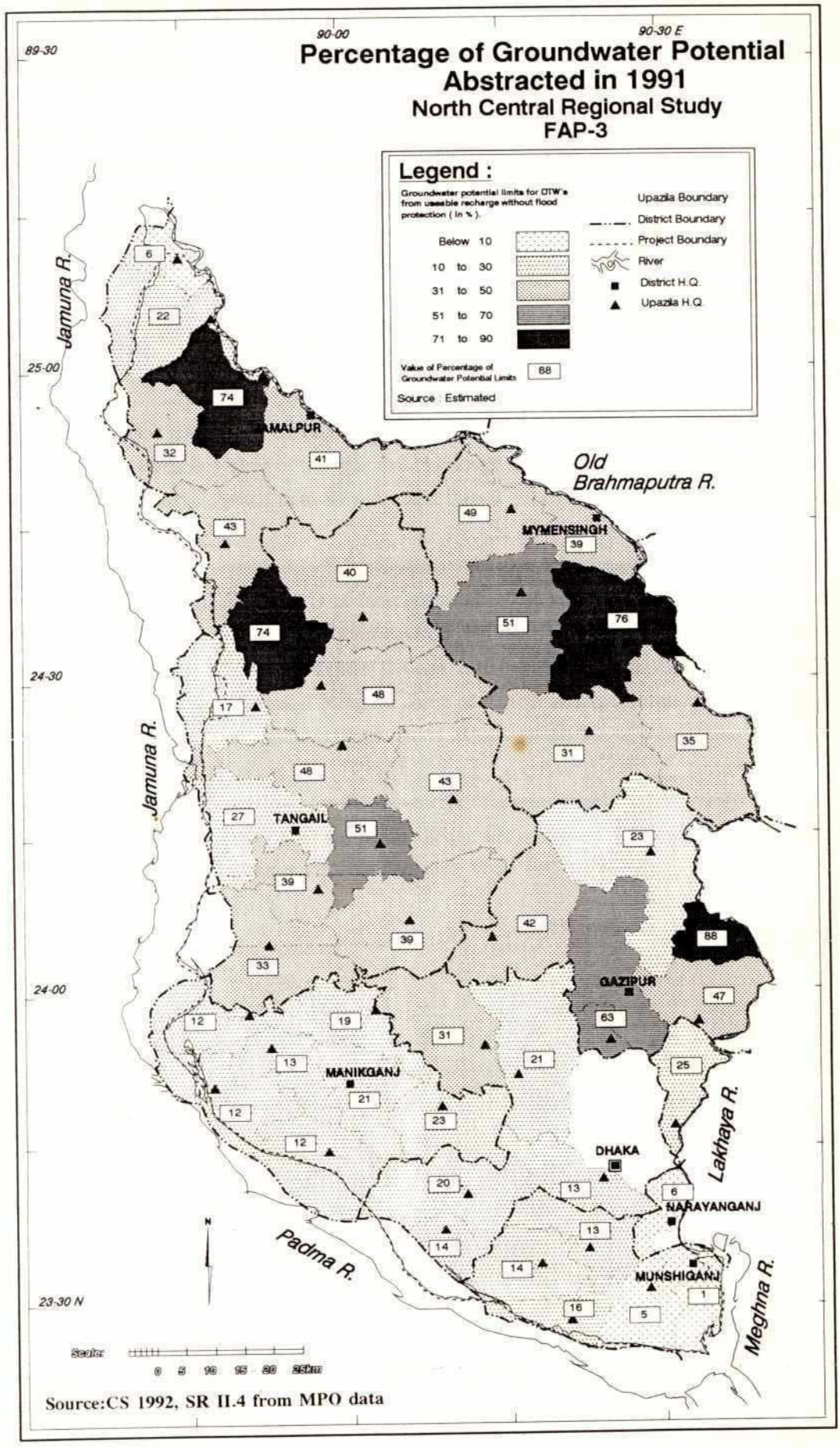
The fragility of survival among the poor people (destitute, landless, non-agricultural wage labour, small farmers) is reflected by the meagre returns they receive and the degree to which they depend upon the market in the absence of the ability to provide for their own subsistence. This fragility is more apparent in areas susceptible to river floods.

The process of agricultural development has shown significant progress in the past few years, though limited to a few specific areas (irrigation near Jamalpur and Mymensingh, growing of fruits and vegetables west of Dhaka, etc.). More widespread efforts will be needed in the near future. The potential for agricultural development still remains high and will concern mainly the shift to HYV which will be possible through flood protection, drainage and better water management, see SR I. A substantial increase of cropping intensity is possible through irrigation of boro crops, it will concern mainly the western part of the region. It is believed that these measures will not be sufficient to solve the problems of the NCR in the long term (and also in the short term for specific areas in the Madhupur Tract and the Brahmaputra Flood Plain).

Considerable efforts are needed to create additional employment in the non-agricultural sectors mainly in industry, and this will require investigations which are not part of this study's TOR, but fall within the Government's fourth five year plan. There is need for further irrigation developments which will be based on a comprehensive and complementary use of both surface and ground-water resources. A significant development of irrigation for boro crop has taken place recently (particularly with STWs) and some supplemental irrigation of aus and aman crops, see Figure 3.3. This will continue in the future as far as resources allow, see Figure 2.8, mainly under private initiative. The water development strategy ensuring an effective flood control is developed below.

Medium scale industries ideally suited to the small towns of NCR are rather rare. The main drawbacks to the extension of industry in each subregion are the cost of fuel, the difficulty of transporting materials and production, and the very poor rate of credit repayment by the borrowers. In such conditions industry and cottage industry do not presently provide sufficient employment opportunities in the very densely populated areas.

Figure : 3.3



Source:CS 1992, SR II.4 from MPO data

3.3 Water Development Strategy

3.3.1 Strategic Background

It should be stressed that the water development strategy should not be considered in isolation, and should take account of the socio-economic, environmental and national planning considerations. Water resources development may prove to be a leading force in rural development or it may just be an accompanying measure, particularly where small scale developments are concerned. The environmental and socio-economic overview presented in the preceding sections allows us to present the major problems and pre-conditions for rural development. It must be underlined that the present economic conditions of Bangladesh do not allow for a broad range of possibilities for financing regional development. This is particularly true for rural development. Bangladesh cannot afford to support development projects that would be uneconomic, as is recognised by the GOB.

For regional development the government undertakes various actions to improve the present socio-economic situation of the NCR. Figure 3.4 summarises some of the principal objectives, measures and actions which are required, and it can be seen that if water development is to be successful then it must be carried out along with several other complementary activities.

In other respects, the small size of the majority of farm households does not allow for any significant build up of regional savings. As illustrated by Figure 3.5, a rural development project should generate important and positive socio-economic effects induced by farm activities through agro-industrial or non-agricultural complementary development. On the other hand it must avoid being the cause of substantial losses resulting from an inappropriate use of natural resources, or from an unbalanced development inducing migration of population.

The above considerations set the background for the framework of a water development strategy which is outlined in Section 3.3.2. Some of the objectives given may be conflicting and a decision has to be made as to which issues take priority (e.g. is growth or equity the prime consideration). These issues will have to be decided at a national planning level.

3.3.2 Framework of the Strategy

The NCR has been subdivided into Planning Units (PU) so that the specific features related to biophysical and socio-economic environments can be identified and grouped together into homogeneous areas. The characteristics of each PU are given in SR IX for hydro-meteorological features (such as rainfall, frequency and depth of flooding, drainage patterns, river activity and instability), and socio-economic conditions (population, infrastructures, activities).

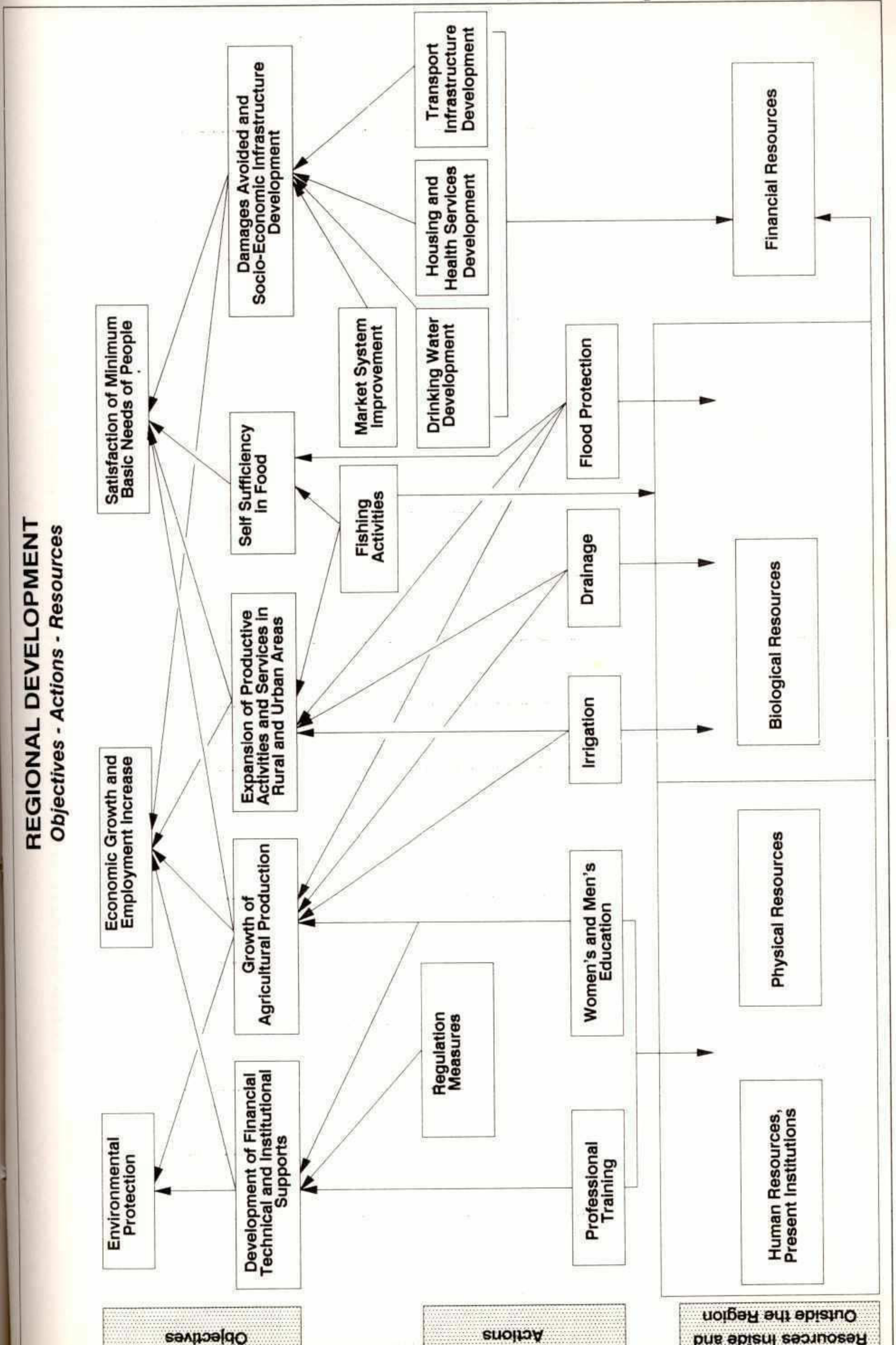
Economically Viable Developments

(B)

Investment costs and resultant added values (direct plus indirect) must be balanced in order to define economically viable developments. In areas where there is the potential for significant increases of the agricultural value, the major flood infrastructures may be justified. On the contrary where the opportunities to sufficiently increase the present level of added value are low then only single low cost water management techniques and non-structural development will be justifiable.

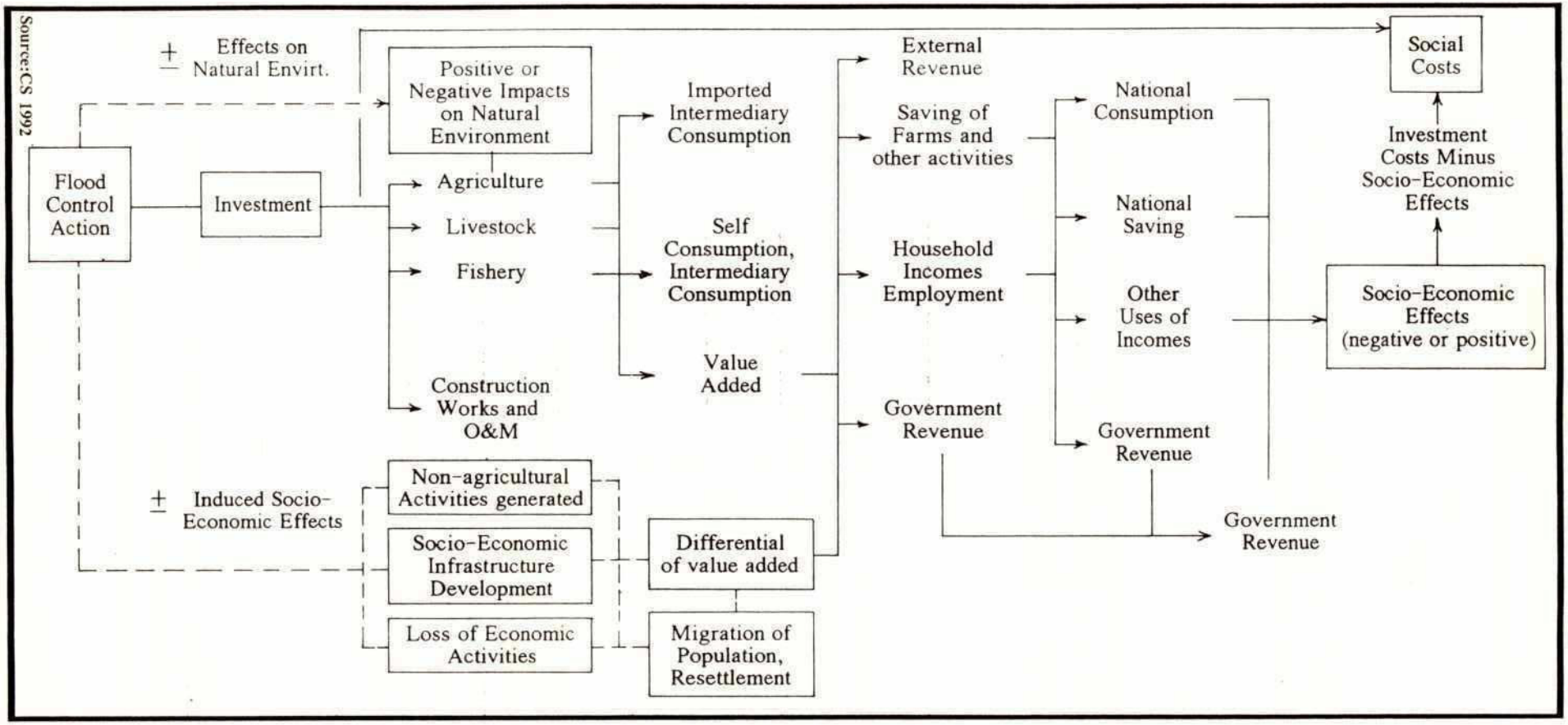
Figure : 3.4

Regional Development



Source:CS 1992

ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS OF A FLOOD CONTROL DEVELOPMENT



C:\123\CENGVREGI-LAG.WK1

Figure : 3.5

However, in the initial planning approach, as the required basic data are not available to assess correctly the flood phase changes resulting from various options, economic criteria will be used with caution. Other criteria may have a higher weighting when ranking the development options. It is clear that economic criteria have to remain the basic ones when performing feasibility studies.

Distressed Sub-Regions

Priority should be given to heavily distressed and densely populated subregions, because without intervention these vulnerable zones can induce important social costs. Areas concerned are essentially in the Jamuna and Padma Flood Plains (PU1, PU2, PU4, PU6, PU7 PU10).

Socio-Economic Framework

In order to lower social costs it is better to develop first those subregions where a socio-economic framework already exists to enable economic growth to be sustained so that direct and indirect value added can be raised quickly to a maximum. This aspect is one of the factors considered in the multicriteria analysis in Section 6.4 (further explanation is given in SR X, section 1.4.2).

Participation

The success of any water resource development project depends largely on its acceptance by the local community and on the active participation and co-operation of individual farmers. Thus it is important to involve the farmers in the management of flood control programmes. This should at least be done at the field level but such an approach requires a long time for informing the public and preparing local communities before carrying out construction works. A participatory approach to planning, construction, operation and maintenance is being evolved by the FAP. This will include the involvement of some local organisations working with the help of government authorities to take and sustain the major initiative and to bear a major socio-economic effect. FAP 12 has concluded that all groups should be involved from the planning stage through to implementation.

Participation at this pre-feasibility level of Regional Planning has consisted of contacts between the Consultants and concerned parties (Government authorities, local government, NGO's and local people). This has taken place both through the individual specialists enquiries and through the socio-economic and agro-economic surveys. Detailed discussions of proposed plans have not yet been held as the present report will form the framework for such discussions to take place. The TOR for the feasibility level of studies include for a substantial element of public participation in both planning and implementation. Further discussion is given on this aspect in the Institutions Report (SR IV.2).

Local Economic Initiatives

For the optimum benefit to be obtained from a water resource development plan, local economic initiative should be encouraged to make full use of the opportunities created by agriculture, livestock, fishery. In this way there would be both a growth of the regional value added and also improvements in the local employment situation.

Such economic promotion would only be possible with the introduction of new institutional measures, changes in economic policy, research and supporting service strengthening towards agricultural and industrial sectors. Other appropriate initiatives would be to assist in setting up small off-farm ventures to benefit disadvantaged groups (such as the landless and women). Such initiatives could be implemented through incorporating any proposed water resources schemes within an integrated rural development project which would extend beyond the end of engineering construction periods.

Multipurpose Use of Developments

Due to the pressure on resources it is important, where possible, to utilise new developments such as proposed embankments for more than just flood protection. Consideration will be given for incorporating multipurpose infrastructure for example using embankments as roads, for cultivation of crops, livestock and for settlements. Such initiatives require the participation of the land owners, and although it will require the use of more land it should help ease the problems of land acquisition and discourage public cuts. These possibilities used to be specified further at feasibility study stage.

Mitigatory Measures

Mitigatory measures will be required wherever groups or persons are adversely affected by the implementation of a proposed development. Such measures in the NCR should include navigational locks for boats, beel conservation areas, plan modifications to allow for fish movements and other measures for disadvantaged groups. The precise mitigatory measures required will have to be identified and assessed at feasibility study level and included in the costings for evaluation before preceding with the possible scheme. Only qualitative assessment of the scale of mitigatory measures requires have been included in the analysis at the present pre-feasibility study level.

Environmental Management Programme

An environmental management programme (EMP) should be instigated that ensures that the future developments improve rather than degrade the natural resources of the region. It is proposed to include elements of this program in the TOR for the next Feasibility Study, following the guidelines recently developed by the FAP (FAP16 1992)

3.3.3 Development Options

General

Development options can be broadly categorised as "structural" and "other" options for flood damage mitigation. The "other" options are essentially non-structural although they may include some structural element. The planning approach for the North Central Region gives due attention to both.

Structural development options are based on the concepts of controlled flooding and controlled drainage whether partial or full. The degree of control which can be imposed on both flooding and drainage within an area are dependent on the structural measures which are applied and the efficiency and effectiveness of the water management system. These controls are also limited by physical constraints, such as the limits to drainage imposed by the high water levels that occur at the Megna/Padma confluence. The degree of control of flooding and drainage which is required is also 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 is an approach which should 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 micro relief within each sub-region
- topography (e.g. Arial Beel)

The development options are proposed to address the problems caused by the above situations.

Structural Development Options

Two main structural development options are being studied, as follows:

- fully controlled flooding and drainage, based on full flood control along the major rivers by embankments and fully gated structures, and major drainage improvements;

- semi-controlled flooding and drainage, where flooding depends partly on embankments with fully gated structures, and partly on natural openings or semi-regulated ones.

These options are being refined by sub-region in order to obtain an optimum development situation according to technical, economical, financial, social and environmental criteria. They are compared to a reference option consisting of minor local drainage improvements and flood proofing.

All these "structural options" also consider additional non-structural options, as described below.

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 - (water management systems comprising peripheral inlet/outlet structures, internal water control works, channel improvement, and infrastructure improvements).
- development of rural & urban unprotected or partially protected areas in terms of flood proofing.

Within the various sub-regions of the North Central Region, compartmentalisation is expected to play a key role in all future development scenarios. The compartmentalisation of protected areas creating water management units organised by the local beneficiaries supported technically by the local institutions. Additional benefits are seen to come from compartments in terms of mitigating and distributing damage caused by the failure of part of an embankment adjacent to a major river.

Other Development Options

In addition to the mainly structural options, there are other options for flood damage mitigation which are essentially non-structural although they may include some structural element. These "others options" include:

- flood zoning
- flood preparedness
- early warning systems (linked to flood preparedness)
- flood proofing or adjustment

Each of these structural and non-structural options require a significant amount of study and include social, institutional and environmental considerations and programmes. The characteristics of some will vary from sub-region to sub-region, although a general approach to certain initiatives such as flood proofing is expected to be developed under the FAP.

The particular studies involved include :

- topography and mapping ;
- river morphology;
- hydrology and hydraulic modelling;
- flooding - occurrence and frequency, location and extent;
- drainage - internal river/drainage system, outfalls, congestion and backwater effects;
- general water resources - surface and groundwater;
- land use;
- agriculture - cropping patterns, yields, irrigation and livestock;
- fisheries;
- forestry;
- urban development
- rural development
- communications, marketing and other productive sectors including rural industries;
- agricultural economics;
- socio-economics;
- social programmes through NGOs etc.;
- environment, and
- national and rural institutions.

3.3.4 Preliminary Screening of Development Options

Flood mitigation actions

Appropriate flood mitigation actions are summarised in Figure 3.6 for each PU, after considering the main physical development constraints.

Development Options and Priorities

Taking into account the strategic conditions enumerated above and the principal socio-economic development and environmental protection measures needed for improving the present situation of each subregion, it is possible to recommend the development options which are needed in each PU based on flood control and water management (see Table 3.2). A preliminary discussion is outlined below, but the full multicriteria analysis is given in Section 6.4.

The agriculture in the subregions of Jamuna and Padma flood plains is constrained by heavy flooding in the kharif season, whereas the other subregions are less affected by flooding. The main constraints to agriculture in PUs 3,5,8 and 9 are rather water shortage (in the rabi season), local drainage and land reclamation. Development of social infrastructure and of non-agricultural economic activities are also basic needs.

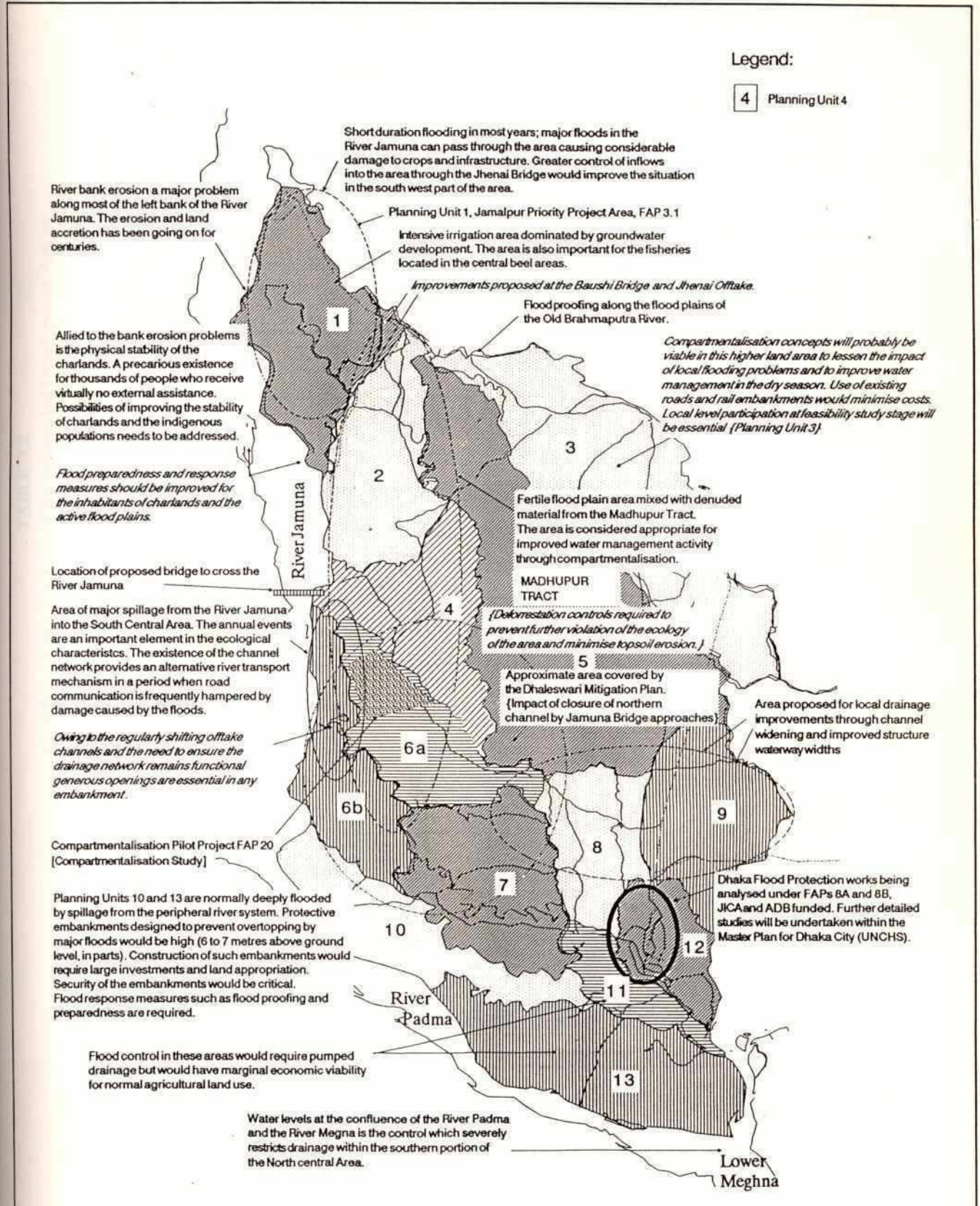
Among the Jamuna and Padma flood plains PUs 1,2,4,6,7 and 10 are the more distressed areas; PUs 1,6 and 7 have the advantage of a socio-economic framework able to sustain economic growth generated by a water resource development project (see SR 1.4.2).

In PU 1 there are contrasted situations. Normal flooding is not a problem in the central and eastern parts which have already a high level of productivity. Floods are serious in the western part near the Jamuna, and restricted drainage in the southern part means a long flood duration. These aspects are being studied in more detail by the FAP 3.1 feasibility study.

As far as average years are concerned, farmers welcome shallow floods which improve the fertility of the soil. However early, high or late floods can cause damage and the farmers will either adjust their cropping patterns to minimise the damage risk (usually by planting lower cost and lower yielding varieties) or suffer extensive damages. At the end of the monsoon the higher lands need supplemental irrigation for intensive cropping whereas the lower lands are in need of drainage.

The water requirement situation is seen to be complex and there is a need to aim for better water management conditions. Some progress can be made by the implementation of recommended actions including some degree of flood protection by rehabilitating/extending existing western embankments; drainage; extension of irrigation; small water management projects. These should be accompanied by flood warning, flood preparedness and flood proofing projects in the areas which cannot be protected, or when the protection is considered uneconomic, or when flood protection may not be implemented for some time. A major factor, however, is institutional as any water management proposal should be agreed by all concerned parties. Obtaining such agreement, particularly where it may involve some concessions on the part of farmers and/or others, proves difficult. The compartmentalisation concept is regarded as appropriate in this regard and the pilot project of FAP 20 is particularly significant.

Figure : 3.6
Development Considerations



Source: CS 1992

TABLE 3.2
Identification and Location of Recommended Development Actions

Actors	Socio-Economic Development and Environmental Protection Needed	SUB-REGIONS											
		JFP					MTN	MTS		PFP			OBFP
		PU1	PU2	PU4	PU6	PU7	PU5	PU8	PU9	PU10	PU11	PU13	PU3
Governmental	o Major Hydraulic Infrastructure (Flood control & Drainage)	x	x	x	x	x				x			
	o Local drainage/Compartmentalisation							x	x				x
	o Urbanisation- Household Settlement-Communication							x	x		x	x	
	o Land preservation	x					x			x			
	o Support to industrialisation	x	x	x	x	x	x	x	x	x	x	x	x
	o Institutional improvements	x	x	x	x	x	x	x	x	x	x	x	x
	o Programmes for distress people	x	x	x	x	x	x	x	x	x	x	x	x
NGO	o Forest						x						
	o Food	x	x	x	x					x			
	o Education Mass Awareness	x	x	x	x		x			x			
	o Environment management						x						
	o Wild life preservation						x						
People (and Local Organisations)	o Small hydroagricultural development	x	x	x	x	x	x	x	x	x	x	x	x
	o Energy	x	x	x	x	x	x						x
	o Industrialisation	x	x	x	x	x	x						x
	o Marketing system	x	x	x	x		x						
	o Fisheries	x	x	x	x	x		x	x	x	x	x	x
	o Agriculture	x	x	x	x	x	x	x	x	x	x	x	x
	o Water and Sanitation						x	x	x	x	x	x	x
	o Tree cover	x	x	x	x	x	x	x	x	x	x	x	x
	o Basic needs (employment-incomes life style)	x	x	x	x	x	x	x	x	x	x	x	x

Hydraulic conditions in PU1 and PU2 are inter-dependent in the vicinity of Baushi Bridge, and due consideration of this is taken into account in the development scenarios. PU1,PU2 and PU4 meet the requirements for a high priority program as is described further in Chapters 4,5 and 6.Another priority programme should concern PUs 6 and 7 where agricultural production can be greatly improved. In these areas numerous basins are flooded during about 6 months of the year and around 90% of the cultivated land is flooded every year. The impact of flooding results not only from the actual flooding event but also from its uncertainty in terms of area, depth, duration or time, or recurrence. In such a situation a flood embankment system can be profitable if this infrastructure is carried out in conjunction with other actions as shown on Table 3.2. Another economic advantage of PUs 6 and 7 is the nearness of Tangail as a potential support centre with required services.

Similar advantages can be also generated by flood control in the PUs 2,4 where agricultural development possibilities are also fairly high. However as far as PU10 is concerned the uncertainties of the effects of embankments and interventions upstream make development in the vicinity of the Padma and Lower Meghna river system inadvisable in the short term (FAP 1989) and the difficulties of providing a workable drainage outlet make development in this area less practicable.

PU 1,2,4,6,7 and 10[1] are thus considered as priority development areas. Thus inside these areas several planning actions have been described in technical and economic terms with or without combination of regional schemes (linking together for instance PU1 and PU2, also PU2 and PU4 for which flood mitigation measures are clearly interrelated). Alternative scenarios have been taken into consideration for the above priority planning units which take include the possible implementation of Jamuna Bridge and possible control options at Baushi Bridge.

In addition to planning for the development of these priority planning units the Regional Water Resources Development Plan (RWRDP) also assesses the other planning units (PU 3,5,8,9,11,12 and 13), and recommends local planning and water management measures.

3.4 Planning Units

A brief description is given below of each planning unit. A summary of the characteristics is given in Table 3.3, a fuller description complete with resource data,characteristics and appropriate development options is given in SR IX.

PU1

PU1 covers a 89,000 ha gross area of active (20%) and young (45%) Jamuna Floodplain as well as Old Brahmaputra Floodplain (35%). The west and south-western areas experience river erosion problems and areas near to the Jamuna and Chatal rivers experience moderate flooding. Much of the area is only shallowly flooded in a normal year. Groundwater conditions are good and minor irrigation is well developed. Crop production is quite high.
The area was identified for priority implementation during the early stages of the FAP and is due to be developed under FAP 3.1 (Jamalpur Priority Project). This development will probably consist of controlled flooding together with local drainage improvements and compartmentalisation on the floodplain; as well as flood proofing and preparedness measures for the active floodplain and charland areas.

---

[1] Although PU 10 should not be developed in the short term due to the uncertainties mentioned, it is still maintained as a priority area due to the potential benefits that would accrue if a practicable intervention can be ascertained to help control flooding.

PU2

PU2 covers a 74,000 ha gross area of Jamuna floodplain (young = 60%, older = 5%) and Old Brahmaputra floodplain (35%). Some 35% of the cultivated area is flooded annually, mostly from rainwater but with periodic flooding in high flood years from the major rivers. Groundwater conditions are favourable and minor irrigation is well developed mainly through STWs. Significant infrastructure already exists with a railway embankment in the north-west and a BWDB embankment in the west. The primary aim of development in the area would be to increase the security of the T. aman cultivation and encourage the growth of HYVs. This could be done by completing and improving the existing embankments and improving the local drainage and water management of the area.

PU3

PU3 covers a 172,000 ha gross area of Young (15%) and Old (80%) Brahmaputra Floodplain with small areas of Madhupur Tract (5%). Substantial areas (some 40%) are flooded annually from local rainwater and runoff from the adjacent Madhupur Tract. There is little direct flooding from the adjacent Old Brahmaputra but drainage from the area is restricted at the south-eastern end by high water levels in the rivers. Groundwater conditions are unfavourable and it is estimated that only 60% of the eventual irrigation demand can be met from groundwater. The aim of development in the area would be to increase agricultural production by improving the drainage and water management. The area would benefit from improved water supply, possibly through the diversion of surface water from the Old Brahmaputra.

PU4

PU4 covers a 76,000 ha gross area of Young (15%) and Older (20%) Jamuna Floodplain, Old Brahmaputra (50%) and Madhupur Tract (15%). The characteristics of the area are similar to PU2 , but with a greater extent of annual flooding (some 60%) and with a significant wetland area in the south-eastern part of the area. The aim of development would be to complete and improve the existing BWDB embankment on the Jamuna; and to improve the water management and drainage of the area into the Bangshi river system.

PU5

PU5 covers 212,000 ha gross area of mainly Madhupur Tract soils (95%) with some Old Brahmaputra Floodplain (5%). The area is generally higher than the surrounding floodplain soils and experiences only limited annual flooding. Groundwater conditions are generally unfavourable in the area. The limitations to agriculture in the area are more due to poor soils and droughtiness rather than flooding, but there is scope for some improvements by improving local poor drainage in waterlogged areas.

PU6

PU 6 covers 114,000 ha of active (15%), young (25%) and older (60%) Jamuna floodplain. The area experiences considerable flooding every year (some 85%). The flooding comes from a combination of overbank spillage from the Jamuna and Dhaleswari rivers and from rainwater and local runoff. Groundwater conditions are good with no limitation to irrigation demand. Despite the flooding, agricultural output is reasonable from the area, but there is good scope for additional output by increasing the security of the T.aman cultivation and encouraging the growth of HYVs.

PU7

PU 7 covers 90,000 ha gross area of active (5%) and young (95%) Jamuna floodplain. The area has similar characteristics to PU 6 and also experiences considerable flooding every year (some 85%). The residual moisture in the area is higher than in PUs 2,4 and 6 and although groundwater conditions are good there is a lesser requirement for irrigation. As well as the requirement to increase the security of the T.aman cultivation there is also a need for improved drainage to dry out the area quicker after the monsoon season. Drainage possibilities are limited by the high water levels encountered at the south-eastern end, largely due to water levels in the Meghna and Padma.

PU8

PU 8 covers 46,000 ha gross area of Madhupur Tract soils (100%). It is generally higher land than the surrounding floodplain soils and only experiences flooding in the narrow valleys within the area. Groundwater conditions are generally unfavourable. The area has relatively low agricultural potential and is generally used for homesteads and limited cropping with fruit trees, sugarcane etc. There are no major limitations to be addressed but some limited drainage works would benefit the area.

PU9

PU 9 covers 79,000 ha gross area of Madhupur Tract (90%) and Old Brahmaputra Floodplain (10%). Valleys within the Madhupur Tract land and the eastern lower land close to the Lakhya river flood in most years (35%). Groundwater conditions are poor and limit the irrigation potential of the area. The area would benefit from improved local drainage in the valleys, but drainage is limited by high water levels in the Lakhya river.

PU10

PU 10 covers 67,000 ha gross area of Eastern Ganges Floodplain (100%). The area experiences considerable flooding every year (some 85%). The flooding comes from a combination of overbank spillage from the Padma, Jamuna and Dhaleswari/Kaliganga rivers and from rainwater. Groundwater conditions are good with no limitation to irrigation demand. There is good scope for additional output by increasing the security of the T.aman cultivation and encouraging the growth of HYVs. However there are practical difficulties in protecting the area against flooding due to the height of embankments required, uncertain morphology at the Padma/Jamuna confluence and in limitations to the drainage possibilities.

PU11

PU 11 covers 25,000 ha gross area of Young Jamuna (90%) and Old Meghna (10%) floodplain. The area is heavily flooded (90%) every year. The groundwater conditions are moderate in the area but the irrigation potential is limited as the soils remain moist for a large part of the year. There would be potential for improving the drainage of the area but the practicality of this option is limited by the high water levels encountered immediately downstream in the Buriganga and the Meghna/Padma confluence.

PU12

PU 12 covers 37,000 ha gross area and consists of the metropolitan area of Dhaka city. The area is largely already flood protected, with further plans proposed under FAP 8A/8B.

PU13

PU 13 covers 101,000 ha of mixed soils (10% Padma active floodplain, 20% Arial Beel, 10% Lower Ganges Floodplain, 35% Old Meghna floodplain and 25% young Jamuna floodplain). The area experiences considerable annual flooding (80%) , but has a high agricultural output due to the growth of potatoes and other vegetables for sale in Dhaka. This is done by the use of raised platforms that are kept above the normal flood level. Groundwater conditions are moderate. There are possibilities of improving seasonal drainage but the possibilities in the monsoon season are limited by the high water levels in the adjacent major rivers.

CHAPTER 4
THE REGIONAL WATER RESOURCES PLANNING PROCESS

4.1 Analysis of Potential Development Activities

Following the Water Development Strategy outlined in Section 3.3, an inventory of development alternatives and components was prepared which covers the whole NCR area. Irrigation development has not been considered as a particular option, and was not included in this Study's TOR. It is assumed that irrigation development is to be entrusted to the private sector without any heavy public investment (private sector irrigation development is presently proving successful in the Region). Nevertheless, irrigation is strongly related to the flooding characteristics of an area and it is recommended that the feasibility studies, identified for further study by this RWRDP, will include an analysis of irrigation development.

4.1.1 The Hydraulic Model

In a first step the physical impact of the different options in the different Planning Units has been investigated with the help of a hydraulic model. The full description of the development and accuracy limitations of the hydraulic model is given in SR II.5, but it should be appreciated that the hydraulic model for the NCRS has only been developed to coarse pilot model status. The limitations of the model and the lack of adequate topographic and hydrometric data at the local level restricts the use of the model to only allow assessment of potential interventions at a regional level. The present Study does not have the facility to analyze possible local level improvements as would be required for effective assessment of compartmentalisation or local drainage improvement initiatives (see SR II.5).

The model does allow us, however, to assess where the potential for some control of flooded areas exists. The accuracy of the model is considered adequate (see SR II.5) to allow for simulation at a regional level and an assessment to be made of the impact of the installation of embankments, control structures and /or improved drainage. The impacts simulated however also assume that local level improvements have also been installed so that the potential benefits shown by the model are in fact achieved at the local level. In this way the Regional Schemes studied are assumed to be inclusive of improvements to the water management (or compartmentalisation) required to enable flood waters to reach the drainage channels.

The pilot hydraulic model has been run to establish flooding characteristics under present conditions (using 1989 as a typical year, see SR II.5) and then to investigate the effect of interventions on the flooding characteristics. This exercise illustrates that the flood characteristics vary significantly across the Region.

The results of runs of the hydraulic model are presented in SR II.5. These runs have been made to show the effect of the following interventions (see SR II.5).

- 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

4.1.2 Pre-selection of Schemes

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.

The pre-selected schemes have been made after consideration of the apparent impact on flooding of the possible interventions. It was found 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 4.1 and Figure 4.1.

Each potential project element is supposed to be self-supporting, i.e., to bring its own benefits and disbenefits. As such it may be a development phase within an overall scheme, it may exclude other projects or may be a part of them with or without any interaction.

The expected effect of project elements will depend on their sequence within the RWRDP. Circumstances due to external decisions, such as the construction of Jamuna bridge with the closing of the northern offtake of Dhaleswari may also modify the actual content and impact of the projects. The feasibility and priority ranking of projects consequently have to be analysed within different scenarios corresponding to the sequences of decisions and events.

Local improvements of water management are considered a necessary complement to controlled flooding. They are included in the potential projects and may consist of compartmentalisation and/or drainage improvement. Non-structural measures have also been considered. Their costing and the assessment of their benefits will require more detailed investigation at feasibility study level.

The potential project elements and possible development scenarios are described in Section 4.3. Those selected for pre-feasibility analysis are then described in Chapter 5.

TABLE 4.1

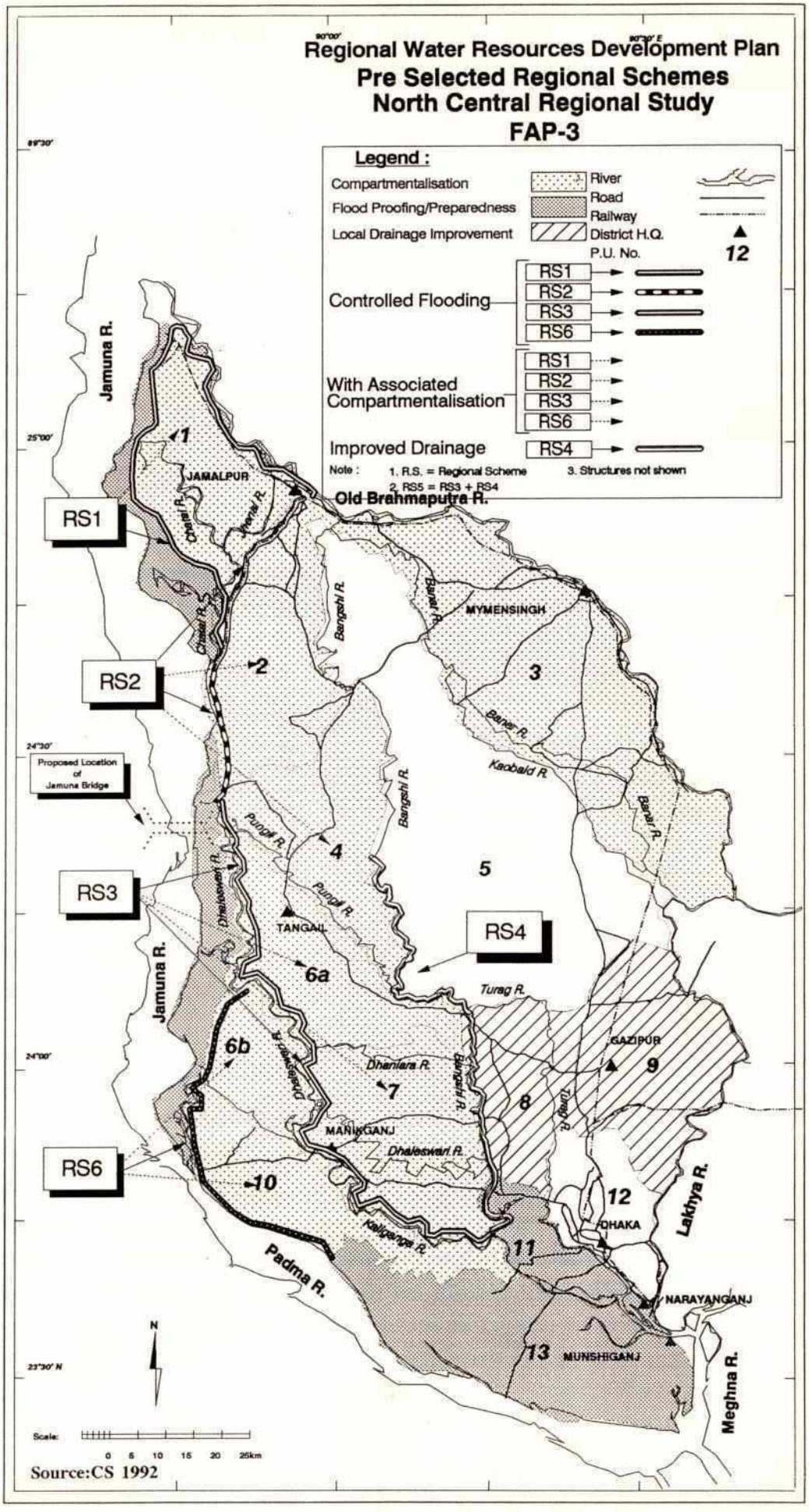
Pre-selected Schemes[1/]

Regional Scheme Nr.	Scheme Name[2/]	Scheme Components				Main PUs Beneficiary
		Controlled Flooding	Rivers/ Drainage Improvement	Local Drainage	Compartmen-talisation	
RS1	Jamalpur Priority Project	Yes	Limited	Yes	some	1
RS2	Bhuapur-Jamalpur	Yes	Limited	Yes	Yes	2+4
RS3	Dhaleswari-Kaliganga	Yes	Limited	Yes	Yes	6a&7
RS4	Bangshi River Improvement	No	Yes	Limited	Limited	6a,7&8[3/]
RS5	RS3 + RS4	Yes	Yes	Yes	Yes	6a,7+8
RS6	Bhuapur-Aricha Embankment	Yes	Limited	Yes	Yes	6a,6b,7+10

Note: 1. Schemes shown are potentially self-supporting, but combinations of schemes may be complementary (Section 4.2)
2. See Figure 4.1 for Location
3. RS4 would have a limited impact also on PUs 2 and 4

Source: CS 1992

Figure : 4.1


Regional Water Resources Development Plan
Pre Selected Regional Schemes
North Central Regional Study
FAP-3
Legend :
Compartmentalisation
Flood Proofing/Preparedness
Local Drainage Improvement
River
Road
Railway
District H.Q.
P.U. No.
12
Controlled Flooding
RS1
RS2
RS3
RS6
With Associated Compartmentalisation
RS1
RS2
RS3
RS6
Improved Drainage
RS4
Note : 1. R.S. = Regional Scheme
2. RS5 = RS3 + RS4
3. Structures not shown
Jamuna R.
JAMALPUR
Old Brahmaputra R.
Jhenai R.
Chatal R.
Bangshi R.
Banar R.
MYMENSINGH
Kaobald R.
Proposed Location of Jamuna Bridge
Dhaleswari R.
Pungli R.
TANGAIL
Turag R.
GAZIPUR
Dhanlara R.
Lakhya R.
MANIKGANJ
Dhaleswari R.
DHAKA
Kaliganga R.
Padma R.
NARAYANGANJ
MUNSHIGANJ
Meghna R.
RS1
RS2
RS3
RS4
RS6
1
2
3
4
5
6a
6b
7
8
9
10
11
12
13
N
Scale:
0 5 10 15 20 25km
Source:CS 1992

4.2 Costs and Benefits Assessment

4.2.1 Costs

Financial Costs

Costs have been estimated as recommended in FPCO Guideline for Project Assessment, GPA (FPCO 1992) at the regional planning stage. Details of the engineering costs are given in SR VII.4; of agricultural and flood damage costs in SR X.

Standard unit costs for construction elements have been determined applicable to June 1991,, see SR VII.4 and provide the basis for costing with a breakdown into local and foreign cost. 25% physical contingencies have been added to base construction costs and 15% engineering costs have been applied to the total. Operation and maintenance costs have been calculated as 6% of earthworks not including land acquisition cost and 3% of structure capital costs.

NCRS believes these cost estimates are representative using current Bangladesh construction practices. Using these standard rates allows for consistency between the Regional Studies, however the implications on using higher construction standards and costs has been investigated and are presented in the sensitivity analysis with both a 40% and 100% increase in costs and O&M demonstrated.

Economic Costs

Project capital and operating costs in financial (market) prices have been adjusted to economic prices by applying the Conversion Factors defined in the GPA (FPCO, July 1991) to the local components of costs. Capital and operating costs for the main items (embankments, structures etc.) in financial prices have been broken down by main category (labour, materials, machinery and equipment, etc.) in terms of percentage share. The relevant conversion factors were then applied to the local cost element of each component to derive the weighted average conversion factor for each category of work, see Table X.4.3, SR X. All costs have been calculated in terms of constant 1991 Taka. The some conversion factor has been used for O&M costs.

Compartmentalisation

The costs for the compartmentalisation options have been calculated as a guide to the likely costs of the structural elements of establishing compartments. The figures have been based on the experience of embankments and drainage works included in the Upper Shila project (these rates have been applied on a per hectare basis but adjusted depending on the length of embankments required according to the preliminary compartmentalisation plans, see PSR IX). 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.

Other Factors

The possible regional schemes have been identified largely due to their ability to effect some control on the flooding patterns in the region. As well as the anticipated improvements to the hydrological regime on the protected side of the controlled flooding embankments, the situation outside the embankments also has to be considered.

The region can be divided into the following areas:-

a) areas that are suited to controlled flooding and further development through improved water management
b) areas that are prone to flooding but not suited to controlled flooding development and thus deserving of an alternative development approach
c) areas that are not prone to flooding and thus are not effected by this RWRDP
d) areas that are effected by nearby development schemes and thus are deserving of mitigatory measures

The areas that fall into either of categories b) and d) should be considered for alternative development or mitigatory initiatives. These initiatives may include the following:-

- flood proofing
- flood warning
- flood preparedness
- mitigatory measures

The FAP has instigated studies to look at these activities, as are being carried out by FAPs, 10,11,14 and 23. Flood Warning, Flood Proofing and Flood Preparedness are seen to be important components of the Regional Plan. Provisional costings have been included in the analysis of these possible intervention activities.

Similarly the issues of land acquisition and resettlement are being studied as a separate element (FAP-15) of the Flood Action Plan studies. At present, individuals who have land or other assets compulsorily acquired for construction of embankments or other works are entitled to compensation payment from the government at the current market value of the assets acquired. An allowance has been made in the costings on land acquisition costs and royalties for earthworks, based on 1991 BWDB rates.

The regional plan, see Section 6.5.6 includes for flood proofing and mitigatory measures to be included. The details of these measures will have to be investigated further and detailed costings prepared at the feasibility study level. Figure 4.2 indicates the type of flood proofing measures likely to be appropriate across the region.

4.2.2 Agro-Economic Costs

Source

Agricultural statistics of cropped areas and crop productions have been collected for each Thana (see SR I). These estimates have been related to the different Planning Units in proportion of the area of each Thana included in each Planning Unit. Crop budgets have been compiled from various publications of BIDS and the Agricultural Economics Division of Bangladesh Agricultural Research Institute with provisional unit prices taken from the GPA (FPCO 1992).

The same operation has been made for livestock using thana records. Animal production has been estimated on the basis of national statistics by using the ratio between total animal production and the number of animals. Animal production budgets are very difficult to assess and it is tentatively assumed that the ratio of the net income to the gross product of the livestock sector is approximately the same as for the crop sector.

Basic data concerning fisheries have been compiled from published documents of the Fishery Department after review and discussions with competent officials of this Department.

An Agro-Economic survey was undertaken by the Consultant from July to August 1991 (see Annex X.I) to complement the available data and for cross-checking (see Chapter 3 of PSR X).

4.2.3 Agricultural Production Costs

Crop budgets have been prepared for all the main crops of the NCR (see SR X.3). These have been based on BIDS and BARI data but checked and adjusted using the NCRS agro-economic survey (see SRX.I).

As required in FPCO Guidelines the estimate of production costs include 16% interest over 6 months (18 months for sugarcane) on 80% of farmers' cash expenditures including the purchase of seeds and chemicals and the payment of hired labour and draft animals or power tillers. In accordance with the agro-economic survey data it has been estimated that about one third of human labour and draft power is hired and two thirds are provided by the farmers on their own.

4.2.4 Gross Product of the Agricultural Sector

Crops

The cropped areas and the production of main crops including rice, wheat, potato, jute, sugarcane, pulses, oil seeds, and onions have been determined through an agricultural survey of each Thana within the North Central Region. This survey was based on records from the local Agricultural Offices supplemented by field observations (see SR I and Tables X.3.8 to X.3.11). Planning Unit 12 is excluded from our estimates as it corresponds to the urban extension of Dhaka city where agricultural activity is marginal and gradually replaced by industries and services. This area is the subject of FAP 8 study.

A very high diversification of production was observed and an average 15 % of the cropped area is used for growing a broad range of cash crops such as vegetables, fruits and spices. This is illustrated by an average cropping intensity of almost 190% and demonstrates the capacity of local farmers to make intensive use of limited land resources and apparently adverse conditions.

An analysis has been carried out to assess for flood damages, see SR X.2, and after allowing for damages from exceptional floods the overall gross product of crops per Planning Unit in normal and average years at market and economic price has been be estimated as given in Table 4.2. (A "normal" year has been taken as a year with a return period of less than 5, whereas an "average" year has been based on the average of 28 years records, see SR X.3).

Livestock

Livestock estimates were also prepared from thana records, (see, SR X.4, Table X.4.12). but animal production is known with much less detail and was roughly estimated by using ratios calculated from national statistics. Its estimated value is very tentative, but may represent some 20 % of the gross product of crops at market price. It is anticipated, however, that controlled flooding will give some benefit to livestock and should improved the economic viability of the controlled flooding schemes. Further investigations are recommended on this aspect at the subsequent feasibility study level of analysis.

TABLE 4.2

Gross Product of Crops per Planning Unit (Million Taka)

Planning Unit	At Market Price		At Economic Price	
	Normal year[1]	Average year	Normal year[1]	Average year
P.U .1	3710	3677	3904	3870
P.U .2	2633	2586	2646	2600
P.U .3	5047	5032	5059	5044
P.U .4	2174	2135	2214	2175
P.U .5	4257	4250	4254	4246
P.U .6	3289	3244	3288	3243
P.U .7	2161	2135	2153	2128
P.U .8	1101	1099	1104	1102
P.U .9	2387	2379	2379	2371
P.U.10	1460	1456	1430	1426
P.U.11	624	620	595	591
P.U.13	5761	5746	5283	5268
Total NCR	**34604**	**34357***	**34308***	**34064**

1. A normal year is taken as one with flood levels below a return period of 5 years
2. The total shows a minor difference with the sum of PU values which have been rounded

Source : CS 1992, see SR X.3

Fisheries

An estimate has been made of the gross product of fisheries, (see SRs III and X.3) using the following average market prices paid to fishermen in Taka per kilo :

- River fish 40 Tk./kg
- Beel fish 30 Tk./kg
- Flood plain fish 25 Tk./kg
- Fish from cultured ponds 45 Tk./kg
- Fish from more or less derelict ponds 25 Tk./kg

The estimate of total fishery gross product per Planning Unit is given in Table 4.3 and the gross product of the fish capture sub-sector in NCR is shown to be about 3% of that of the whole agriculture sector in the Region.

TABLE 4.3

Fishery Gross Product per Planning Unit (Million Taka)

Planning Units	Fish Capture	Fish Culture	Total
P.U .1	108.9	15.6	124.5
P.U .2	45.4	11.6	57.0
P.U .3	185.1	62.1	246.2
P.U .4	28.8	10.6	39.4
P.U .5	87.3	51.2	138.5
P.U .6	58.4	18.7	77.1
P.U .7	50.1	25.6	75.7
P.U .8	19.4	13.9	33.3
P.U .9	34.0	23.8	57.8
P.U.10	31.8	20.6	52.4
P.U.11	46.7	8.0	54.7
P.U.13	90.3	34.2	124.5
Total NCR	**786.2**	**295.9**	**1082.1**

Note:- 1. The total shows a minor difference with the sum of PU values which have been rounded

Source : CS 1992, see SR X.3

4.2.5 Net Agricultural Benefit

The net benefit derived from the main crops in normal year, i.e. without damage due to exceptional floods (with a return period of more than 5 years), is estimated by the difference between the gross product and the production costs at market and economic prices. Details are given in SR X.4, but the overall net agricultural benefit is presented accordingly in Tables 4.4 and 4.5. The total amount for the whole region is about 9,050 million Taka at market price and about 10,971 million Taka at economic price.

The lowest net benefit per hectare is provided by wheat, jute, the local varieties of aus and by deep water aman with, however, fairly broad variations between Planning Units (see Table 4.6). For the whole cropping system the average return per cropped hectare is also variable with the lowest in Planning Units 4 and 6 and the highest in Planning Unit 13 followed by Planning Units 11 and 1.

The farm employment estimate shown in Table 4.7 is derived from crop budgets and cropped areas. It strictly covers the cultivation works and does not include the ancillary activities that are common in any farm for repairs, miscellaneous transport and marketing. A total of about 267 million work-days are used in the whole NCR region for cropping. They are shared between rice for about 60 %, jute for about 7%, potato and wheat for a little more than 3% each, sugarcane for about 2% and around 50 other crops for the remaining 25%.

TABLE: 4.4

Net Value of Agricultural Production in Average Year at Market Price – Present Situation (Tk. million)1/

P.Unit	D.W. Aman	Local T.Aman	HYV T.Aman	Local Aus	HYV Aus	Local Boro	HYV Boro	Wheat	Jute	Potato	Sugarcane	Pulses	Oilseeds	Onions	Others	Total
1	1	94	174	-14	1	24	420	6	-2	27	168	6	-4	8	304	1276
2	30	55	144	-15	2	5	84	-5	2	11	8	6	9	8	87	432
3	1	295	488	-12	186	25	268	-10	-5	-5	29	7	1	15	52	1334
4	-48	44	86	-24	4	-1	165	-4	5	6	10	18	12	5	19	330
5	1	215	452	-33	54	13	167	-5	-8	2	81	21	9	7	98	1074
6	-40	48	26	-70	1	0	45	-12	-27	5	72	32	31	24	37	172
7	-9	11	17	-140	-1	3	241	-17	-15	12	88	62	-25	4	11	240
8	1	7	56	-2	12	7	113	0	-1	3	4	6	1	0	109	317
9	47	16	143	32	45	8	175	-3	3	2	30	17	1	17	168	700
10	-3	0	0	-71	0	4	153	-11	-7	21	2	54	-2	20	32	192
11	10	1	6	3	1	1	59	-1	-1	116	1	3	2	1	28	231
12																
13	-3	0	3	38	7	7	248	-16	-13	1784	10	29	9	7	640	2753
Total NCR	-12	787	1595	-308	313	96	2137	-78	-68	1984	503	262	45	115	1678	9050

TABLE: 4.5

Net Value of Agricultural Production in Average Year at Economic Price – Present Situation (Tk. million)1/

P.Unit	D.W. Aman	Local T.Aman	HYV T.Aman	Local Aus	HYV Aus	Local Boro	HYV Boro	Wheat	Jute	Potato	Sugarcane	Pulses	Oilseeds	Onions	Others	Total
1	2	111	203	-3	3	26	525	26	45	14	160	5	-4	6	403	1504
2	38	66	170	-5	4	6	193	7	36	3	7	5	7	7	133	678
3	1	338	551	30	223	30	393	9	35	-14	28	6	0	12	66	1708
4	-24	50	96	-11	6	0	254	12	35	1	9	15	8	4	49	503
5	4	240	503	7	69	16	287	8	26	-4	78	17	7	6	126	1391
6	-1	53	30	-36	5	1	169	24	27	-8	69	26	24	20	93	496
7	17	13	19	-105	-1	3	311	20	13	0	84	52	-27	3	18	420
8	1	8	63	1	14	8	149	3	5	1	3	5	0	0	139	404
9	52	20	163	42	52	10	250	-1	17	0	29	14	1	14	208	871
10	20	0	0	-54	0	5	191	5	3	13	2	44	-3	14	48	289
11	13	1	6	5	1	2	76	1	5	90	1	2	1	1	29	236
12																
13	22	0	3	57	8	9	308	-4	19	1426	10	24	6	6	575	2470
Total NCR	146	901	1808	-72	385	118	3107	110	266	1523	480	215	20	94	1921	10971

Note:- 1. negative values occur due to the use of standars manpoer costs in the calculation, the use of lower rates for farm family (own) labour wpuld result in positive net values.

Source: CS 1992

After incorporating the value of farm labour in farming benefits an estimate of the value added by crops is calculated as 22,499 million taka, i.e., about 2/3 of the gross product at market price.

The average productivity of farm labour is estimated at 83 taka/man-day at market price. The average situation of farm households shows that the average farm size is 0.65 hectare with limited variations between the different P.U. It provides about 211 work-days per farm with an added value of about 18,000 Taka as average. The ranking of P.U according to their economic return shows that the poorest areas are Planning Units 4, 5, 6, 7, 10, 11 while the most promising are Planning Units 1 & 13. A particular case is that of Planning Unit 11 with a low cropping intensity and a relatively high productivity of farm labour. It can be explained by the combination of severe flooding and the proximity of Dhaka city with its labour market.

Further details and supporting tables on the above descriptions can be found in SR X.3.

4.2.6 Assessment of Project Benefits and Disbenefits

General

The anticipated effect of projects will primarily result from changes in flooding conditions, i.e., % of total area flooded as F0 (0 to 30 cm), F1 (30 to 90 cm), F2 (90 to 180 cm) and F3 (more than 180 cm), and area protected against exceptional floods.

Flooded areas in a normal year have been determined using simulations undertaken by the regional hydraulic model (see SR II.5) and necessary interpolation for the scenarios not covered by a specific run of the model. The areas protected against exceptional floods (5 to 100 years return period) have been estimated by the consultant depending on the design options and on hydrological information.

Project benefits and disbenefits can be identified as follows:

- modifications of cropping systems, yield changes,
- decrease of crop losses due to flood,
- land losses for infrastructures,
- modifications of flood plain fish resources,
- decrease of flood damage losses to dwellings, industries and public infrastructures.
- increased employment

Other direct economic impacts may be considered as negligible. Livestock industry is not directly linked with flood occurrences and much more concerned with cropping intensity which is already high. With the projects envisaged here, there will be a slight increase of the cropping intensity, thus probably a slight decrease of bovine livestock and of corresponding production. This will probably be compensated by an increase of small livestock and chicken - W and WO project benefits are considered similar and not accounted for. Forestry is marginal in NCR and is not expected to develop as a result of the currently proposed water development projects, however any initiatives to encourage reafforestation should be encouraged as this should amongst other benefits assist in reducing the degree of soil erosion from the Madhupur Tract and decrease runoff.

TABLE: 4.6

Added Value per Hectare Cropped in Normal Year - Present Situation

P.Unit	D.W. Aman	Local T.Aman	HYV T.Aman	Local Aus	HYV Aus	Local Boro	HYV Boro	Wheat	Jute	Potato	Sugarcane	Pulses	Oilseeds	Onions	Others
1	8152	11732	15538	5947	10555	17819	22522	9234	12354	30818	61921	10531	3485	43152	19081
2	10035	11101	14855	5810	11236	12221	12567	6610	12706	24578	36418	9303	7351	59011	12342
3	12753	12597	17675	7247	15788	13302	16826	6218	11981	9837	30273	6671	5336	44982	14023
4	4831	12780	19008	5330	12487	6799	15847	7033	13212	21829	44602	9613	6489	62423	9285
5	7239	13742	19206	6595	14050	11747	14431	6635	11510	15830	35205	8615	7153	54327	13763
6	5828	14621	17303	5009	9876	8100	11308	6817	10471	16008	39831	9426	7627	56542	9396
7	6473	11653	18079	2407	7335	11844	20749	6445	10353	20772	40768	11220	2811	24260	9896
8	8282	11067	17159	6819	17234	12641	19949	8009	12110	27081	35047	8797	5368	47534	15516
9	14024	10705	16646	11218	17202	12819	17339	3998	13598	19463	33262	7765	5796	91731	15568
10	6666	9130	14260	2297	9835	11197	22637	5857	9622	37098	18446	9860	4416	23771	9799
11	9821	9880	15328	9631	13081	10675	20823	6711	11724	78915	26055	9767	6243	48027	20446
12															
13	6679	7902	16115	9995	17980	11525	22954	4169	10810	99535	29317	10306	6645	43781	28815
Total NCR	**6735**	**12589**	**17328**	**5994**	**14924**	**12546**	**16968**	**6582**	**11643**	**73045**	**40600**	**9628**	**5537**	**37360**	**15619**

TABLE: 4.7

Farm Employment in Normal Year (,000 work-days) - Present Situation

P.Unit	D.W. Aman	Local T.Aman	HYV T.Aman	Local Aus	HYV Aus	Local Boro	HYV Boro	Wheat	Jute	Potato	Sugarcane	Pulses	Oilseeds	Onions	Others	Total
1	138	2516	3699	1254	215	354	6953	792	2730	427	1028	30	290	92	7947	28465
2	1266	1689	3359	1261	256	171	7281	562	1990	266	104	32	326	60	4220	22843
3	27	6701	8072	5343	5626	661	8264	917	2321	397	533	67	155	160	1569	40813
4	3290	972	1252	1626	251	142	5961	726	1686	204	93	101	680	31	2898	19912
5	363	4083	6460	5067	2268	465	8037	615	2046	277	1141	137	352	62	3116	34490
6	5540	806	449	4099	603	118	8321	1669	3269	528	827	183	1030	186	5883	33509
7	3736	291	274	4090	118	94	4651	1742	1731	446	970	287	1237	145	834	20646
8	72	216	975	382	301	208	2363	139	351	53	51	37	169	5	2787	8109
9	883	543	2642	1351	1108	239	4989	138	768	78	463	129	109	70	4198	17707
10	3371	20	10	2049	10	169	2503	802	606	243	158	291	504	817	2288	13841
11	468	43	121	244	54	57	1136	93	350	477	18	16	130	13	439	3659
12																
13	3729	23	55	2414	159	280	3964	648	1938	5599	203	151	465	85	5940	25652
Total NCR	**22883**	**17903**	**27368**	**29180**	**10968**	**2959**	**64422**	**8843**	**19787**	**8995**	**5589**	**1460**	**5447**	**1727**	**42119**	**269647**

Agricultural Benefits

Major changes which are likely to take place with a flood protection project are anticipated to be:

- Some transformations of cropping patterns together with a shift towards the use of higher yielding varieties,
- An increase of cropping intensity,
- The application of higher levels of inputs.
- Reduction in crop losses and damage
- Increased agricultural employment

The FAP-12 FCD/I agricultural study (FAP-12 1992) has shown that usually:

- "The major impact of FCD/I projects has been on cropping patterns in the kharif season. Reduced flood depths and durations led to a move from B.Aman to TL Aman and T. Aman HYV, and sometimes from B.Aman to Aus followed by T.Aman.
- In general, changes in cropping patterns made possible by FCD/I interventions tend to increase the preponderance of paddy, as this is the main monsoon crop and it generally gives the highest financial returns.
- FCD/I projects have rarely resulted in increased cropping intensities. Project impacts on cropping intensity are in general modest, except where irrigation alleviates a soil moisture constraint in the Boro or Aus season crops. However, most FCD/I projects affect only the monsoon season, when most land would be cultivated in any case".

In the GPA (FPCO 1992) specific attention is given to the assessment of benefits accruing from irrigation by tubewells through private investments:-

- "Crop produced through private investments" : "in the W and WO cases these will cancel out unless the project influences the rate of private investment".

A careful analysis of possible transformation of cropping systems in NCR following the improvement of flood protection, drainage and water management induces the following conclusions:

i) The conversion of flooded land into land which is not flooded at all, or flooded up to 20 or 30 cm, with a very short duration, permits the growing of HYV T.Aman. This is the major improvement: Local Aman (Broadcast or transplanted depending on the present severity of flooding) is converted into HYV T.Aman. (Note that HYV/L T. aman is only suitable on FO land with non-permeable soils). In the lower areas, where deep water Aman is presently grown, this shift to HYV T.Aman is possible only if a good drainage system is developed along with accompanying flood protection.

   Aus crop is usually not affected, as it is harvested before the flood. However flood protection prevents the damage due to exceptional floods to this crop (this may encourage farmers to deliver some supplemental irrigation for Aus crop).

ii) Cropping intensity changes. Flood protection may facilitate the possibility to grow an Aman crop where flooding previously prevented it, however in most cases there is actually no increase of cropping intensity as the new Aman crop replaces a shorter cycle kharif crop.

   Cropping intensity changes are also linked to the development of irrigation. Irrigation has been developed to grow primarily rice (which represents often more than 90% of irrigated crops) and sometimes potatoes and vegetables (see PU 13). Although increased irrigation will generally result in increased output, the

cropping intensity may fall (e.g. B.aman +/- aus - rabi may be replaced by a single crop of boro i.e., triple or double cropped replaced by a single crop) In NCR irrigation with STW and DTW has been developed independently of flood protection, and this will continue in the future. In deeply flooded area Boro cropping may also be benefitted from early drainage rather that flood protection. However flood protection is a pre-requisite to develop irrigated boro in two cases:

- where early floods prevent this crop, which is exceptionally the case in NCR,
- in very deeply flooded areas, which have not drained until mid or end of December. In this case benefits of flood protection and irrigation cannot be separated, all costs and benefits of flood control, irrigation and drainage have to be considered in the economic analysis.

The NCRS has been limited in its analysis of irrigation by the poor accuracy of information available on flood phases, see Section 4.1.1, and this has hindered the quantification of the impact of controlled flooding on irrigation at this stage of study. It has therefore been assumed that the development of irrigation will be the same in the WO and W project situations, but this assumption should be revised at the feasibility study stage.

iii) A higher level of inputs is used in kharif season due to the increase level of security (from FCD), which makes the investment more profitable. This concerns mainly the crops which benefit directly from the flood control plan: specifically HYV T.Aman. It is possible that these effects will concern some other crops, but this is very difficult to assess. The economic analysis thus considers a higher level of inputs used, and higher yields that are induced with the project.

The principles described above have been developed following the "Guidelines for Project Assessment" (FPCO 1992).

Methodology

Agricultural studies (such as FAP 12) show that the main crops affected by floods are Deep Water and Transplanted Aman. The strategy of farmers is to minimise risks by planting the varieties that can be safely grown. This strategy is confirmed by cropping patterns in different areas with different flood patterns.

Detailed estimations of the effect of project proposals on cropping patterns should be made at the feasibility level of analysis, however at this pre-feasibility study level preliminary estimations have been made of the main anticipated agricultural practices in accordance with the GPA (FPCO 1992). This has involved making estimates based on crop yields and cropping patterns already grown elsewhere in the region on land with similar flooding patterns and soil types. (This approach allows for the present farmers' approach to deciding on cropping patterns by assuming that farmers' future decisions on improved land will be as those taken by other farmers already cropping on similar land). The NCRS used an approach which has evolved out of that used by the MPO (MPO 1987). The MPO's approach for Flood Control with Gravity Drainage (FCD) assumed the following:-

100% of F1 class land moves to F0 class land
75% of F2 class land moves to F0 class land, 25% of F2 class land moves to F1 class land
20% of F3 class land moves to F1 class land, 45% moves to F2 class land, 35% remains as F3 class land

The NCRS, through the hydraulic model allows for a more specific analysis, in that the model predicts the changes in flood phases resulting from the development scheme under consideration. It should be reminded however, that the analysis at this stage has been based on a coarse pilot model, and it would be inadvisable to rely entirely on the results of the model (more detailed analysis should be carried out with an improved and more detailed model at feasibility level).

The resultant methodology for this pre-feasibility level of study, is as follows:-

i) **For DW Aman**

Future area = present area x f_1/p_1
with p_1 = present proportion of (F2 + F3)
f_1 = future proportion of (F2 + F3)

ii) **For T.Aman (Local and HYV)**

Future area = present area + NCA x (p_2 - f_2)
with NCA = net cultivable area (total)
p_2 = present % of (F0 + F1 + F2 + F3)
f_2 = future % of (F0 + F1 + F2 + F3)

F0 being taken in a restrictive sense, excluding all flood free zones as shown in SR II.5, Annex II.15.

This gives an estimation of the total area of Aman cropping based on present proportions under Aman of the total area flooded and predicted changes in flooded area (future T. Aman area is increased by assessing the difference between flooded area at present and in the future); note that the Aman crops grown are mainly on the F0 and F1 lands within the total flooded area. The split between HYV and Local varieties is estimated by observing present practices and thus:-

T.Aman (HYV) is taken as the HYV% of the total Aman area as observed in the less flooded thana (subject to the condition $f_2 < p_2$, otherwise as at present)

Other crops are not expected to change significantly as a result of proposed infrastructures. Present yields and crop budgets have been used to calculate expected gross produce, production costs and net income in a normal year at economic prices. Land losses are deducted as a percentage of total area in each Planning Unit concerned.

The results of the above approach have been checked and found to give consistent results. Although adequate for regional planning purposes, more detailed analysis will be required at the feasibility study level. The TOR for the feasibility studies include for the carrying out more detailed field surveys and for the development of a sub-regional model based on improved topographical and hydrological data that should give a more accurate representation of the flood situation.

Flood Damage

Flood damage losses have also been estimated, (see SR X.2, Table X.2.30) and the percentage of protected area in each Planning Unit with each scenario is taken into consideration to determine the residual losses and the average net agricultural income. Average flood damage to Dwellings, Industries and Public Infrastructures for different levels of protection have also been estimated with the percentage of protected area used to estimate the impact of proposed projects.

Impact on Flood Plain Fishery

As explained in the Fishery Report (see SR III), the estimate of fish resources in flood plains is assumed to be proportional to the area flooded with a depth above 30 cm (F1 + F2 + F3) as determined by the hydraulic model. As this fishery resource is of local importance only a conversion factor of 1 (from market to economic prices) has been assumed in the pre-feasibility level analysis. This should be revised at the feasibility study level (when guidelines on the fishery sector should be available from the FPCO).

Project Disbenefits

The main negative impact, of flood control and drainage schemes is anticipated to be on fisheries, especially on capture fisheries. An estimate of this impact on fish capture and production is presented in SR III in relation to the decrease of flooded areas, depth and duration of flood. Other environmental impacts have been assessed qualitatively at this pre-feasibility level of analysis as is described in SR IV and in Chapter 5 following.

Timing of Benefits Disbenefits

It is assumed that scheme construction would be completed within 3 years and that the agricultural benefits grow after construction at the rate of 20% per year (this being recommended by FPCO guidelines), Project elements are assumed to be constructed in 3 years. A more detailed analysis will be necessary in a next stage and is considered not appropriate in this preliminary analysis (some scenarios may need 5 years or more to be implemented). Sensitivity analysis have been carried out to allow for changes in these assumption times.

4.3 Selection of Schemes

4.3.1 Pre-selected Schemes

As described in Section 3.3 the priority development areas have been identified as those PUs that show some potential benefit from flood control measures and include in particular PUs 1,2,4,6,7,8 and 10.

The types of development that are envisaged in these areas include controlled flooding, compartmentalisation, flood proofing/preparedness and flood early warning (see also SR VIII). These are all considered as an integral part of the Regional Water Resources Development Plan (RWRDP). For the optimum benefits of controlled flooding to be achieved it is important that the water management in the controlled flooding areas is improved. The controlled flooding options considered in the RWRDP include both the costs and benefits of improved water management through the compartmentalisation approach. However the pre-feasibility analysis of some of these options is limited at this stage for the following reasons:-

Compartmentalisation

It is considered that compartmentalisation or water management units form a suitable development approach for a large proportion of the region (see Figure 4.1). However this approach is being analysed in some detail by FAP 20, who have a 4 year programme in Tangail district (within NCR) and Serajganj (within North-West Region) to both develop at a pilot level, assess the applicability of the approach and to assess the likely costs and benefits.

Being a detailed development option an affective analysis of the approach should include:-

- detailed micro-topographic and hydrometric information
- detailed inventory of local farmers present water control actions, i.e. which channels are left opened or closed at various times of the year
- assessment of institutional concerns
- socio-economic surveys of the views and actions of local people
- development of sub-regional 2-dimensional hydraulic model incorporating flood plain details and all channels
- detailed assessment of the costs and benefits of the approach (preliminary cost and benefit have been included in the report).

All the above are beyond the scope of the present study and should have to be developed further during feasibility level studies. However improvements to the hydrological regime will be instigated by the formation of water management units under the compartmentalisation concept. These apply both to some areas that at present receive reasonable flood water amounts mainly from rainfall (e.g PU 3) and also to areas that presently receive considerable flood waters from the major rivers that will be suitable for compartmentalisation after major embankments works are first completed. This situation applies to PUs 6,7 and 10.

Flood Proofing, Flood Preparedness, Flood Early Warning

A combination of flood proofing, flood preparedness and flood early warning will be recommended for all areas experiencing significant flooding (PUs 1,6,7,10,11 and 13) but these will not be required in those areas where controlled flood protection is implemented in accordance with the development implementation programme, see Figure 4.2. Again this Study has not attempted to develop this approach and has only made a preliminary estimate of costs or benefits. Such an assessment requires detailed analysis and is dependent upon development of an approach that is acceptable and implementable by the local people. FAP studies 14 and 23 are looking at these aspects in some detail.

Three categories of flood proofing are proposed:-

Full flood proofing, required for flood vulnerable areas that may never be protected, or may not be protected for some time (say more than 15 years);

Partial flood proofing, required for flood vulnerable areas that may not be [protected for some 6 to 15 years.

Special flood proofing, required in protected areas for extreme events

Mitigatory Measures

The type and extent of mitigatory measures are dependent on adequate monitoring of existing and future hydrological, environmental and sociological conditions. These measures should become the subject of considerable debate between the implementation authorities and those people affected by the schemes. Guidelines should be established at the feasibility study level and adequate provision allowed for public participation to be taken into account in the project preparation process.

Structural Options

Any reduction in the flood levels in the Region will only be achieved by the implementation of flood control and drainage in some form. The NCRS has investigated these options by simulation of the effects of various structural interventions using a hydraulic model. These model runs confirmed that the potential for economic benefits from controlled flooding and drainage improvements lies in the western and south-western flood plains which currently experience considerable flooding. A total of 66 scenarios have been investigated (see Table 4.8). These consists of a combination of regional schemes as described in Chapter 5. Where appropriate these schemes include the provision for flood proofing/preparedness/early warning measures as well as compartmentalisation and water management programmes.

4.3.2 Possible Scenarios

In the context of further development of the North Central Region the following two sets of scenarios may be envisaged:

- One without Jamuna Bridge as at present
- The other with Jamuna Bridge and an associated guide embankment being constructed.

Scenarios have accordingly been investigated (see Table 4.8) and hydraulic model runs have been made relating to these scenarios as described in SR II.V.

TABLE 4.8

Scenarios Studied at Pre-feasibility Level[1]

A. Without Jamuna bridge

OA.	No structural development (simulated by the base run of the regional hydraulic model)
1.	Development of Jamalpur Pilot Project through RS1bN project (simulated by run B2).
2.	Development of Jamalpur Pilot Project through RS1cN only (simulated by run C2).
3.	Development of Jamalpur Pilot Project through RS1dN only (simulated by run D2).
4.	Drainage improvement of PU2, PU4, PU6, PU7 and PU8 through RS4 only (simulated by run 34).
5S-5C.	1st phase of Dhaleswari embankment through RS3A1S or RS3A1C only.
6S-6C.	1st phase of Dhaleswari embankment associated with RS4.
7S-7C.	2nd phase of Dhaleswari embankment only (simulated by run 33).
8S-8C.	2nd phase of Dhaleswari embankment associated with RS4.
9S-9C.	Jamuna embankment down to Harirampur only.
10S-10C.	Jamuna embankment associated with RS4
11.	RS2 project only.
12.	RS2 project associated with Jamalpur Pilot Project development through RS1bY project (simulated by run B1).
13.	RS2 project associated with Jamalpur Pilot Project development through Rs1cY project(simulated by the run C1).
14.	RS2 project associated with Jamalpur Pilot Project development through RS1dY project (simulated by run D1).
15.	RS2 project associated with RS4 project (simulated by run 1).
16S-16C.	RS2 project associated with Dhaleswari embankment 1st phase (simulated by runs 9 and 7).
17S-17C.	As 16s or 16c associated with RS4 (simulated by runs 24 and 18).
18S-18C.	RS2 associated with Dhaleswari embankment 2nd phase (emulated by runs 5 and 3).
19S-19C.	As 18s or 18c associated with RS4 (simulated by runs 23 and 11).
20S-20C.	RS2 associated with Jamuna embankment only (simulated by runs 27 and 25)
21S-21C.	As 21S or 21C associated with RS4 (simulated by runs 28 and 26).

B. With Jamuna bridge (no impact on Jamalpur Pilot Project)

OB.	No structural development
22.	RS4 project only (drainage improvement)
23s-23C.	1st phase of Dhaleswari embankment
24S-24C.	As 23S or 23C associated with RS4.
25S-25C.	2nd phase of Dhaleswari embankment
26S-26C.	As 25S or 25C associated with RS4.
27S-27C.	Jamuna embankment only.
28S-28C.	Jamuna embankment associated with RS4.
29.	RS2 project only (simulated by run 16).
30.	RS2 associated with RS4 project (simulated by run 17).
31S-31C.	RS2 associated with Dhaleswari embankment 1st phase (simulated by runs 10 and 8).
32S-32C.	As 31S or 31C associated with RS4 (simulated runs 20 and 19).
33S-33C.	RS2 associated with Dhaleswari embankment 2nd phase (simulated by runs 6 and 4).
34S-34C.	As 33S or 33C associated with RS4 (simulated by runs 21 and 22).
35S-35C.	RS2 associated with Jamuna embankment (simulated by runs 32 and 29).
36S-36C.	As 35S or 35C associated with RS4 (simulated by runs 31 and 30).

Note:- 1. All embankment options are considered as having either controlled or semi-controlled structures included

CHAPTER 5
PRE-FEASIBILITY STUDIES

5.1 Regional Schemes

5.1.1 General

The regional schemes identified as worthy of consideration at the pre-feasibility level have been identified in Chapter 4. These scenarios studied allow for workable alternatives to be identified, that will best meet the multi-criteria requirements. The priority schemes should be shown to be acceptable in economic, socio-economic, and environmental grounds.

The Jamuna Bridge has been given the go-ahead by the GOB and the donor agencies. This means that certain works will definitely be constructed such as Contract 7 (approach road and flood embankment from Bhuapur) and other works are likely to be implemented during the coming years (such as the bridge itself and the approach works). One option that has been proposed by the Dhaleswari Mitigation Study is for a downstream guide embankment[1]. This embankment is proposed as a consequence of cutting off the northern intake of the Dhaleswari. The NCRS considers the Jamuna Bridge works as including all these works (approach roads, bridge and guide embankment) and the with bridge situation in our options below are identified with the suffix B. For economics in the with-bridge situation a cost has been included for the downstream embankment but any additional mitigatory measures required (such as provision of a control structure to allow water into the Pungli river, required as a result of closure of the Northern Dhaleswari intake) would be part of the Jamuna Bridge funding. It is quite possible that the downstream guide embankment will not eventually be constructed in which case the cost for an embankment on the east of the Dhaleswari would be required, but this eventuality would need to be the subject of further analysis at feasibility level.

5.1.2 Scheme Components

The components of the pre-feasibility studies and their alternatives are summarised in Figure 4.1, detailed in Figures 5.1 to 5.10 and are described below. Further detailed description of each scheme is given in SR IX.

The schemes considered all show a potential impact on the present flooding conditions. This is achieved by a combination of structural and non-structural developments. The engineering elements of these potential schemes consist of embankments and structures which are fully described in SR VII. The main design criteria for the proposed embankments are given in Table 5.1.

All structures are designed to have some control, but both fully controlled structures (with operable gates to allow flow in both direction) and semi-controlled structures (designed to exert some restriction to flow) are used as appropriate. Preliminary costings have also allowed for navigational locks and fish passes to be included in the structures in certain locations (see SR VII).

---

[1]. Note: 1. Another proposal now being considered is for a connecting cut out to be made using an existing spill channel, downstream of the Bridge. The purpose would be to keep water levels in the northern Dhaleswari close to that in the Jamuna (at high flood flows).

TABLE 5.1

Main Design Criteria[1]

Characteristic	Design Criteria
1. Embankment Slopes (a) "Interior" (b) "Marginal"	 1:3/1:2 1:2/1:2
2. Embankment Crest width (a1) with road (a2) without road (b) without road	 7m 4.5m 2.4m
3. Embankment Foundation	0.1m stripping,limited requirement for toe drain
4. Compaction	85%
5. Return Period	Use 40 years but review at Feasibility Level
6. Freeboard	1.2m
7. Basic costs Unit rates O&M costs - embankment - structures	 BWDB 1991 rates 6% 3%

Note : 1. GPA (FPCO 1992) has been followed with outline designs prepared as necessary, see SR VII.
Source: CS 1992

5.2 RS1 - Jamalpur Priority Project

Description

The Jamalpur Priority Project, (JPP), scheme RS1 (see Figure 5.1) is located at the northern upstream corner of the NCR. The scheme was identified early in the FAP as being suited for priority development, and the FAP 3.1 feasibility study for the area has been carried out concurrently with this NCRS.

The JPP covers some 90,000 ha between the Jamuna to the west, the Old Brahmaputra to the north and east; and the Jagannathganj-Jamalpur railway line on the south-east.

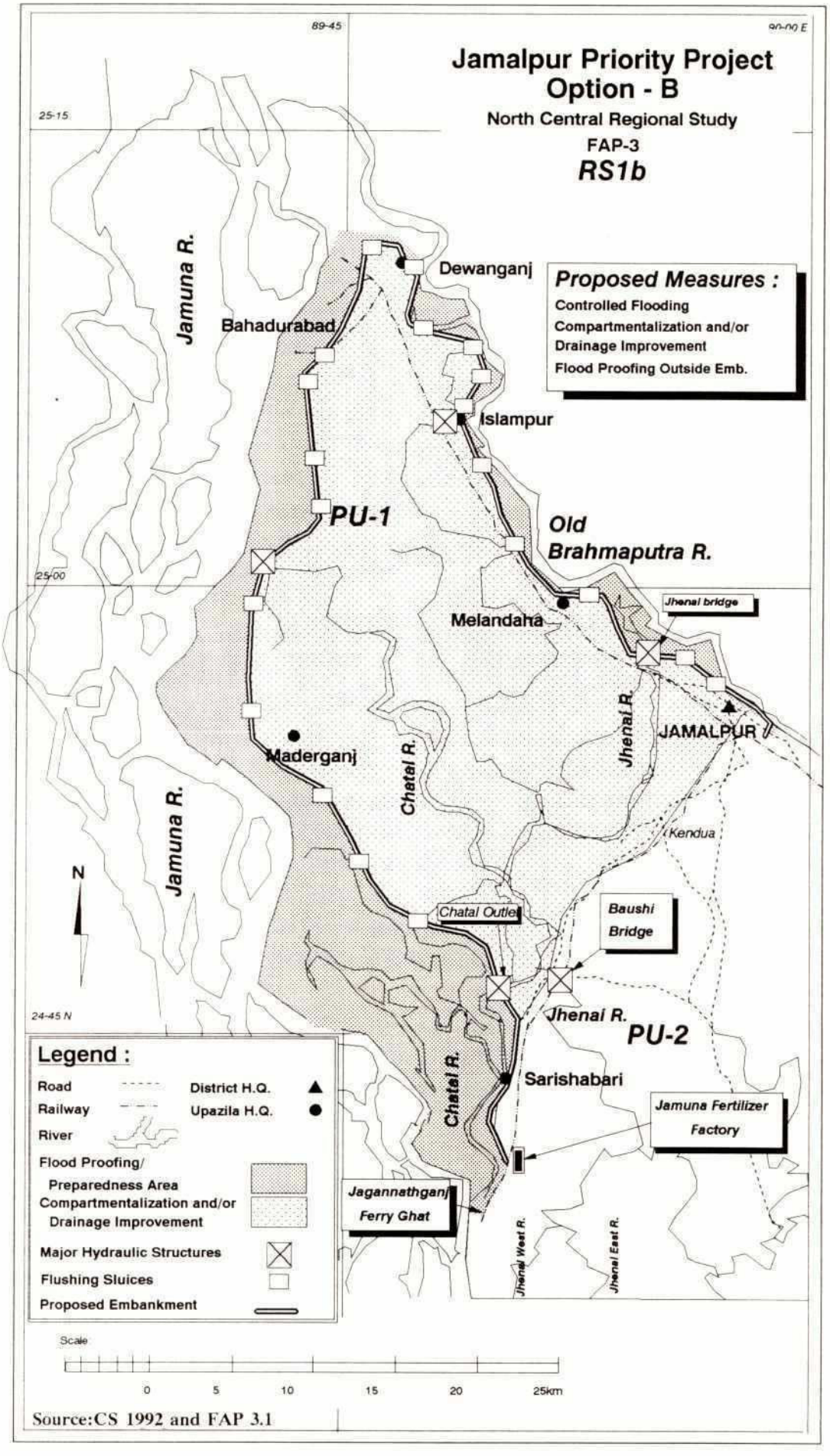
The area comprises parts of several thanas and is predominantly medium high to medium low lands (F1/F2). Two major internal distributaries flow through the area - the Chatal which originates from the Jamuna and the Jhenai which branches off from the Old Brahmaputra.

Justification

The JPPS area has been selected for a variety of reasons (NCRS 1991b), the main reasons being summarised below:-

- the existence of a substantial part of the required infrastructural requirements
- relatively simple administrative setup with the majority of the area comprising of only three thanas (Madarganj, Islampur and Melandaha) and all within the one district of Jamalpur (this will particularly help minimise the institutional problems related to compartmentalisation)

Figure : 5.1



Source:CS 1992 and FAP 3.1

- anticipation of significant monsoon season water regime improvements
- consistency with future possible compartmentalisation development approach and the desirability of such a development progressing from upstream downwards
- relatively simple drainage network with only three major drainage paths out of the area
- relatively high crop losses experienced in the 1987 and 1988 floods,
- high distress levels in most of the project area (see Figure 2.12)
- anticipated relatively small impact on navigation and fisheries (except for the low lying beel areas of Melandah and Jamalpur)
- the relatively good groundwater resource availability of the area should ensure negligible deleterious impact on the domestic water supply (HTW) performance of the area
- compared to other potential priority areas in the North Central area it is considered that the Jamalpur area selected is better defined as a separate area relatively independent of influences on or from adjacent areas.
- relatively good access for use as a demonstration area

The early analysis indicated that the JPPS area would probably not be as economically attractive as other possible areas within the NCR (NCRS 1990, Section 3.6.2) due to the relatively high cropping intensities already occurring in parts of the area. However, the other advantages of the area (as outlined above) coupled with appropriate use of the existing infrastructure (thereby reducing implementation costs) should enable an economically justified project to be implemented, as outlined below:-

- the area is bounded on most sides by embankments of various descriptions, although the embankment along the Jamuna needing considerable attention. Nevertheless, with the existing embankments in some part in place, the development cost in terms of capital works is likely to be lower than might otherwise be the case.

- the problems associated with flooding in the area are considered to be manageable without recourse to major works apart from the main embankment required along the left bank of the Jamuna. Control of the inflow of water into the area from the Old Brahmaputra through the structures on the main railway line may be possible at acceptable cost levels in relation to the probable benefits.

- the area to be provided with flood control and drainage improvements are predominantly F1 and F2 type land which is generally accepted (FFYP and NWP, MPO 1991) as being the most economically viable to provide with such facilities.

- the area has proven experience in intensive agriculture based on HYV crops with the significant level of STW utilisation in the dry season, it is therefore considered likely that the farmers in the region will be open to a transition from local t. aman to HYV aman.

More recent analysis, (see SR I) shows that the cropping intensities have indeed increased in the area significantly during the last seven years. This increase makes the estimated economic benefits of the JPPS less attractive than previously envisaged as the farmers have already successfully increased cropping intensities within the existing flooding situation. However, it is considered that the JPPS area is still justified as a priority project, particularly if it is considered in conjunction with the implications of future development of the areas downstream (PUs 2 and 4).

Development Options

The NCRS consultants (FAP 3) have maintained close contact with the JPPS consultant team (FAP 3.1) and four basic development option types appropriate for the JPPS area, have been analysed (see SR IX). These were as follows:

RS1a (FAP 3.1's Option A) - Flood Response Measures

Flood proofing, flood preparedness and flood warning measures to be implemented along with improvements to local drainage problems.

RS1b (FAP 3.1's Option B) - Controlled Flooding and Flood Proofing

Controlled flooding for the majority of the floodplain area, with intakes on all rivers/streams. The boundary embankments would not be reinforced but set back to avoid river erosion of embankments where necessary. Drainage to be improved. Flood proofing and other flood response measures in the adjacent unprotected floodplains, and char lands, see Figure 5.1.

RS1c (FAP 3.1's Option C) - Combination Approach (Controlled Flooding/Flood Response Measures)

Controlled flooding only to the area east of the Chatal river, the area to the south and west would have flood response measures. Drainage to be improved.

RS1d (FAP 3.1's Option D) - Full Flood Protection

Flood embankments around the whole area with bank protection on the Jamuna left embankment. Control structures on the major rivers (but with less capacity than for RS1b) .Drainage to be improved.

These options have been costed and potential benefits estimated, see Section 6.3. However it should be appreciated that FAP 3.1 are carrying out their studies to a greater level of detail (Feasibility Study level) than FAP 3 (Pre-feasibility level), and the FAP 3.1 Interim Feasibility Report (FAP 3.1 1992) should be referred to for a fuller analysis.

Recommendations

The FAP 3 and 3.1 analysis of JPP (RS1) shows that option B, see Figure 5.1 is the most effective option. Options C and D prove to be uneconomic, see Table 6.2. Option A (flood proofing and local drainage) would provide benefits in terms of security from floods but it is difficult to justify this option on economic grounds as the assessment of costs and benefits of flood proofing have not yet been well quantified.

Option B allows for the best use to be made of the advantages of the JPPS area. An option is being developed by FAP 3.1 that will utilise the existing embankments where appropriate and keep construction costs down to a minimum. FAP 3 calculate that such an approach would give an IRR of 12% (without taking into account the costs or benefits of flood proofing), see Tables 6.3 and 6.5. If allowances are made for indirect benefits (of damages avoided and increased agricultural benefit) then the IRR increases to more then 13%.

There are uncertainties in the erosive behaviour of the Jamuna river in the western part of the river and these are being studies further by both the feasibility study of FAP 3.1 and FAP 21. It may prove appropriate to carry out the

development in a staged approach with implementation over several years to allow for a better understanding of the relative unknowns such as river trends and for participatory development of water management systems to take place.

Nevertheless, RS1 is seen to be justified for early development. It is not the highest priority area in terms of economic returns (as was predicted in the Reconnaissance Study, NCRS 1990), but its other advantages justify its selection as a priority area. In particular the advantages that it should exact a relatively small impact on adjacent areas; and that its development should be complementary to the development of the RWRDP's highest priority scheme of RS2, which is immediately downstream.

5.3 RS2 - Jamalpur to Bhuapur Development

Description

The Jamalpur to Bhuapur development scheme, RS2 (see Figure 5.2) covers an area of 149 000 ha (116 000 ha NCA), consisting of PUs 2 and 4. The area is already partly flood protected by the Jagannathganj-Jamalpur railway embankment and a BWDB embankment from Bhuapur to Jagannathganj.

Although cropping intensities are high at 213% the cropping patterns and yields are such that the average return per cropped area is low (see Table 4.5). The land types are predominantly medium highland (F1):- F0 = 25%, F1 = 45%, F2 = 20%, F3 = 10% (see SR X.9).

The proposed development is to complete the already existing hydraulic infrastructures by improving the railway embankment where necessary (and taking into account initiatives from FAP 3.1), heightening the existing BWDB embankment, adding control structures as necessary (in particular at Baushi Bridge) and implementing compartmentalisation with local drainage improvements where required. Some improvements to the regional drainage system may also be required.

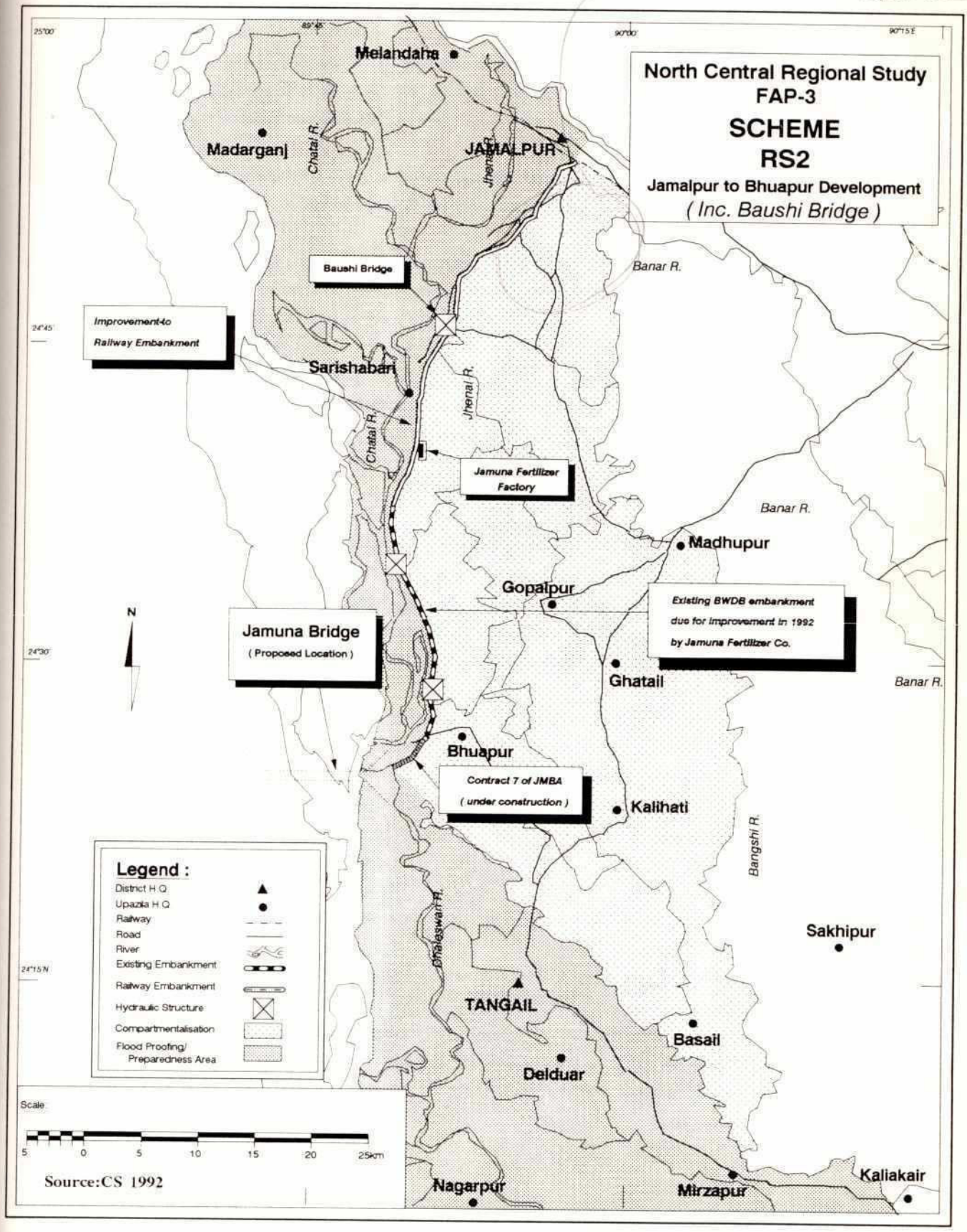
Recommendations

The prefeasibility analysis shows that this scheme gives a high economic return (18 % IRR, NPV of Tk. 476 million, see Table 6.3). This is largely due to the existing hydraulic infrastructure which has reduced the required investment capital. In social and environmental terms it is also relatively attractive as fishery resources are relatively low in the area, see Table 4.2 and as the embankments are already largely in position, there is a relatively small additional impact on flood levels outside the embankments resulting from the scheme.

As well as the controlled flooding, the compartmentalisation concept is a significant initiative of the scheme and RS2 can be seen to be an extension of the FAP 20 pilot project which is located immediately downstream, see Figure 5.3.

The success of this concept is dependent on socio-economic and institutional factors as well as a good detailed understanding of the hydrology, topography, fishery and ecological characteristics of the area. It is recommended that a detailed feasibility study be carried out including further investigations of these factors across a full annual cycle. The importance of public participation and the development of a workable institutional framework should be recognised. Draft TOR for such a feasibility study will be presented in a forthcoming Annex to this report.

Figure : 5.2


North Central Regional Study
FAP-3
SCHEME
RS2
Jamalpur to Bhuapur Development
(Inc. Baushi Bridge)
Melandaha
Madarganj
JAMALPUR
Chatal R.
Jhenai R.
Baushi Bridge
Improvement to Railway Embankment
Sarishabari
Banar R.
Jamuna Fertilizer Factory
Madhupur
Gopalpur
Existing BWDB embankment due for improvement in 1992 by Jamuna Fertilizer Co.
Jamuna Bridge
(Proposed Location)
Ghatail
Bhuapur
Contract 7 of JMBA
(under construction)
Kalihati
Bangshi R.
Dhaleswari R.
Sakhipur
TANGAIL
Basail
Delduar
Nagarpur
Mirzapur
Kaliakair
N
Legend :
District H.Q
Upazila H.Q
Railway
Road
River
Existing Embankment
Railway Embankment
Hydraulic Structure
Compartmentalisation
Flood Proofing/ Preparedness Area
Scale
5 0 5 10 15 20 25km
Source:CS 1992

5.4 RS3 - Dhaleswari to Kaliganga Development

Description

The Dhaleswari - Kaliganga Development Scheme, RS3 (see Figures 5.3 and 5.4) covers an area of 150 000 ha (117 000 ha NCA), consisting of PUs 6a and 7. The area includes within it the FAP-20 Compartmentalisation Pilot Project at Tangail. Limited embankments already exist in the area, particularly in the FAP 20 area; but most of the Dhaleswari-Kaliganga remains unembanked.

Cropping intensities are presently at 203% and there is a low average return per cropped area (Table 4.5). The land types are predominantly medium highland(F1) & medium lowland(F2): F0= 10%, F1= 42%, F2= 30% & F3= 18%.

The proposed development is to construct embankments for controlled flooding along the Dhaleswari-Kaliganga from Joker Char (near the Pungli offtake) down to Kalatia. The possible development has been split into two phases and should be considered as either with or without the Jamuna bridge:

RS3A (without Jamuna bridge) consisting of RS3A1+RS3A2, see Figure 5.3

RS3A1 - Phase 1; Dhaleswari left embankment from Joker Char (at Pungli offtake) via Dhula near Porabari (at Southern Dhaleswari offtake) to the Barinda River offtake.

RS3a2 - Phase 2; Dhaleswari left embankment from Barinda River offtake down to the Kaliganga left embankment and then to Kalatia at confluence with the Bangshi river.

RS3B (with Jamuna bridge) consisting of RS3B1+RS3B2, see Figure 5.4

RS3B1 - Phase 1; Jamuna Bridge downstream guide embankment crossing the Northern Dhaleswari near Dhula and keeping to the left embankment from Southern Dhaleswari offtake to the Barinda River offtake.

RS3B2 - Phase 2; Dhaleswari left embankment from Barinda River offtake down to the Kaliganga left embankment and then to Kalatia at confluence with the Bangshi river.

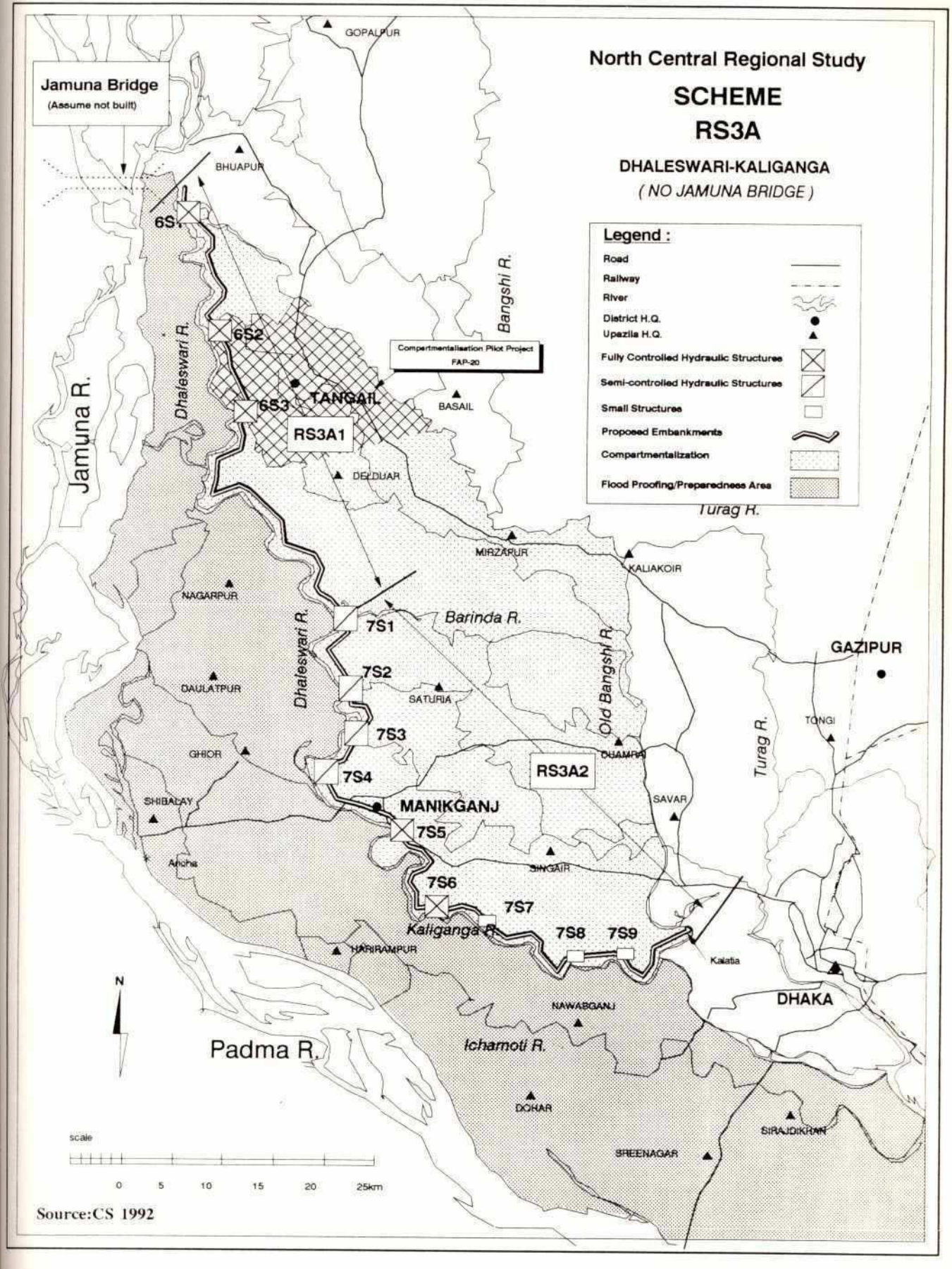
All the above scheme options have been considered with either fully controlled or semi-controlled hydraulic structures. For full utilisation of the possible benefits that the controlled flooding will provide, it is also assumed that improved water management will be required through compartmentalisation in PUs 6a and 7. The case for semi-controlled structures has to be examined carefully. The possibility of achieving effective drainage in the "protected area" may well depend on the ability of being able to cut off unwanted water from the Jamuna/Dhaleswari.

Recommendation

The prefeasibility analysis shows that this scheme with controlled structures (RS3A1C+RS3A2C) gives the highest economic return (IRR of 22%, NPV of Tk. million 1700). These benefits are achieved by the reduction of flooding levels in the monsoon season and protection against sudden high fllod levels thus encouraging farmers to grow higher yielding varieties and more T. aman. However the proposed development is a large scale scheme requiring substantial capital investment (Tk. million 2700, US $60 million) and the consequences of such a development need careful investigation before it can be justified. The impact on the adjacent areas of PUs 6b, and 10 plus the environmental consequences need to be fully estimated. The scheme would affect a major floodplain fishery area (one of the largest remaining unembanked fishery resources areas), see SR III and the consequences of such an interference may have far reacting effects beyond the NCR area.

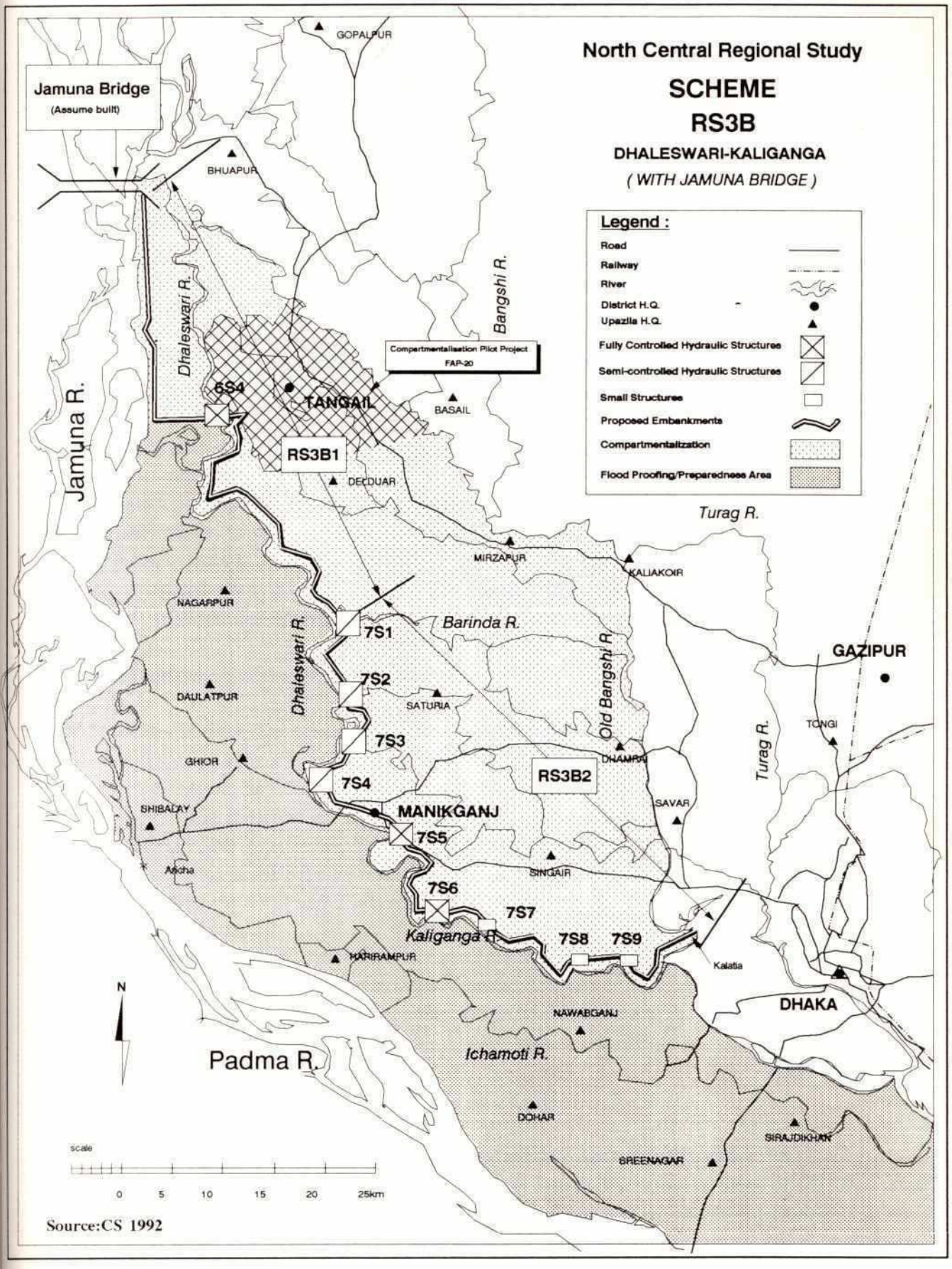
It is therefore recommended that RS3 be taken through to feasibility study, but that time is allowed for preparatory studies to be made to adequately establish the environmental, hydrological and socio-economic characteristics of the area and the consequences of such a development.

Figure : 5.3



Source:CS 1992

Figure : 5.4



Source:CS 1992

5.5 RS4[1/] - Bangshi River Improvement

Description

The Bangshi River Improvement and Drainage Scheme, RS4 (see Figure 5.5) would improve the flow capacity of the main drainage channel for the western part of the region. The river would be straightened, widened and deepened for a total length of 81 km. Most of the excavated material would be utilised to construct river embankments which should assist against river flooding.

The work would start at Kalatia (constraints downstream of this point are determined by the high water levels backing up from the Meghna/Padma confluence) and be implemented upstream to include strengthening and improvement of the Bangshi river east of Basail.

Recommendation

Although works should enable some limited compartmentalisation to be implemented, the majority of these works are dependent on controlled flooding first being implemented through schemes RS2 and RS3.

The prefeasibility studies show that this scheme on its own would not be economically viable (IRR of 6%, see Table 6.3). But RS4 is also found to be complementary to other regional schemes, and thus the scheme is recommended to be studied as a possible addition to the scope of works to both RS2 and RS3 [1/] feasibility studies. Another factor which may show RS4 to be more economically attractive is the potential for increased rabi and boro cropping (with irrigation) that may occur as a result of earlier drying out of the land, after the monsoon season, as a result of the improved regional drainage through RS4. The level of detail required to carry out this analysis has not been possible (see Section 4.1.1) at this pre-feasibility level of study but should be included in analysis at feasibility study level.

5.6 Muktagacha - Bhaluka Development

The Muktagacha - Bhaluka Development, RS5, covers an area of 172,000 ha in PU3. substantial areas are flooded annually from local rain water and runoff from the adjacent Madhupur Tract. There is little direct flooding from the adjacent Old Brahmaputra but drainage from the area is restricted at the south-eastern end by high water levels in the rivers. Groundwater conditions are unfavourable and it is estimated that only 60% of the eventual irrigation demand can be met from groundwater. The aim of development in the area would be to increase agricultural production by improving the drainage and water management. The area would benefit from improved water supply, possibly through the diversion of surface water from the Old Brahmaputra.

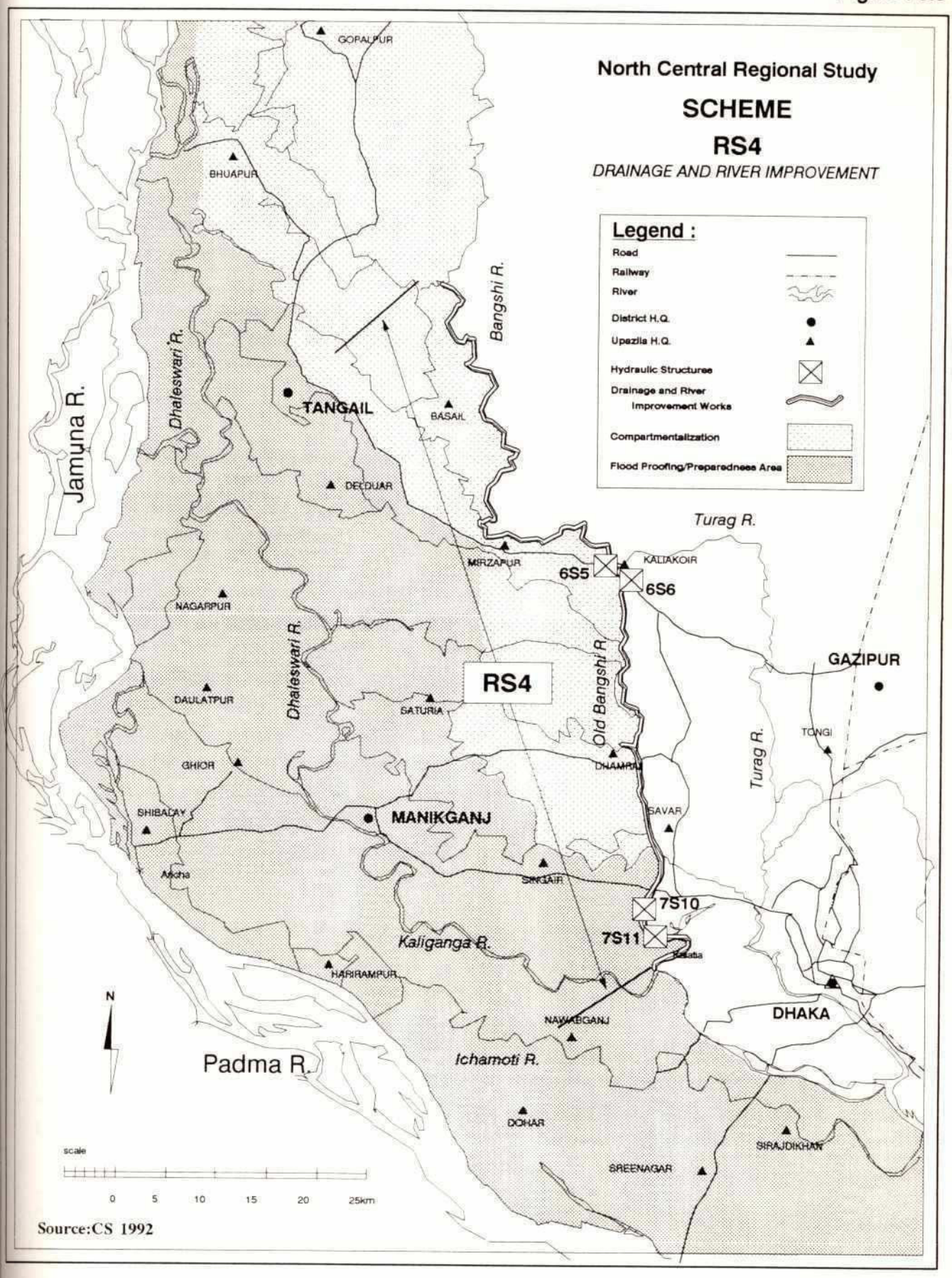
The main benefits of development for RS5 are anticipated to come from the irrigation aspects of development and although the scheme has not been included in the pre-feasibility analysis of flood related development schemes, it has been included in the overall regional water resources plan, see Section 6.5.6. and Figure 6.3.

5.7 Bhuapur - Aricha Development

Description

The Bhuapur - Aricha Development, RS6 (see Figures 5.6 and 5.7), forms an alternative to RS3. The upstream section is the same as RS3 (following the left bank as far as Dhula), but instead of following the Dhaleswari downstream of Dhula, another embankment would be constructed on the south side of the Dhaleswari offtake following the left bank of the Jamuna down to Aricha and finally connecting up with existing BWDB embankment works close to Harirampur.

Figure : 5.5



Source:CS 1992

The scheme forms part of the earlier proposed Dhaka South West Project (DSW 1969), see SR VII. There are at least two complicating elements to this scheme. The basic Scheme aims to maintain the current flow levels into the Dhaleswari. This will require some limited control works at the site of the Dhaleswari offtake (a preliminary design is included in the SR VII) but the precise arrangement would have to be determined at feasibility level. An alternative to this approach is to leave the Dhaleswari free flowing and provide some lower level embankments on both sides of the Dhaleswari down to at least the Barinda offtake.

This scheme impacts on PUs 6b, 10 and part of 6a and compartmentalisation would be implementable in those areas. There is little potential for regional drainage improvements to be made for these areas as the drainage constraint relates to the high water levels of the Padma/Meghna. Thus although such drainage improvements have been investigated they have not been included in the list of priority schemes.

The scheme has been considered to be implemented in two phases (RS61 and RS62) and with the alternative of with (RS61B and RS62B) or without Jamuna Bridge (RS61A and RS62A).

Recommendations

This scheme is potentially a large scale development, but it involves major changes to the present hydraulic regime of the major rivers 1/ (Jamuna, Padma, & Dhaleswari). The prefeasibility analysis has shown the scheme to be economically marginal (IRR of 11%, see Table 6.3); and there are major potential environmental consequences that are envisaged as a result of the scheme.

The scheme is seen to be even more complicated to assess than RS3 and should have a high risk factor applied to its assessment. It is not recommended for further study until later in the RWRDP, see Section 6.5.5.

5.8 Tongi - Gazipur Development

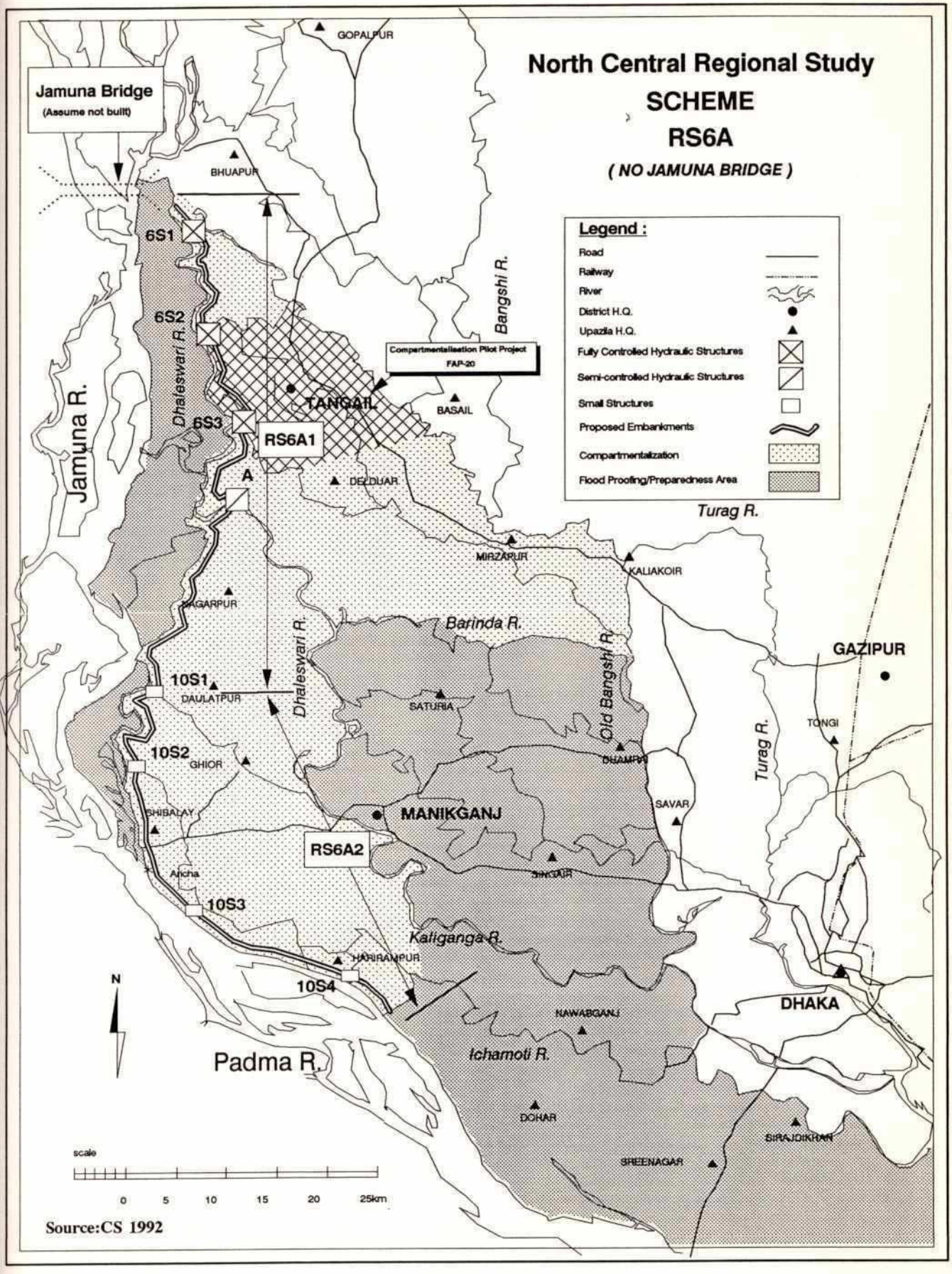
The Tongi - Gazipur Development, RS7 covers PU 8 and PU 9. The part in PU 8 covers 46,000 ha gross area of mainly Madhupur Tract soils. It is generally higher land than the surrounding floodplain and only experiences flooding in the narrow valleys within the area. Groundwater conditions in the area are generally unfavourable with relatively low agricultural potential, and the land is generally used for homesteads and limited cropping with fruit tress, sugarcane, etc.. There are no major flooding limitations to be addressed but some limited drainage works would benefit the area.

PU 9 covers 79,000 ha gross area of both Madhupur Tract and Old Brahmaputra Floodplain. Valleys within the Madhupur Tract land and the eastern lower land close to the Lakhya river fllod in most years. Groundwater conditions are poor and limit the irrigation potential of the area. The area would benefit from improved local drainage in the valleys, but drainage is limited by high water levels in the Lakhya river.

The main benefits of development for RS7 are anticipated to come from the irrigation aspects of development and although the scheme has not been included in the pre-feasibility analysis of flood related development schemes, it has been included in the overall regional water resources plan, see Section 6.5.6. and Figure 6.3.

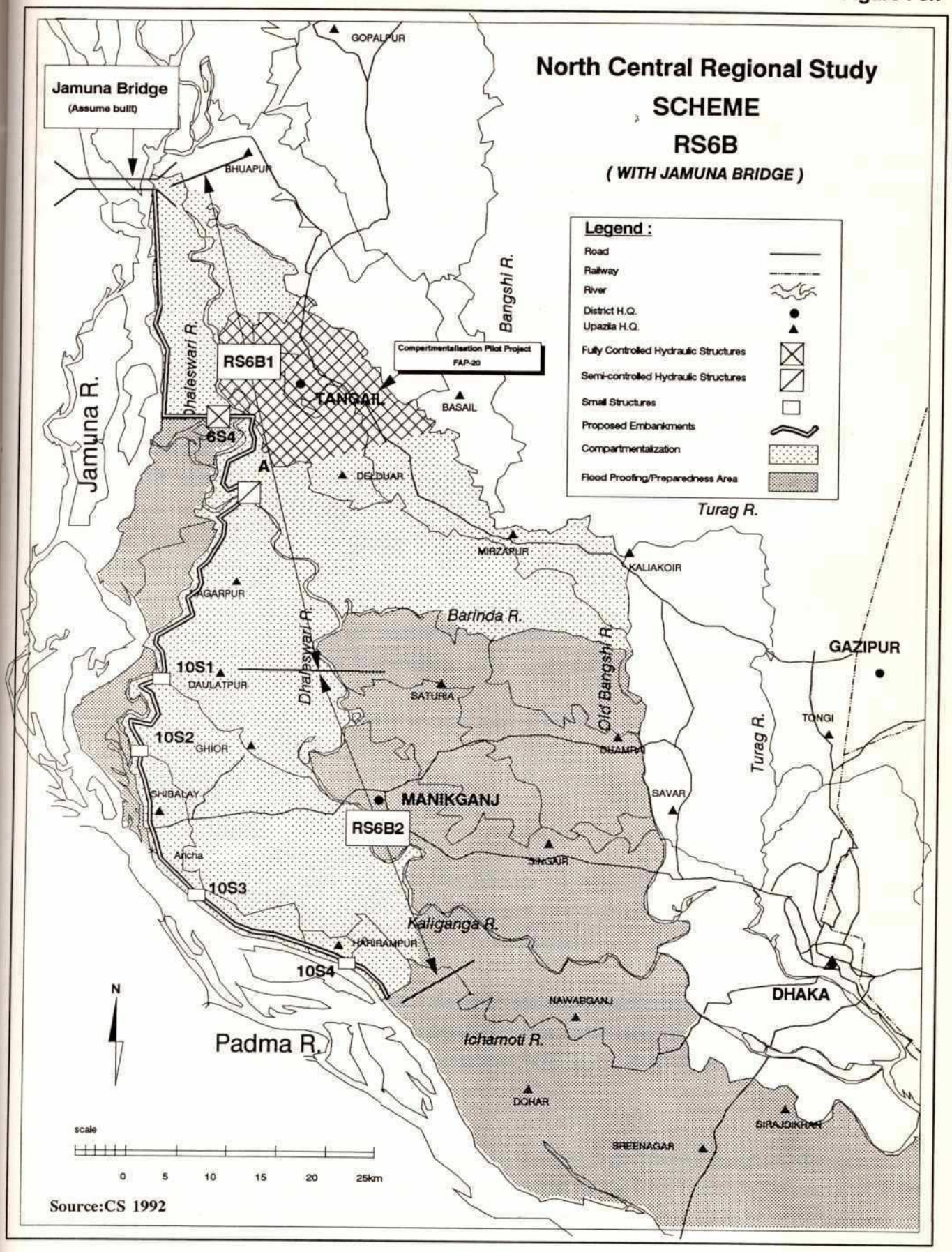
Note : 1. The FAP study report of 1989 recommended that embankments along the Padma and Lower Meghna should be deferred until such time when the effects of upstream embankments are monitored and the implications understood.

Figure : 5.6



Source:CS 1992

Figure : 5.7



Source:CS 1992

CHAPTER 6
REGIONAL WATER RESOURCES DEVELOPMENT PLAN

6.1 Objectives

The Regional Water Resources Development Plan (RWRDP) has been prepared to identify appropriate developments that could be instigated to fulfil the aims and objectives of the regional water development strategy. That strategy is outlined in Section 3.3 but can be summarised as given in Table 6.1.

TABLE 6.1
Regional Water Development Strategy

- identify economically viable developments
- identity areas where high increased agricultural value can be added from controlled flooding interventions
- priority to heavily distressed sub-regions
- develop first where socio-economic frameworks exist to sustain growth
- involve local people in the planning and management of flood control programmes
- promote local economic initiatives induced by agricultural, livestock, fisheries improvements
- use embankments for several socio-economic purposes
- apply mitigatory measures wherever persons are adversely affected by a proposed development
- economic promotion through improved institutional measures
- develop environmental management programme so as to sustain the region's resources.

Source : CS 1992, see Section 3.3

6.2 Formulation of the Plan

The basis and methodology of the planning process have been set out in previous chapters, and in the Supporting Reports. The prioritisation for future development has been based on a multi-criteria analysis, as described below, but at this prefeasibility level some of the analysis has only been possible on a qualitative basis.

The economic analysis of the pre-feasibility studies should be regarded as preliminary. The North Central Region is a complex hydrological, socio-economic and environmental area and detailed studies are required before the impacts of potential schemes can be quantified with confidence. Appropriate detailed studies are recommended to follow on from this RWRDP at feasibility level.

During the formation of the Draft Plan, participation was largely confined to government authorities, the consultants and those local bodies, NGOs and individuals who were approached by the FAP-3 team in the course of their investigations. A public meeting was held to discuss the Draft Plan which heard the views of some Members of Parliament and other representatives of the Region. This has resulted in the inclusion of certain additional regional schemes which although not receiving a high priority in terms of a response to flooding problems alone are included

in broad outline as they are significant for the overall water resource development of the Region. The importance of local and public participation is recognised, and it is hoped that this RWRDP will form the framework for further discussion and modification as the proposed feasibility studies are carried out.

Environmental and socio-economic analysis has been limited at this pre-feasibility level of analysis. Both aspects will require substantial field level investigations to identify and quantify the impacts of the proposed regional schemes, both within and outside the development areas. The environmental analysis has further been hampered by the paucity of ecological and environmental data in Bangladesh; and the limited resources with which to address these issues at this stage of the studies.

The analysis is presented both by regional schemes, which are compared with each other and then also by looking at a series of scenarios which look at combinations of these schemes. This allows for the overview to be assessed and includes for a regional strategy to be developed that will allow for complementary development to take place rather than concentrating on individual schemes that would be implemented in isolation.

6.3 Economic Analysis

6.3.1 Economic Indicators

Project costs, benefits or disbenefits are summarised in Tables 6.2, 6.3 and 6.4 which differentiate for the without and with Jamuna Bridge situation.

a) Without Jamuna Bridge

Among the 35 Scenarios which have been compared to the base case (the reference situation), 14 appear economically feasible. Their economic ranking is as follows:-

When comparing individual components, RS3, phases 1 and 2 (Dhaleswari-Kaliganga Embankment), have the highest EIRR and NPV then RS2 (flood control between Jamalpur and Bhuapur). Consequently, all alternatives which group them together are good, and sometimes also scenarios including additional components (5 scenarios with RS4, 2 with RS1b, 2 with RS6, 1 with RS1b and RS4). However the RS4-drainage improvement of Bangshi river shows a low EIRR (6%) and it may not be advisable to keep the 3 scenarios including it. In the case of RS1b, the EIRR reaches 12% if the cost of flood proofing is excluded (or 10.3% including flood proofing costs but no benefits). RS1b also has hydraulic interrelations with RS2 deserves further analysis. RS6 shows an EIRR of 10.9%, but would be a high risk investment, see discussion in Chapter 6.

The sensitivity analysis confirms the feasibility of RS2 and RS3 as described in Section 6.3.2.

Considering overall regional development the comprehensive development scenario which includes RS1b, RS2, RS3 and RS4 shows a good economic rate of return. All of these 4 schemes are complementary to each other and form a good basis for a regional development program as has been set out in the medium term plan (see Section 6.5.6). However, the environmental impact of such a large scale of development requires more investigation and analysis (see Section 5.4).

b) With Jamuna Bridge

It is much more difficult to compare the various "with Jamuna Bridge" scenarios. The hydraulic model of the with Jamuna Bridge base case cannot be well calibrated (as it has not yet been built) and thus may not be representative. It has been found to be difficult to differentiate the impacts of the Jamuna bridge alone, and that of additional structures. However the provisional analysis confirms RS2 as an outstanding scenario, which seems a sound conclusion, as Jamuna Bridge has only small interferences with this scenario. All other scenarios (except RS1b which is not significantly affected by the bridge) have much lower EIRR with Jamuna Bridge than without it. The combination of RS2 and RS3 remains attractive (EIRR of 15.4%), as do combinations of RS4 with RS2 and RS2 & RS3. However, the EIRR of RS4 again shows to be rather low (8.3%), and alternatives with RS4 were no longer considered in the analysis.

In conclusion it was decided to concentrate the efforts on more detailed comparisons of the above selected "without Jamuna Bridge" scenarios, and to provide some additional information on only those "with Jamuna bridge" scenarios that include RS2 and show promising economic returns.

6.3.2 Sensitivity Analysis

Sensitivity analyses have been carried out on the significant variables as recommended in the GPA (FPCO 1992) as follows :

i) On the cost side : construction costs and the time required for construction. The sensitivity analysis thus assumes 3 possibilities:
   - Project implementation doubled from 3 years to 6 years.
   - Construction and Operation and Maintenance costs increased by 40%.
   - Construction and Operation and Maintenance costs doubled.

   This method was preferred to the "switching values" method, the results being easier to interpret due to the large number of scenarios which have been considered.

ii) On the benefit side:
   - Changes of cropping patterns, in relation to changes of flood categories (assessed through the hydraulic model).
   - Consideration of changes to the benefits from avoiding flood damage (both improved benefits by 25% and less benefit by 25% have been considered).
   - Consideration of changes to the benefits from increased agricultural production and avoiding flood damage (both improved benefits by 25% and less benefit by 25% have been considered).
   - A longer time required to achieve the anticipated agricultural benefits (taking 7 years instead of 5 years).
   - Economic prices; the main analysis was carried out using FPCO economic prices of February 1992. These were subsequently revised by the FPCO in their GPA of May 1992 (FPCO 1992), and the effect of the generally lower conversion factors has been shown by recalculating the base case analysis for each of the potentially viable scenarios (see last column of Table 6.5) .
   - Macro-economic impacts (see SR X.4.3)

On the benefit side only this last factor has been systematically considered. Changes of cropping patterns have been compared with two sets of runs of the model in the without Jamuna bridge situation. The sensitivity analysis has considered indirect benefits in PU1 only. Other factors are deemed minor when compared to those.

The results of the sensitivity analysis are shown in Table 6.5. If these analyses are taken into account then only 4 scenarios still appear definitely feasible without Jamuna bridge. They consist of

- First phase of Dhaleswari embankment only (RS3A1C)
- First and second phase of Dhaleswari embankment only (RS3=RS3A1C+RS3A2C)
- First phase of Dhaleswari embankment associated with RS2 (Baushi bridge structure and upgraded embankments in PU2), or second phase of the same with RS2.

Only 1 scenario appears feasible in all circumstances with Jamuna bridge. It consists of the construction of RS2 alone (flood control between Jamalpur and Bhuapur).

The construction period assumed for each scheme is according to the size of the scheme. 3 years has thus been assumed for the main construction period for all schemes, except for RS3 and RS6. RS3 and RS6 are larger schemes and have been split into 2 phases of 3 years each (6 years total). Certain aspects of the schemes, however, may require longer than the main construction period of 3 years. The compartmentalisation aspects for example require time for the institutional and public participation aspects to be resolved and thus may take longer to complete, see Table 6.5.

6.3.3 Indirect and Macro-Economic Impacts

Indirect and macro-economic impacts have been considered in the multicriteria analysis which assembles all economic, financial, socio-economic and environmental impacts (see Section 6.4, and are discussed in SR X.4.3.

In the best case (scenarios RS1b + RS2 + RS3) the level of increase in added value (26%) is significant at the regional level. However, it is probably limited at the national level. To have some rough assessment of the impact at national level, it is needed to consider the gross product. With the scenarios RS1b + RS2 + RS3, the production increase is 22% when considering the concerned PUs, and 8.7% of the total NCR product. The share of NCR in the National Gross Product is 15% (see SR X.1.4). Assuming that the share of agriculture is the same, the variation of the Agricultural Gross Product with the above referred scenario could be around 1.3% of the national level. It is considered that the production increase has a direct impact on food availability, and an indirect impact on employment, and on activity of linked sectors, see SR X.4.3.

Indirect benefits will appear in the sectors which are linked to agriculture, such as related commercial activities, transport (of inputs and outputs), and agro-industries. If it is assumed that the net benefit of these sectors represent more or less the same as the benefit of the agricultural sector (or 40% of the Gross product, which for commerce is a very conservative assumption), their incremental value adds a minimum of 40% to the direct agricultural benefits. Part of these benefits is given to farmers' family through farm employment, and also to other categories of labourers.

Employment will increase significantly during the construction of structures and, less so, for operation and maintenance. Employment will also increase due to the intensification of agricultural production and activities of linked sectors. Care should be taken to reserve part of construction jobs for the landless and distressed people, and to keep these people employed as much as possible for operation and maintenance. NGO's and local authorities should assist them in their participation in other activities in the project, such as farming activity (at peak demand and for post harvest operations), rice milling, cottage industries, etc.

TABLE 6.2
Project Cost Estimates

(Financial Cost in Tk.million)

Project designat.	Major embankments				Major Structures	Water Management Units						Total construct. costs	Physical contingenc. 25 %	Admin. & engin. cost 15 %	Total financial cost	O & M costs earthworks@ 6% structures@ 3%
	Loss of land (ha)	Land acquisit. cost	Royalty cost road factor =	Embankm. (earthwork) 100.00%		Loss of land (ha)	Land acquisit. cost	Embankm. (earthwork)	Structures	Roads	Channel improv.					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
RS1bY *	490	132.25	59.91	334.52	262.91	115	30.92	30.65	123.68	0.00	62.40	1037.24	259.31	194.48	1491.03	53.55
RS1bN *	447	120.57	53.91	300.99	244.5	115	30.92	30.65	123.68	0.00	62.40	967.62	241.91	181.43	1390.95	49.86
RS1cY *	563	151.82	86.76	484.38	218.38	135	36.39	38.87	151.06	0.00	62.40	1230.06	307.52	230.64	1768.21	66.44
RS1cN *	519	140.14	80.08	447.13	199.97	135	36.39	38.87	151.06	0.00	62.40	1156.04	289.01	216.76	1661.81	62.44
RS1dY *	701	189.02	108.01	603.08	1588.61	115	30.92	30.65	123.68	0.00	62.40	2736.37	684.09	513.07	3933.53	133.88
RS1dN *	657	177.35	101.34	565.82	1570.9	115	30.92	30.65	123.68	0.00	62.40	2663.06	665.77	499.32	3828.15	129.91
RS2	184	49.60	28.34	158.25	55.94	148	39.90	28.99	138.85	6.92	57.99	564.78	141.20	105.90	811.87	30.15
						146	39.52	28.72	137.52	6.85	57.43	270.04	67.51	50.63	388.18	13.95
RS3A1S	241	65.02	37.16	207.46	76.37	142	38.26	27.80	133.14	6.63	55.60	647.44	161.86	121.40	930.70	34.69
RS3A1C	241	65.02	37.16	207.46	87.31	142	38.26	27.80	133.14	6.63	55.60	658.38	164.60	123.45	946.42	35.17
RS3A2S	409	110.29	63.02	351.86	19.07	174	47.03	34.17	163.66	8.15	68.35	865.60	216.40	162.30	1244.30	47.77
RS3A2C	409	110.29	63.02	351.86	156.98	174	47.03	34.17	163.66	8.15	68.35	1003.51	250.88	188.16	1442.55	53.72
RS3B1S	106	28.69	16.39	91.53	1.56	142	38.26	27.80	133.14	6.63	55.60	399.60	99.90	74.93	574.43	21.47
RS3B1C	106	28.69	16.39	91.53	1.56	142	38.26	27.80	133.14	6.63	55.60	399.60	99.90	74.93	574.43	21.47
RS3B2S	409	110.29	63.02	351.86	19.07	174	47.03	34.17	163.66	8.15	68.35	865.60	216.40	162.30	1244.30	47.77
RS3B2C	409	110.29	63.02	351.86	156.98	174	47.03	34.17	163.66	8.15	68.35	1003.51	250.88	188.16	1442.55	53.72
RS4	485	145.18	82.96	463.18	16.07	305	82.17	59.71	285.94	14.24	119.42	1268.87	317.22	237.91	1824.00	69.65
RS6AS	533	143.91	82.23	459.14	213.87	194	52.32	38.02	182.07	9.07	76.04	1256.67	314.17	235.63	1806.46	67.30
RS6AC	533	143.91	82.23	459.14	227.41	194	52.32	38.02	182.07	9.07	76.04	1270.21	317.55	238.16	1825.93	67.88
RS6BS	399	107.57	61.47	343.20	139.63	194	52.32	38.02	182.07	9.07	76.04	1009.39	252.35	189.26	1451.00	54.09
RS6BC	399	107.57	61.47	343.20	142.23	194	52.32	38.02	182.07	9.07	76.04	1011.99	253.00	189.75	1454.74	54.21
RS7AS	901	243.19	138.97	775.89	225.35	194	52.32	38.02	182.07	9.07	76.04	1740.92	435.23	326.42	2502.57	95.11
RS7AC	901	243.19	138.97	775.89	317.13	194	52.32	38.02	182.07	9.07	76.04	1832.70	458.18	343.63	2634.51	99.07
RS7BS	767	206.86	118.20	659.97	151.11	194	52.32	38.02	182.07	9.07	76.04	1493.66	373.42	280.06	2147.14	81.91
RS7BC	767	206.86	118.20	659.97	231.95	194	52.32	38.02	182.07	9.07	76.04	1574.50	393.63	295.22	2263.34	85.40

* Y: Including Baushi Bridge Structure, N: Not Including Baushi Bridge Structure

Source: CS 1992, see PSR X.4

C:\DFR\MAIN\LOTUS\TAB-62.WK1

TABLE 6.3
Economic Analysis of Scenarios without Jamuna Bridge

Scenarios	Projects	Public costs (Tk,000,000)				Fishery net income (Tk,000,000)		Ag.net inc. (Tk,000,000)	Flood damage (Tk,000,000)		IRR	NPV	NPVR(1)	IRR * with 1.25 factor
		at market price		at economic price										
		Capital	O & M	Capital	O & M	at market price	at econ.** price	at econ. price	at market price	at econ.** price				
0A	No	0.0	0.0	0.0	0.0	1082.1	941.4	11023.6	288.5	251.0				
1	RS1bN	1391.0	49.9	928.5	37.4	1073.5	933.9	11186.6	261.6	227.6	10.1%	-142	-0.099	11.4%
1a	RS1bN with 40% agr.benefits	1381.0	49.9	928.5	37.4	1073.5	933.9	11251.8	261.6	227.6	13.9%	158	0.110	14.8%
1b	RSIbN ex.Flood proof	1217.2	42.4	812.5	31.8	1073.5	933.9	11186.6	261.6	227.6	11.8%	-13	-0.011	12.8%
2	RS1cN	1661.8	62.4	1093.9	46.8	1076.9	936.9	11100.0	266.0	231.4	0.4%	-739	-0.426	
3	RS1dN	3828.1	129.9	2791.0	97.4	1070.0	930.9	11191.8	261.6	227.6	-1.2%	-2013	-0.515	
4	RS4	1824.0	69.7	1174.0	52.2	1076.1	936.2	11197.3	288.5	251.0	6.0%	-509	-0.266	
5S	RS3A1S	930.7	34.7	616.2	26.0	1101.8	958.6	10902.2	268.1	233.2	-ve	-1019	-1.050	
5C	RS3A1C	946.4	35.2	628.9	26.4	1081.8	941.2	11332.7	268.1	233.2	24.4%	850	0.863	
6S	RS3A1S+RS4	2406.2	89.3	1511.0	67.0	1098.6	955.8	11011.5	268.1	233.2	-ve	-1512	-0.604	
6C	RS3A1C+RS4	2421.9	89.8	1523.7	67.3	1077.7	937.6	11470.9	268.1	233.2	15.5%	485	0.193	
7S	RS3A1S+RS3A2S	2175.0	82.5	1409.0	61.9	1092.0	950.0	10997.4	209.5	182.2	-ve	-1203	-0.529	
7C	RS3A1C+RS3A2C	2389.0	88.9	1581.6	66.7	1059.2	921.5	11702.2	209.5	182.2	22.4%	1725	0.693	
8S	RS3A1S+RS3A2S+RS4	3650.5	137.1	2303.8	102.8	1087.8	946.4	11139.7	209.5	182.2	0.2%	-1546	-0.406	
8C	RS3A1C+RS3A2C+RS4	3864.5	143.5	2476.4	107.6	1054.2	917.2	11869.7	209.5	182.2	18.2%	1496	0.372	
9S	RS6A1S+RS6A2S	1806.5	67.3	1190.9	50.5	1101.6	958.4	10892.0	270.2	235.1	-ve	-1695	-0.900	
9C	RS6A1C+RS6A2C	1825.9	67.9	1206.6	50.9	1084.3	943.3	11256.2	270.2	235.1	10.8%	-121	-0.064	
10S	RS6A1S+RS6A2S+RS4	3630.5	136.9	2364.9	102.7	1098.1	955.4	11009.0	270.2	235.1	-ve	-2450	-0.646	
10C	RS6A1C+RS6A2C+RS4	3649.9	137.5	2380.6	103.1	1080.0	939.6	11384.6	270.2	235.1	7.3%	-828	-0.217	
11	RS2	1200.1	44.1	816.4	33.1	1064.4	926.1	11298.7	255.7	222.5	18.1%	476	0.382	
12	RS1bY+RS2	2591.0	94.0	1744.9	70.5	1057.6	920.1	11447.8	246.1	214.1	13.3%	195	0.073	
13	RS1cY+RS2	2861.9	106.5	1910.3	79.9	1061.0	923.1	11359.7	252.8	219.9	9.2%	-422	-0.142	
14	RS2+RS1dY	5028.2	174.0	3607.4	130.5	1055.8	918.6	11467.8	246.1	214.1	5.6%	-1599	-0.310	
15	RS2+RS4	2635.9	99.8	1715.8	74.8	1064.0	925.6	11366.9	255.7	222.5	10.6%	-201	-0.073	
16S	RS2+RS3A1S	2130.7	78.8	1432.6	59.1	1105.4	961.7	11118.2	235.3	204.7	4.3%	-708	-0.320	
16C	RS2+RS3A1C	2146.5	79.3	1445.2	59.4	1074.8	935.1	11717.7	235.3	204.7	24.1%	1893	0.848	
17S	RS2+RS3A1S+RS4	3218.1	119.4	2052.8	89.6	1103.3	959.9	11124.7	235.3	204.7	0.1%	-1381	-0.412	
17C	RS2+RS3A1C+RS4	3233.8	119.9	2065.4	89.9	1065.0	926.6	11752.4	235.3	204.7	18.5%	1312	0.390	
18S	RS2+RS3A1S+RS3A2S	3375.0	126.6	2225.4	94.9	1088.8	947.3	11228.8	176.7	153.7	6.5%	-848	-0.241	
18C	RS2+RS3A1C+RS3A2C	3589.0	133.0	2398.0	99.7	1043.2	907.6	12107.2	176.7	153.7	23.1%	2832	0.758	
19S	RS2+RS3A1S+RS3A2S+RS4	4462.4	167.2	2845.6	125.4	1087.2	945.9	11252.6	176.7	153.7	4.3%	-1439	-0.309	
19C	RS2+RS3A1C+RS3A2C+RS4	4676.3	173.6	3018.2	130.2	1038.5	903.5	12167.1	176.7	153.7	19.9%	2394	0.492	
20S	RS2+RS6A1S+RS6A2S	3006.5	111.4	2007.3	83.5	1102.6	959.2	11114.3	237.4	206.5	-0.2%	-1369	-0.438	
20C	RS2+RS6A1C+RS6A2C	3026.0	112.0	2023.0	84.0	1070.8	931.6	11640.8	237.4	206.5	16.7%	887	0.282	
21S	RS2+RS6A1S+RS6A2S+RS4	4442.3	167.1	2906.7	125.3	1097.4	954.7	11115.3	237.4	206.5	-6.3%	-2379	-0.513	
21C	RS2+RS6A1C+RS6A2C+RS4	4461.8	167.7	2922.4	125.8	1067.3	928.6	11672.8	237.4	206.5	12.1%	28	0.006	
37C	RS1bY+RS2+RS3A1C+RS3A2C	4980.0	182.9	3326.5	137.1	1052.0	915.3	12120.7	149.8	130.3	19.2%	2342	0.453	
38C	RS1bY+RS2+RS3A1C+RS3A2C +RS4	6067.3	223.5	3946.7	167.6	1047.5	911.3	12224.9	149.8	130.3	17.1%	1872	0.311	

Note:- ve = Negative, * A 1.25 factor has been applied to the avoided flood damages to allow for indirect and macro-economic impacts

** A standard conversion factor of 0.87 has been used, for fishery and flood damage economic prices

Source: CS 1992, see PSR X.4

F:\MAS\DAB\NCRS\LAST\MAIN\TAB63.WK1

TABLE 6.4
Economic Analysis of Scenarios with Jamuna Bridge

Scenarios	Projects	Public costs (Tk,000000)				Fishery net income (Tk,000000)		Ag.net inc. (Tk,000000)	Flood damage (Tk,000000)		IRR	NPV	NPVR(1)
		at market price		at economic price									
		Capital	O&M	Capital	O&M	at market price	at econ. * price	at econ. price	at market price	at econ. * price			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
0B	No	0.0	0.0	0.0	0.0	1052.0	915.3	11719.2	288.5	251.0			
22	RS4	1824.0	69.7	1174.0	52.2	1047.5	911.3	11896.6	261.6	227.6	8.2%	-333	-0.176
23S	RS3B1S	574.4	21.5	383.1	16.1	1079.9	939.6	11318.0	266.0	231.4	-ve	-1968	-3.315
23C	RS3B1C	574.4	21.5	383.1	16.1	1076.5	936.5	11421.5	261.6	227.6	-ve	-1487	-2.505
24S	RS3B1S+RS4	2226.9	84.4	1446.6	63.3	1071.1	931.8	11459.2	268.1	233.2	-ve	-2537	-1.099
24C	RS3B1C+RS4	2226.9	84.4	1446.6	63.3	1067.6	928.8	11559.6	268.1	233.2	-ve	-2096	-0.908
25S	RS3B1S+RS3B2S	1818.7	69.2	1176.0	51.9	1067.8	929.0	11444.9	209.5	182.2	-ve	-2004	-1.061
25C	RS3B1C+RS3B2C	2017.0	75.2	1335.9	56.4	1056.3	919.0	11764.6	209.5	182.2	2.5%	-746	-0.358
26S	RS3B1S+RS3B2S+RS4	3260.4	123.8	2071.8	92.9	1065.3	926.8	11550.8	209.5	182.2	-ve	-2510	-0.742
26C	RS3B1C+RS3B2C+RS4	3458.6	129.8	2220.5	97.3	1052.2	915.4	11925.5	209.5	182.2	5.3%	-999	-0.279
27S	RS6B1S+RS6B2S	1451.0	54.1	958.5	40.6	1081.0	940.5	11217.0	270.2	235.1	-ve	-3069	-2.047
27C	RS6B1C+RS6B2C	1454.7	54.2	961.5	40.7	1077.0	937.0	11345.0	270.2	235.1	-ve	-2506	-1.668
28S	RS6B1S+RS6B2S+RS4	3275.0	123.7	2132.5	92.8	1076.0	936.1	11345.3	270.2	235.1	-ve	-3786	-1.116
28C	RS6B1C+RS6B2C+RS4	3278.7	123.9	2135.5	92.9	1072.3	932.9	11486.3	270.2	235.1	-ve	-3161	-0.931
29	RS2	1200.1	44.1	816.4	33.1	1029.9	896.0	12154.6	255.7	222.5	25.1%	1199	0.971
30	RS2+RS4	3024.1	113.8	1990.4	85.3	1026.1	892.7	12222.3	255.7	222.5	13.2%	211	0.068
31S	RS2+RS3B1S	1774.5	65.6	1199.5	49.2	1064.4	926.0	11697.2	235.3	204.7	-ve	-1004	-0.549
31C	RS2+RS3B1C	1774.5	65.6	1199.5	49.2	1061.6	923.6	11790.6	235.3	204.7	4.3%	-589	-0.322
32S	RS2+RS3B1S+RS4	3038.8	114.5	1988.4	85.9	1053.0	916.1	11733.0	235.3	204.7	-ve	-1774	-0.564
32C	RS2+RS3B1C+RS4	3038.8	114.5	1988.4	85.9	1054.7	917.6	11833.3	235.3	204.7	0.6%	-1300	-0.413
33S	RS2+RS3B1S+RS3B2S	3018.8	113.3	1992.4	85.0	1050.6	914.1	11830.0	176.7	153.7	4.0%	-997	-0.319
33C	RS2+RS3B1C+RS3B2C	3217.0	119.3	2152.3	89.5	1040.3	905.0	12147.1	176.7	153.7	13.4%	259	0.078
34S	RS2+RS3B1S+RS3B2S+RS4	4072.3	154.0	2613.6	115.5	1048.6	912.3	12205.5	176.7	153.7	12.2%	41	0.010
34C	RS2+RS3B1C+RS3B2C+RS4	4270.5	159.9	2762.3	120.0	1037.7	902.8	11881.0	176.7	153.7	1.8%	-1677	-0.380
35s	RS2+RS6B1S+RS6B2S	2651.1	98.2	1774.9	73.6	1067.2	928.5	11585.5	237.4	206.5	-ve	-2135	-0.781
35C	RS2+RS6B1C+RS6B2C	2654.8	98.3	1777.9	73.7	1062.4	924.3	11730.0	237.4	206.5	-ve	-1498	-0.547
36S	RS2+RS6B1S+RS6B2S+RS4	4086.9	153.9	2674.3	115.4	1061.7	923.6	11611.3	237.4	206.5	-ve	-3038	-0.718
36C	RS2+RS6B1C+RS6B2C+RS4	4090.6	154.0	2677.3	115.5	1058.6	921.0	11774.9	237.4	206.5	-ve	-2303	-0.544

Note: -ve = Negative

* A standard conversion factor of 0.87 has been used, for fishery and flood damage economic prices

Source: CS 1992, see PSR X.4

F:\MAS\DABN\CRS\LAST\MAIN\TAB64.WK1

TABLE 6.5
Sensitivity Analysis

Scenarios	Projects	Base case			Flood damage		Agric'tral Net Income and flood damage		Delayed implement'tn. (construct.=6 years)		Increase of capital and O&M costs				Delay in achieving benefits (by 2 years)		Conversion factors* (June 1992 nrs.)	
											increase by 40%		doubled costs					
		IRR	NPV	NPVR(1)	IRR ** with 0.75 factor	IRR ** with 1.25 factor	IRR *** with 0.75 factor	IRR *** with 1.25 factor	IRR	NPV	IRR	NPV	IRR	NPV	IRR	NPV	IRR	NPV
Without Jamuna Bridge																		
1	RS1bN	10.1%	-142	-0.099	9.2%	11.2%	6.5%	13.0%	8.3%	-267	6.1%	-585	2.2%	-1239	9.4%	-212	7.9%	-303
5C	RS3A1C	24.4%	850	0.863	23.7%	25.2%	19.5%	28.7%	19.3%	494	-18.7%	575	13.5%	177	22.2%	731	21.3%	605
6C	RS3A1C+RS4	15.5%	485	0.193	15.1%	15.9%	11.6%	18.8%	12.7%	92	-11.0%	-176	6.7%	-1144	14.2%	314	13.0%	122
7C	RS3A1C+RS3A2C	22.4%	1725	0.693	21.3%	23.8%	17.6%	26.6%	17.9%	964	16.9%	1036	12.0%	44	20.4%	1463	19.7%	1200
8C	RS3A1C+RS3A2C+RS4	18.2%	1496	0.372	17.4%	19.2%	13.9%	22.0%	14.8%	659	13.3%	419	8.8%	-1145	16.6%	1169	15.6%	832
9C	RS6A1C+RS6A2C	10.8%	-121	-0.064	10.3%	11.4%	7.4%	13.6%	8.9%	-313	6.7%	-725	2.8%	-1615	9.9%	-226	8.7%	-337
10C	RS6A1C+RS6A2C+RS4	7.3%	-828	-0.217	7.0%	7.6%	4.0%	9.9%	5.9%	-982	3.5%	-1889	-0.7%	-3456	6.6%	-972	5.1%	-1140
11	RS2	18.1%	476	0.382	17.1%	19.3%	13.6%	21.9%	14.7%	204	13.2%	128	8.8%	-380	16.5%	370	15.4%	252
12	RS1bY+RS2	13.3%	195	0.073	12.6%	14.1%	9.4%	16.6%	11.0%	-127	9.0%	-511	5.0%	-1546	12.2%	39	10.8%	-147
15	RS2+RS4	10.6%	-201	0.073	10.0%	11.3%	7.0%	13.6%	8.7%	-444	6.6%	-1007	2.5%	-2193	9.7%	-345	8.3%	-513
16C	RS2+RS3A1C	24.1%	1893	0.848	23.3%	25.1%	19.2%	28.4%	19.1%	1099	18.4%	1262	13.3%	354	21.9%	1624	21.1%	1342
17C	RS2+RS3A1C+RS4	18.5%	1312	0.390	17.9%	19.3%	14.2%	22.2%	15.0%	589	13.6%	409	9.1%	-903	16.9%	1031	15.9%	737
18C	RS2+RS3A1C+RS3A2C	23.1%	2832	0.758	22.1%	24.4%	18.1%	27.3%	18.4%	1623	17.5%	1782	12.6%	275	21.0%	2410	20.2%	1982
19C	RS2+RS3A1C+RS3A2C+RS4	19.9%	2394	0.492	19.0%	21.0%	15.4%	23.9%	16.1%	1214	14.8%	1071	10.1%	-836	18.1%	1948	17.2%	1500
20C	RS2+RS6A1C+RS6A2C	16.7%	887	0.282	16.0%	17.5%	12.7%	20.2%	13.6%	305	12.0%	28	7.7%	-1225	15.3%	652	14.2%	404
21C	RS2+RS6A1C+RS6A2C+RS4	12.1%	28	0.006	11.6%	12.7%	8.5%	15.1%	10.0%	-215	7.9%	-601	3.9%	-1524	11.1%	-97	9.9%	-229
37C	RS1bY+RS2+RS3A1C+RS3A2C	19.2%	2342	0.453	18.1%	20.5%	14.8%	22.9%	15.6%	1149	14.1%	923	9.6%	-1127	17.5%	1899	16.5%	1430
38C	RS1bY+RS2+RS3A1C+ RS3A2C+RS4	17.1%	1872	0.311	16.1%	18.2%	12.9%	20.7%	13.9%	724	12.3%	196	7.9%	-2236	15.6%	1413	14.6%	927
With Jamuna Bridge and Guide Embankment																		
22	RS4	8.2%	-333	-0.176	7.3%	9.2%	4.8%	11.0%	6.6%	-432	4.3%	-858	0.2%	-1630	7.4%	-409	6.0%	-496
29	RS2	25.1%	1199	0.971	24.1%	26.1%	19.7%	29.7%	19.8%	707	19.3%	842	14.3%	342	22.6%	1015	21.7%	837
30	RS2+RS4	13.2%	211	0.068	12.7%	13.8%	9.3%	16.5%	10.9%	-161	8.9%	-604	5.0%	-1793	12.0%	12	10.7%	-184
33C	RS2+RS3B1C+RS3B2C	13.4%	259	0.078	11.8%	15.2%	9.5%	16.7%	11.0%	-153	9.0%	-626	4.9%	-1918	12.4%	84	11.5%	-68
34S	RS2+RS3B1S+RS3B2S+RS4	12.2%	41	0.010	10.8%	13.8%	8.5%	15.3%	10.0%	-295	7.9%	-814	3.8%	-2070	11.2%	-114	2.1%	-2362

Note : * The conversion factors used in the main economic analysis were based on FPCO figures of February 1992

** A corrective factor has been applied to the avoided flood damages, both +ve and -ve by 25%

*** A corrective factor applied both to avoided flood damages and to increase in agricultural income, both +ve and -ve by 25%.

Source: CS 1992, see PSR X.4

B:\123\TAB65.WK1

6.3.4 Balanced Development

The construction of the Jamuna bridge will change completely the patterns of development in the NCR. Any kind of project in the agricultural sector will not be sufficient to provide employment to the increasing population. It has been indicated that all efforts should be devoted to the creation of jobs in other sectors, industry and services. A major constraint to the development of such opportunities is the lack of good communications. The Jamuna bridge, and the road network linking it to Dhaka will naturally offer a strong boost to economic development in the south western part of NCR (which probably will justify the protection against floods of specific areas to create new industrial zones). There is a risk attached with southwestern third of NCR growing quickly, at the detriment of the other two thirds resulting from the movement of population that it is likely to induce (which would just increase the rural to urban irrigation which is already taking place towards Dhaka and the south of NCR).

An answer to.this potential problem is to give priority to the development of northern areas, providing better communications, better social infrastructures (this is specifically true for the cities of Jamalpur and Mymensingh), and flood control projects. In this way implementation could start in PU1 (scenario RS1) then in PU 2 and 4 (scenario RS 2). Other actions should concern the Old Brahmaputra flood plain (PU 3), with local drainage improvement and irrigation, and the northern part of Madhupur Tract (development there not being mainly related to water management). In PU3 where the potential of groundwater resources is limited, the possibility to improve the water supply for irrigation should be analysed (groundwater resources will cover 28% of the potential needs with STW, and 59% with DTW, see SR II). A possible solution lies with an improved supply through the Old Brahmaputra.

6.3.5 Macro-Economic Impact on Growth Prospects

It has been shown (Maurice 1991) that if the detrimental effects of floods could be overcome, the growth path of Bangladesh with flood control options could be above the growth path with floods, this being due to two factors:

- Capital erosion due to floods induces lower GDP in the following years;
- Output losses entails lower incomes, thus lower amounts available for financing,lowering capital and GDP.

The methodology developed by Maurice and Diallo (Maurice 1991) has shown that macro-economic effects can be accounted for by applying a single corrective factor to the standard expected avoided losses (capital and output losses). This corrective factor is presently tentatively estimated at 1.25. Such a corrective factor has been considered when preparing the sensitivity analysis, see Table 6.5, but the methodology for inclusion of benefits from macroeconomic analysis has yet to be approved by the FPCO.

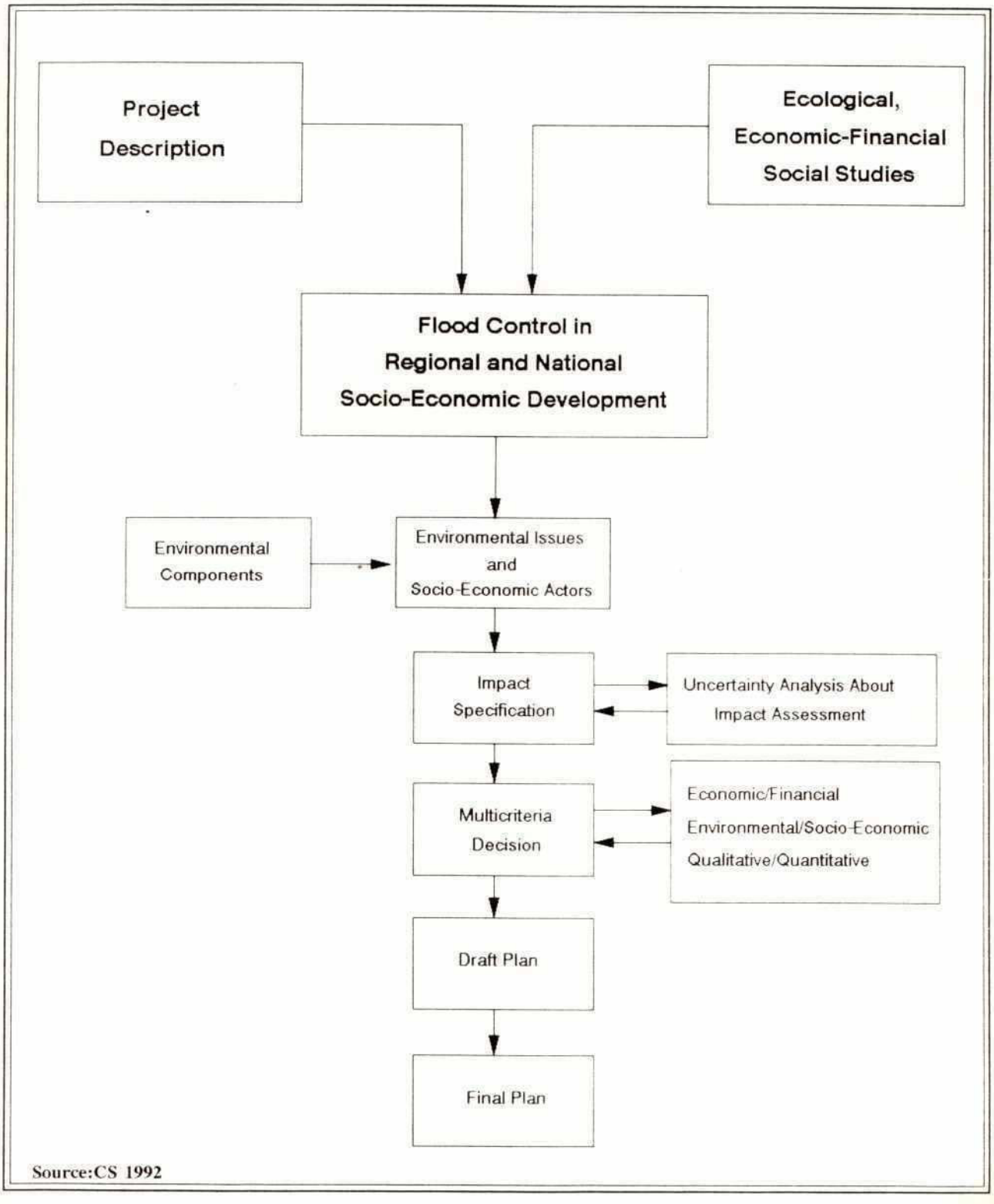
6.4 Multicriteria Analysis

6.4.1 Introduction

The multicriteria analysis followed has been a two stage process including, at first the impact assessment, then grouping together the criteria selected in this first stage, and ranking them (see Figure 6.1). The impact assessment process has illustrated the relationship of the biophysical and socio-economic environment to flood control and water management activities. These activities should be adapted to development objectives and the natural and human resources of the NCR.

Figure 6.1

Multicriteria Analysis And Impact Assessment



Source:CS 1992

The preliminary screening (see Section 3.2.3) identified a total of 16 project elements to be studied at prefeasibility level (See Figures 5.1 to 5.10):-

- 4 projects concerning PU1 (RS1a to RS1d),
- 3 projects concerning PU2 and PU4 (RS2aS, RS2aC and RS2b),
- 9 projects concerning PU6 and PU7 and PU6+PU7+PU10 (RS3 phase 1, phase 2, with controlled or semi-controlled structures, RS4 drainage option, RS6 phase 1, phase 2 with controlled or semi-controlled structures.

Taking into account several possible situations with or without combination of elementary projects, with or without control structure at Baushi Bridge, and with or without construction of Jamuna Bridge the analysis has identified 64 scenarios (see Table 4.3.2).

Each project element (named Regional Scheme, RS) should be self supporting, i.e., to bring its own benefits and disbenefits. As such it may be carried out alone or added to other projects (with possible interactions between them) inside a "development area". This development area can coincide with a PU (for instance RS1 for the PU1) or cover several PU (for instance RS2 for the PU2 and PU4).

The Regional Schemes involved in the NCR's FAP can be classified as follows:

- No hydraulic structure. No change to surface-water regime. It includes some flood proofing which means interventions to provide protection such as flood shelters and elevated housing sites;
- No hydraulic structures, drainage improvements only.
- Controlled or semi-controlled hydraulic structures (no significant embankment).
- Setback embankments: no hydraulic structures,
- Major embankments: controlled or semi-controlled hydraulic structures.
- Compartmentalisation

Each regional scheme (and the various scenarios) has been dealt with in an economic assessment (Section 6.3), but as far as socio-economic and biophysical aspects are concerned the degree of precision of assessments does not allow to differentiate sufficiently a project from another of its kind. Multicriteria analysis has thus been made only on the most contrasted scenarios in each development area. The contrasted scenarios concerned are :

i) Without Jamuna Bridge
   - RS1b, RS2, RS1b+RS2, RS3.1, RS3.1+RS3.2, RS4, RS1b+RS2+RS3 (1+2), RS6

ii) With Jamuna Bridge
   - RS2, RS4, RS2+RS4, RS2+RS3.1, RS2+RS3.2, RS5.2, RS6.

6.4.2 Impact Assessment

A systematic approach to the assessment of the NCRS environment has been developed, see SR X.5. This includes establishing the interaction between the components of the natural and socio-economic environment; and of the various parties involved. The tables from this analysis are included in Appendix A to this report for easy reference.

The assessment includes both quantitative and qualitative criteria in determining impact matrices. At the present pre-feasibility level of analysis insufficient information has been available to quantify some important issues and thus a significant part of the analysis has required subjective assessments. The matrix of valuation describes impacts in terms of their magnitude, but more information is required in terms of:-

- the impact development process
- geographic, chronological and temporal extent and variability
- reliability of information for the present situation
- sustainability
- reversibility
- uncertainty of long term estimates

6.4.3 Method of Valuation

The purpose of the multicriteria analysis at the pre-feasibility level has been to compare the quantitative and qualitative criteria in their performances in alternative or complementary development scenarios. Criteria have been chosen to give decision makers (National and International Institutions) the necessary elements on the major impacts. The analysis follows the presentation recommended in the Guidelines for Project Assessment, Table 1. (FPCO, 1992).

a. The Economic criteria are EIRR, NPV and NPVR1
b. Quantitative criteria are in line with the national objectives:
   - increase of agricultural production which is partly balanced by a decrease of fish production, both being considered.
   - improvement of nutrition levels
   - employment increase.

c. Qualitative criteria are presented with a scale from - 3 to + 3, when the impacts cannot be quantified. Although the data available at this stage of analysis is insufficient for these factors to be quantified, they have been considered to identify whether there are any major issues or differences between possible schemes that should be taken into account when making recommendations for further studies to be carried out at feasibility level. Five categories of impacts have been assessed:-

   i) Mitigation measures outside protected area.
   Obviously a project which leaves a lot of people outside the project area is not fully satisfactory as it is always difficult to prepare mitigation measures for the distressed people, and there is uncertainty, in an emergency situation, whether the proposed measures will apply efficiently. The criterion considers both the number of affected people and the degree of risk they are facing.

   ii)&iii) Socio-Economic, and Environmental impacts (these grouping together numerous effects).
   A specific analysis has been prepared for each of them applying the Adkins and Burke method which is a means of displaying relative impacts by the ratio of the plus rating to the minus rating as well as the average of all algebraic ratings. For each of these two categories of impacts a specific matrix has been prepared.

(iv) Balanced Development

This criterion considers what could be the future of the NCR, in its broad sense, involving flood control with other elements in the overall development process. Obviously priority should be given to the most distressed areas like the Jamuna and Padma Floodplains which are located in the South-West of the NCR with high population densities, very small holdings, factor aggravated by severe flood conditions, resulting in low incomes, unemployment, and migration towards the Dhaka region. However, a new element, the Jamuna bridge construction, is foreseen to modify completely the economic future in these areas. In such a case priorities will be reversed and should be given to the northern and north eastern parts of the NCR (see Section 6.3.4).

v) Organisation and Institutions

The larger the project the greater the difficulties to manage its construction, and subsequently to operate and maintain (as shown by FAP 12). It is known that this issue is a major concern in Bangladesh. An analysis of involved parties has been presented in section 5.2.2, and recommendations made to improve the present system (see SR IV). It is thus justified to include this criterion.It is believed that the Jamuna Bridge will have a positive impact on the level of organisation in the NCR, and due consideration should be given to this element.

d. Financial criteria are as follows:
   - investment costs
   - O&M costs
   - farmer net income

6.4.4 Summary of the Multicriteria Analysis

A summary of the multicriteria analysis for the potential projects is presented in Table 6.6, with supporting Tables 6.7 and 6.8 on Socio-Economic and Environmental impacts. Only a few scenarios have been compared, following the results of the economic analysis (see Sections 6.3), their impacts being analysed and compared for the without-Jamuna Bridge scenario (some indications also being given with Jamuna Bridge scenario). The following observations are made:-

a. Economic Criteria

As already underlined in Section 6.3, RS3 (phases 1 and 2) and RS2 have the higher EIRR, the combination of RS1bY, RS2 and RS3 (1 and 2) being also attractive (For location of these scenarios, see Figure 4.1).

When considering the net present values, it is this last scenario which gives the higher NPV, and should be preferred. The NPVR values are also given, and should only be used to compare alternative scenarios (not mutually exclusive ones).

b. Quantitative Criteria

Scenarios RS 3.1 and RS 3 (Phase 1 and 2) indicate very promising agricultural production, grain nutrition level and employment increases. The second criteria is obviously important since for WO there is a noticeable grain deficit in this area. However, the floodplain fish losses are high (the highest locally when compared to other PU).

At the regional level, RS1b + RS2 + RS3 (1 and 2) appears to be the best alternative as it gives significant agricultural production and employment increases. The resulting food surplus could be useful to cover the serious deficit existing in RS6 (the single area which will remain a deficit one, in Jamuna - Padma floodplain even W.). unfortunately it has a potentially severe detrimental impact on flood plain fisheries.

It is to be noted that employment increase during the construction phase in PU1 is noticeable, which could be a very positive factor for assisting the poor people and boosting the economic development provided efforts are made after construction to maintain the involvement of the poor in subsequent activities.

c. Qualitative Criteria

Giving the same weight to socio-economic and environmental considerations (which means adding together the overall mark given to each of these criteria) RS 3.1 is ranked first (+0.3), followed by RS1b + RS2 + RS3 (1 and 2), with 0.1 mark, them by RS1b + RS2 (its mark is O).

Balanced development will be a major concern with Jamuna Bridge, and priority should be clearly given to the northern scenarios (specifically RS1b + RS2). When implementing the above selected project a careful attention should be paid to the mitigation of detrimental impacts outside the project area, and the institutional and organizational aspects. In this respect, among the best scenarios selected above, RS 3.1 is the least affected, followed by RS1b, then RS1b + RS2, then RS1b + RS2 + RS3 (1 and 2).

d. Financial

The financial constraint could be a determining factor. A logical choice could be to select the Scenario RS1bY + RS2 + RS3 (1 and 2), giving due consideration to the mitigation of negative impacts and problems highlighted above. From the economic point of view, and considering also the socio-economic and environmental assessment, this scheme should be split into 2 parts, RS3.1 and 3.2 on one side, RS1bY plus RS2 on the other, of more or less the same cost, priority being given to the first one.

However RS3 cannot start quickly, as it involves the resolution of difficult hydraulic problems which require additional studies to be made. Fishery impacts will also require a long and careful assessment. It is thus advisable to start with RS1b + RS2, which is also logical because these areas are located upstream of RS3, and their improvement will also bring some envisaged improvements downstream. Since RS2 has better prospects than RS1b it appears, to have a higher priority, however hydraulic considerations linking together the downstream part of RS1b, and the upstream one of RS2 recommend the simultaneous development of RS1bn and RS2.

These problems can be better resolved following more detailed hydraulic, economic and financial analyses at the feasibility level. As the feasibility study of RS1 is already going on under FAP 3.1, it is advisable to recommend an early start of the feasibility study of RS2. Due to the very positive results obtained from RS3 it is also advisable to start soon the corresponding feasibility study. In this area, the increase of farmers income, the last criterion shown in Table 6.5, will be higher, which adds on to the other advantages previously described in favour of scenario RS3.

TABLE 6.6
Multicriteria Analysis. Summary of Project Results

Data Type	Criteria	Scenario[1]*	RS1bn	RS2	RS1bY + RS2	RS 3.1	RS 3.1 + RS 3.2	RS 4	RS 6	RS1bY + RS2+RS3 (1+2)
		PU [2]*	1	2,4	1,2,4	6 (7)	6,7	(2)4,6,7(8)	6,10	1,2,4,6,7
1. Economic	EIRR (%)		10.3	18.2	13.4	24.6	22.7	5.9	10.9	18.8
	NPV (Million Tk)12%		- 128	488	209	865	1770	- 513	- 106	2179
	NPVR 1 12%		- 0.089	0.392	0.078	0.878	0.712	- 0.268	- 0.056	0.421
2. Quantitative	Agricultural Production Increase:	- in PU %	12	12	11	29	31	7	17	22
		- in NCR %	1.2	1.8	2.9	2.6	4.7	1.6	1.8	8.7
	Grain Nutrition Level[3]*	- WO	124	114	118	79	76	83	68	103
	(% of basic needs)	- W	139	126	131	103	99	106	79	119
	Eloyment Increase	- in PU% [4]*	8 (21)	4(9)	6 (11)	12(8)	10(6)	4(8)	5 (12)	8(7)
		- in NCR %	0.8	0.7	1.4	1.5	2.0	1.0	0.9	3.5
	Floodplain Fish Losses	- in PU %	22	22	20	27	36	3	8	27
		- in NCR %	2	3	5	3	6	1	2	11
3. Qualitative	Mitigation Measures outside protected area[5]*		-1	-1	-2	-1	-1	0	-2	-2
	Socio-Economic[6]*		+0.5	+0.3	+0.8	+0.9	+0.6	+0.4	+0.7	+0.9
	Environmental[7]*		- 0.7	-0.8	-0.8	-0.6	-0.8	-0.5	-0.8	-0.8
	Balanced development[8]*		(+ 2)	(+2)	(+3)	(-2)	(-3)	(-2)	(-1)	(+2)
	Organizational/Institutional[9]*		-1(-1)	-1(-1)	-2(-2)	-1(0)	-2(-1)	-1(-1)	-1(-1)	-3(-2)
4. Financial	Investment costs(Million Tk)		1391	1200	2591	946	2389	1824	1826	4980
	O&M Costs (Million Tk)		50	44	94	35	89	70	68	183
	Net Income/Day [10]*	- WO	95	67	78	55	58	60	58	69
		- W	101	73	83	68	73	62	64	80
		- increase %	7	8	7	24	26	4	11	16

Notes on Table 6.6

(1) Scenarios described here are as follows (see also table 5.2 chapter 5):
- RS1bn: Jamalpur P.P. with controlled flooding, improved drainage and no restriction at Baushi bridge
- RS2 : Controlled flooding by improving the railway embankment from Jamalpur to the fertilizer factory, then rehabilating and completing the Jamuna embankment to Bhuapur (restriction at Baushi bridge, when associated or not with RS1b, option RS1bY).
- RS 3.1 Controlled flooding with Dhaleswari left embankment from Joker Char to Barinda river.
- RS 3.2 Controlled flooding with Dhaleswari left embankment from Barinda river to Kalatia, at confluence with the Bangshi river.
- RS4 Drainage improvement along the Bangshi river from east of Basail to Kalatia.
- RS6 Controlled flooding with first and second phase of Dhaleswari-Jamuna embankment down to Harirampur.

(2) Between brackets: quoted PU is also concerned to some extent
(3) Considering a population increase of 20% WO and W (could be after around 10 years).
(4) Employment increase in concerned PU : first figure at full development, second figure between brackets during construction.
(5) from - 3 to + 3
(6) Average of ratings of 13 criteria resulting from the detailed analysis, see Table 5.9 (range for each of them being from - 3 to +3)
(7) Average of ratings of 18 criteria from the detailed analysis sea Table 5.10 (range for each of them being from - 3 to +3)
(8) In case Jamuna Bridge is being built
(9) from - 3 to + 3. Between brackets revised figures assuming that Jamuna bridge is being built.
(10) Including hired labour.

Source : CS 1992

TABLE 6.7
Socio-Economic Assessment 1/

Assessment Criteria	Regional Schemes without Jamuna Bridge Effects																Regional Schemes with Jamuna Bridge													
	RS1b		RS2		RS1b+RS2		RS3-1		RS3-1+RS3-2		RS4		RS6		RS1b+RS2 RS3(1+2)		RS2		RS4		RS2,RS4		RS2+RS3-1		RS2+RS3-2		RS52		RS6	
	C 2/	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O
Quantitative																														
Income																														
(Changes with respect to situation without intervention):																														
- Floodplain Capture fishery (%)		- 2.3		-3.0		-4.7		-2.6		-6.1		-0.7		-1.9		-10.9		-4.8		-3.2		-5.2		-1.9		-3.8		-3		-1.8
		(0)		(-1)		(-1)		(0)		(-2)		(0)		(0)		(-3)		(-3)		(-2)		(-3)		(-1)		(-2)		(-2)		(-1)
Resettlement																														
- Popul.to be resettlet.000,hab.	4.1		3.0		7.1		2.0		7.9		4.6		7.6		15.0		3.0		4.6		7.6		5.0		8.9		11.7		7.5	
	(-1)		(0)		(-1)		(0)		(-2)		(-1)		(-2)		(-3)		(-1)		(-1)		(-2)		(-1)		(-3)		(-3)		(-2)	
Qualitative																														
Population affected																														
- Flood pl.fishery		-1		-1		-2		-1		-3		0		-2		-3		-1		0		-1		-2		-3		-3		-3
- Agricul.labour		+1		+1		+2		+2		+3		+1		+3		+3		+1		+1		+2		+2		+3		+3		+3
- Rickshaw,petty trader		+1		+1		+1		+2		+3		+1		+3		+3		+1		+1		+2		+3		+3		+3		+3
- Farm household	-1	+1	-1	+1	-2	+2	-1	+2	-3	+3	-2	+1	-2	+2	-3	+3	-1	+1	-1	+1	-2	+3	-1	+3	-3	+3	-3	+3	-2	+3
Transport																														
- Waterways		-1		-1		-1		-1		-2		-2		0		-2		-1		-2		-2		-3		-3		-3		-1
- Roads		+2		+1		+2		+1		+3		+1		+2		+3		+1		+1		+2		+1		+3		+3		+2
- Railways		+3		0		+3		0		0		0		0		+1		0		0		0		0		0		0		0
Life Style																														
- Security		+1		+1		+2		+1		+1		0		+2		+3		+1		0		+1		+1		+3		+3		+2
- Nutrition		+1		+2		+2		+3		+2		+1		+2		+3		+2		+1		+2		+2		+2		+2		+2
- Health		-1		-1		-1		0		-1		+1		-2		-2		-1		+1		+1		-2		-2		-2		-2
- Water supply		-1		-1		-1		-1		-1		0		-3		-2		-1		0		-1		-1		-1		-2		-2
- Women condition		+1		+1		+2		+3		+2		+1		+2		+3		+1		+1		+1		+3		+3		+3		+2
Qualitative criteria analysis																														
Nr.of plus rating	-	8	-	7	-	8	-	7	-	7	-	7	-	7	-	9	-	8	-	8	-	9	-	8	-	8	-	8	-	8
Nr.of minus rating	2	4	1	5	2	5	1	3	2	5	2	1	2	4	2	5	2	5	2	2	2	4	2	5	2	5	2	5	2	5
Algebric sum of rating	-2	+7	-1	+4	-3	10	-1	11	-5	+8	-3	+5	-4	+9	-6	+11	-2	+1	-2	+3	-4	+7	-2	0	-6	+9	-6	+8	-4	8
Average of rating	-1	+0.5	-0.5	+0.3	-1.5	+0.8	-0.5	+0.9	-2.5	+0.6	-1.5	+0.4	-2	+0.7	-3	+0.9	-1	+0.1	-1	+0.2	-2	+0.5	-1	0	-3	+0.7	-3	+0.6	-2	+0.6

Note : 1. When quantitative, an equivalent qualitative assessment is given between brackets with a mark between - 3 and +3

2. C = Construction phase; O = Operation phase

Source : CS 1992

C:\123\DMREP\TABLE67.WK1

TABLE 6.8
Environmental Assessment

Assessment Criteria	Regional Schemes without Jamuna Bridge								Regional Schemes with Jamuna Bridge						
	RS1b	RS2	RS1b+RS2	RS3-1	RS3-1+RS3-2	RS4	RS6	RS1b+RS2 RS3(1+2)	RS2	RS4	RS4+RS2	RS31+RS2	RS32+RS2	RS52	RS6
Bio-diversity	- 1	- 2	- 2	- 1	- 1	- 1	- 1	- 2	- 2	- 1	- 3	- 2	- 2	- 2	- 2
Endangered Species	- 1	- 1	- 1	- 2	- 2	- 1	- 1	- 2	- 1	- 1	- 2	- 1	- 2	- 2	- 2
Fauna	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 2	- 2	- 2
Fish Habitat	- 2	- 2	- 2	- 1	- 2	- 1	- 3	- 3	- 2	- 1	- 3	- 3	- 3	- 3	- 3
Fish Migration (pathway)	- 2	- 2	- 3	- 2	- 2	0	- 3	- 3	- 3	0	- 3	- 3	- 3	- 3	- 3
Birds (Migratory)	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 2	- 2	- 2	- 2	- 2
Flora	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1	- 1
Forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Homestead Trees	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetland	- 2	- 2	- 2	- 1	- 2	- 2	- 2	- 2	- 2	- 2	- 2	- 2	- 3	- 3	- 3
Water Quality															
Beels	- 2	- 2	- 2	- 1	- 2	0	- 3	- 2	- 2	- 2	0	- 3	- 3	- 3	- 3
River	- 2	- 2	- 2	0	0	- 2	- 1	- 2	- 2	- 2	- 2	0	- 1	0	- 2
Ground water	- 1	- 1	- 2	- 1	- 2	0	- 1	- 2	- 1	0	- 1	- 2	- 3	- 2	- 1
Soils Fertility and Structure	0	0	- 1	- 1	- 1	0	- 1	- 1	0	0	- 1	- 1	- 1	- 1	- 1
Induced Drought	- 2	- 1	- 2	- 1	- 1	0	- 1	- 2	- 2	0	- 2	- 2	- 1	- 1	- 1
Flood damage to land	+ 2	+ 1	+ 2	+ 1	+ 1	+ 1	+ 1	+ 3	+ 2	+ 1	+ 1	+ 2	+ 2	+ 2	+ 1
Erosion/Jamuna	+ 2	+ 1	+ 3	+ 1	+ 1	0	+ 2	+ 3	+ 1	0	+ 1	+ 2	+ 1	+ 1	+ 2
/within area	+ 2	+ 1	+ 2	+ 1	+ 2	0	+ 2	+ 3	+ 1	0	+ 1	+ 2	+ 1	+ 1	+ 2
Qualitative criteria analysis															
Nr.of plus rating	3	3	3	3	3	1	3	3	3	1	3	3	3	3	3
Nr. of minus rating	12	12	13	12	12	8	13	13	12	9	12	12	13	12	13
Algebric sum of rating	-12	-15	-15	-11	-14	-9	-15	-15	- 16	- 11	- 21	- 17	- 23	- 21	- 21
Average of rating	-0.67	-0.83	-0.83	-0.61	-0.78	-0.50	-0.83	-0.83	-0.89	-0.61	-1.17	-0.94	-1.28	-1.17	-1.17

Source : CS 1992

C:\DFR\MAIN\LOTUS\TABLE68.WK1

6.5. The Regional Water Resources Development Plan

6.5.1 General

The North Central Region suffers heavily from flooding in its western part (Jamuna and Padma flood plains), on around 45% of its total area, severity of flooding increasing towards the south. Analyzing the present conditions by Planning Unit (PU), it was found that flood control measures including embankments, control structures, drainage and water management are likely to improve substantially the situation in the above two flood plains. In the Old Brahmaputra flood plain and the southern part of Madhupur Tract only local drainage improvements are needed. Refining the analysis of possible solutions in homogeneous areas (taking consideration of socio-economic and environmental factors), 64 alternative scenarios have been defined for screening and comparison.

A multicriteria analysis has then been prepared. Following the FPCO Guidelines for project assessment, it has classified the project impacts into four categories: economic, quantitative, qualitative and financial. All considered the forecast "social" benefits in a broad sense, quantitative and qualitative analyses being mainly devoted to an assessment of socio-economic and environmental impacts.

6.5.2 Recommended Schemes

Two regional schemes appear very promising :
RS3 = With embankment along the Dhaleswari-Kaliganga from Pungli river to the Bangshi river (at Kalatia),
RS2 = With controlled flooding along the railway line from Jamalpur to the Jamuna fertilizer factory (near Sarishabari), and embankment along the Jamuna down to Bhuapur (mainly improvement of existing or ongoing structures). The corresponding costs of investments are (respectively 2.4 and 1.2 billion Taka (approximately 70 and 35 million US $). Both will have some detrimental consequences on environment and fish resources which shall have to be addressed carefully and if possible compensated (these aspects needing a more detailed assessment during further stages of the study). Both will require that institutional and organizational problems linked to their implementation are properly solved.

RS 3 has higher economic prospects, and more generally slightly better performances than RS 2.

However RS 3 cannot start quickly as it has complicated hydraulic implications which require further study (embankment location and embankment impact in its very downstream part, and interrelation with the Jamuna bridge in the northern part if the decision to build this bridge is finalised).

Thus it is recommended to start with RS2.

In the overall NCR context, the best scenario was found to be RS1b + RS2 + RS3, which consists of the above two regional schemes plan plus the development of the Jamalpur Priority Project. Due to the hydraulic linkages between RS1b and RS2 (including the need to optimize the control structure of Baushi bridge) it is recommended to develop these two schemes in parallel. In terms of balanced development RS1b and RS2 have the highest priority in the Region. If the Jamuna bridge is built, this will help prevent large scale migrations of population toward Dhaka and the south of the Region.

The group RS1b and RS2 has a good economic prospect. For most of the parts of this area the level of distress is fairly high (except in the eastern part of Jamalpur priority area), partly due to the small size of farms. A very favourable factor is the role played by local initiative in PU1, which has already given very good results as far as the construction of the Jamuna embankment and the recent development of irrigation are concerned.

6.5.3 Limitations of the Analysis

The consultant has used existing basic data, and has produced as reliable results as possible, at this pre-feasibility level of study, by cross-checking information and conducting field survey to arrive at a better interpretation of the data. However, at feasibility study level additional investigations will be needed in such fields as topography, classification of flood phases, analysis of fishery activities, environmental impact assessment, etc. More consideration of people living on char land is also needed.

The hydraulic model needs substantial improvements, based on a better knowledge of flooding conditions (depth, durations), basically linked to topography and hydrology. Improvements will also have to be considered in more detail in the existing and planned structures, such as embankments and compartments and boundary conditions for typical flood events. This model is considered essential to project the W. project flood conditions, thus the W changes in flood patterns which are determining the project benefits.

A multicriteria analysis implies to some extent subjective judgements. They have been made to the best of the consultant expertise with the manpower resources allocated to the project. With the improvement of the basic socio-economic and environmental knowledge, it will be possible to refine some of the analyses. As far as the choice of development alternatives is concerned within the proposed plan, results are considered as being contrasted enough to give a good picture of development priorities.

6.5.4 Institutional Requirements

A study of the present institutional structure relating to water resource developments in the NCR indicates several key areas that may form a barrier to effective development. These issues are described in SR IV and are also being covered by FAP 26. A summary of the issues is given below and should be the subject of further discussion before detailed institutional arrangements are set down at future feasibility study level.

Local government in Bangladesh is based on the Thana, which forms the focal point for the provision of field staff from Ministries and ministerial representation occurs through "officers" or "engineers". While there is wide agency provision at Thana level, only two departments maintain out-reach programmes. These are BRDB through its system of block inspectors to supervise co-operative formation and the Department of Agricultural Extension through block supervisors to provide agricultural extension information via key (demonstration) farmers.

All government agencies suffer severe financial shortages, which result in a shortage of resources to develop adequate programmes and insufficient transport to supervise existing activities. This has been a perennial problem and the absence of widespread services has led to the non-governmental sector playing an increasingly important role.

Until recently local government was based on the Upazila system (Upazilas have now been superseded by Thanas), and Upazilas were headed by the Upazila Chairman, who was an elected official and was assisted by the Upazila Nirbahi Officer (UNO) who was an established civil servant. There was a distinct division of responsibility, with the UNO being responsible for regulatory functions, such as the judiciary and police and the Upazila Chairman being responsible for area development through directing line agency implementation. GOB has however, recently abolished the Upazila Chairman system and the alternative Thana based structure has yet to be fully developed.

Two major agencies operate at rural level independently of the Thana. These are the Bangladesh Water Development Board (BWDB), which is responsible for the development of national water resources, and the Bangladesh Agricultural Development Corporation (BADC).

One of the major constraints to the development of the effective delivery of services to end-users in the village is the existing lack of accountability. Line agency officials receive their orders from above and are only accountable to their superiors. It has also been shown that placing line agencies under the supervision of the Upazila Chairman in many instances served to impede rather than enhance service provision. Furthermore, there is an the absence of any legal body at Upazila level responsible for government service co-ordination and public participation.

The present system is essentially a "top down" approach and some consideration should be given to allowing for a "demand driven" institutional structure that can more effectively allow for the villagers' needs. It is also important that the present project approach of making the "farmer" as the primary object of development be abandoned in favour of the concept of "villager" encompassing all residents irrespective of relationship to the land.

A number of problems arise during the existing planning process which contribute to a negative view of water resources development projects. Principally, these are :

- Lack of Consultative Mechanism
- Social Disbenefits (including those who lose land,those with diminished productivity of land, those who lose their livelihood and those whose livelihood is likely to diminish)
- Public Participation

These institutional issues are discussed further in SR IV and a proposed model for a demand driven approach outlined. This is summarised below:-

The proposed institutional model is for a demand driven approach which includes for group formation at village level (both of individuals and small/marginal farmers). Group priorities once defined would be discussed together with those of medium/large farmers at Union/Ward level in order to determine the required services. These requirements would be supplied via a Union Services Coordination Committee which in turn would be coordinated by a Thana Development Committee. It is recommended that NGOs play an important role in such activities as promoting group formation/mobilisation. Additional targeted provisions should be made for certain disadvantaged groups such as fishermen, women and the destitute.

Certain responsibilities currently held by government agencies would be devolved to other organisations, and it is recommended that the higher levels of this institutional model be evolved through a consultative process, particularly as relates to water resources development implementation.

6.5.5 Other Considerations

The development of irrigation was not considered in the economic analysis , as it is only partly linked with flood control. Irrigation is dependent on flood control only where the Rabi crop (and mainly Boro rice) cannot be grown due to water being still on the land in December, for poor drainage conditions. In the Jamuna-Padma flood plains, it was not possible to assess with enough accuracy the local drainage conditions and a refinement of the hydraulic model will be needed to assess these circumstances.

In fact it is arbitrary to separate irrigated crops from the whole farming system. Any development project that includes a flood control element should consider all aspects of production within an integrated development project. Without irrigation it will not be possible to reach any satisfactory development level within the NCR, to fulfil the basic objectives, such as increased productions, good nutrition levels and raised incomes. For this reason the draft TOR for the Feasibility Studies have been drawn up to include for irrigation analysis to be carried out.

In the long term it is however believed that without the development of sources of income other than agricultural ones it will not be possible to solve the very difficult employment problems already existing. It is anticipated that rapid urbanization will occur in the region in the next 10-20 years. Industries are badly needed. The conditions for their development will probably be linked to the construction of better communications, and better social infrastructures in secondary towns, which will have in turn a very positive impact on all other projects including flood control and agricultural ones.

6.5.6 The Plan

The Regional Water Resources Development Plan (RWRDP) is presented below. The priorities are based on the conclusions, described earlier in the multicriteria analysis, see Section 6.4. The regional development plan allows for the inclusion of appropriate mitigation measures for all flood prone areas. The plan as described includes outlines of the larger schemes the other measures such as flood proofing and minor drainage improvements are mentioned but not detailed. The draft TOR for the identified additional feasibility studies to be undertaken in the short term (RS2 and RS3; RS1 is already being covered by FAP 3.1) include for a programme approach to be developed. The feasibility studies would include the adjacent charland and floodplain land as well as the area to be developed with controlled flooding and compartmentalisation. In this way the sub-region would be considered as an entity to be developed through staged development. Such an approach would consider priorities and phases, public participation, implementation policies, intermediate goals, institutional adjustments and decentralisation policies, O and M etc.

The anticipated developments have been categorised as suitable for short, medium and long term development [1]:

---

[1] Note: 1. Year 1 of the plan is considered to be 1993, and hence Year 25 will be the year of 2017.

Short Term

Short term development is considered as those schemes that could be prepared and implemented within the next 6 years, see Figure 6.2. These schemes consist of priority projects that are expected to have a relatively small environmental impact on adjacent areas, and thus require only 1 to 2 year feasibility study.

The schemes included in this category are:

(i) **RS1b (FAP 3.1)**. RS1 was identified in the early stage of the FAP during 1990 as a priority project and the feasibility study for this scheme, the Jamalpur Priority Project is already underway. The FAP 3.1 schedule is to complete project preparation by 1993, thus allowing for implementation to begin in 1994 (Year 2).

(ii) **RS2.** Significant structural elements of the RS2 (Jamalpur to Bhuapur Development) are already in place. The main control embankments consisting largely of the existing railway embankment (from Jamalpur to Jagannathganj) and the existing BWDB embankment from Jagannathganj to Bhuapur. (The Jamalpur Fertilizer Co. are already funding further improvements, in 1992, to this embankment to be used as a road). The scheme complements the development of RS1b and will also benefit from control to be made under RS1b on Baushi and the Jhenai Bridges.

The significant benefits envisaged from this scheme result from the compartmentalisation that would be developed in the area. The findings of the adjacent FAP 20 Tangail compartmentalisation project will be relevant in this respect.

(iii) **Flood Proofing and Mitigatory Measures**. Flood proofing will be required in those area impacted by the RS1b and RS2 schemes. This consists mainly of the char land area and active flood plain left outside of the embankments, see Figure 6.2. Other mitigatory measures may be required for certain disadvantaged groups. There include the landless and fishermen. Detailed initiatives will have to be developed at the Feasibility Study level and may include such measures are multipurpose use of embankments (see SR VIII) and integrated fish development projects (see SR III, Section 8.2.1).

Medium Term

Medium term development is classified as implementation within 7 to 15 years, see Figure 6.3. It is considered appropriate for those schemes that require several more years of study, before a fair appraisal can be made on their advisability.

(i) **RS3**. This scheme (Dhaleswari-Kaliganga Controlled Flooding and Compartmentalisation) would be a major development. It is recommended that it should be developed in 2 phases (Phase 1 being viable as a self-contained development). RS3 shows significant potential benefits to agriculture indicating a large net present value. However the impact of such a development on the existing environment, nearby areas and related sectors such as fisheries will be very significant. Such a large scale development (engineering funding is estimated at Tk. million 2730, approximate US $60 million) requires a comprehensive feasibility study, and time for the implication of such a development to be analysed, comprehended and decided upon.

Figure : 6.2

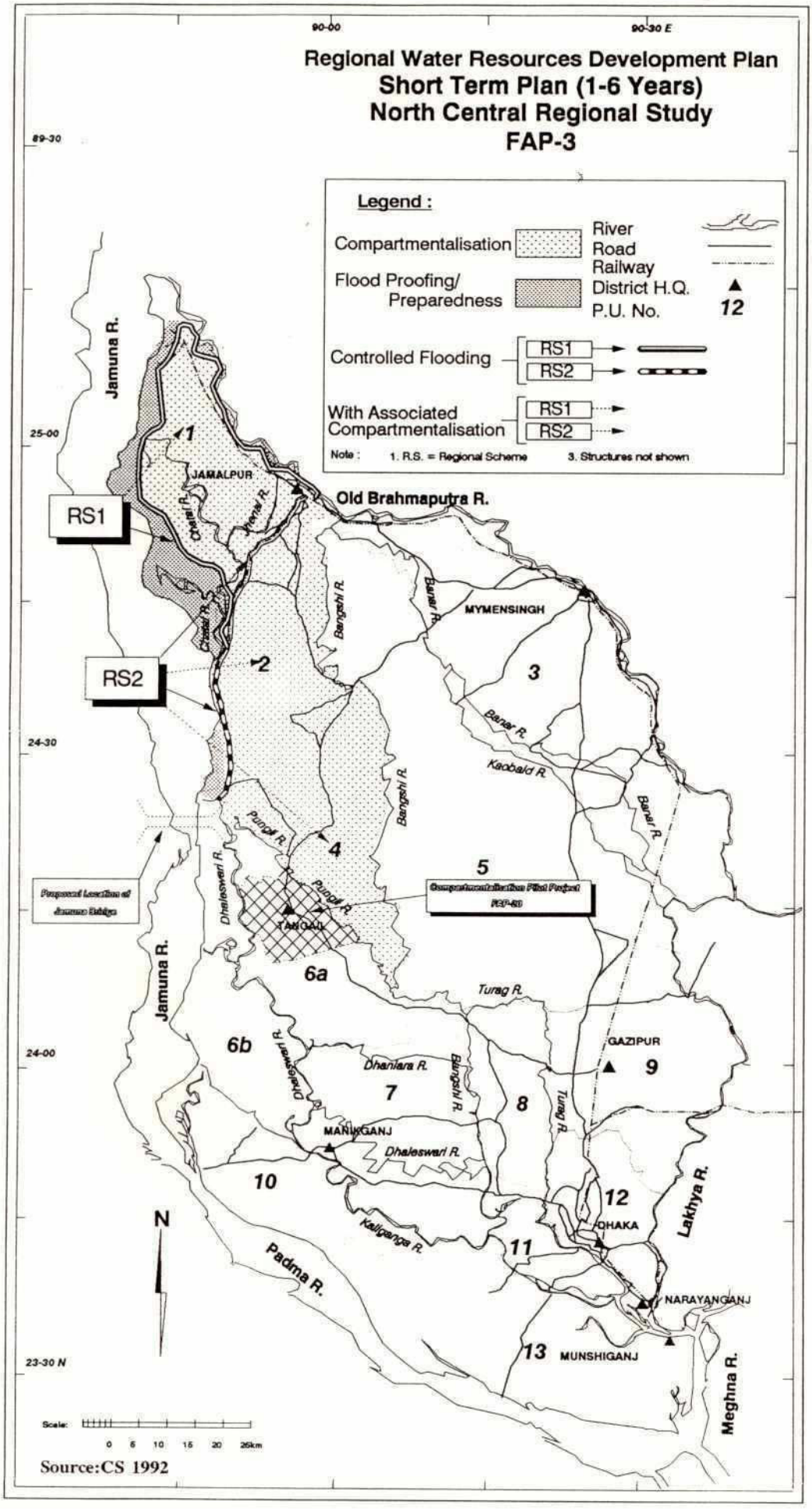
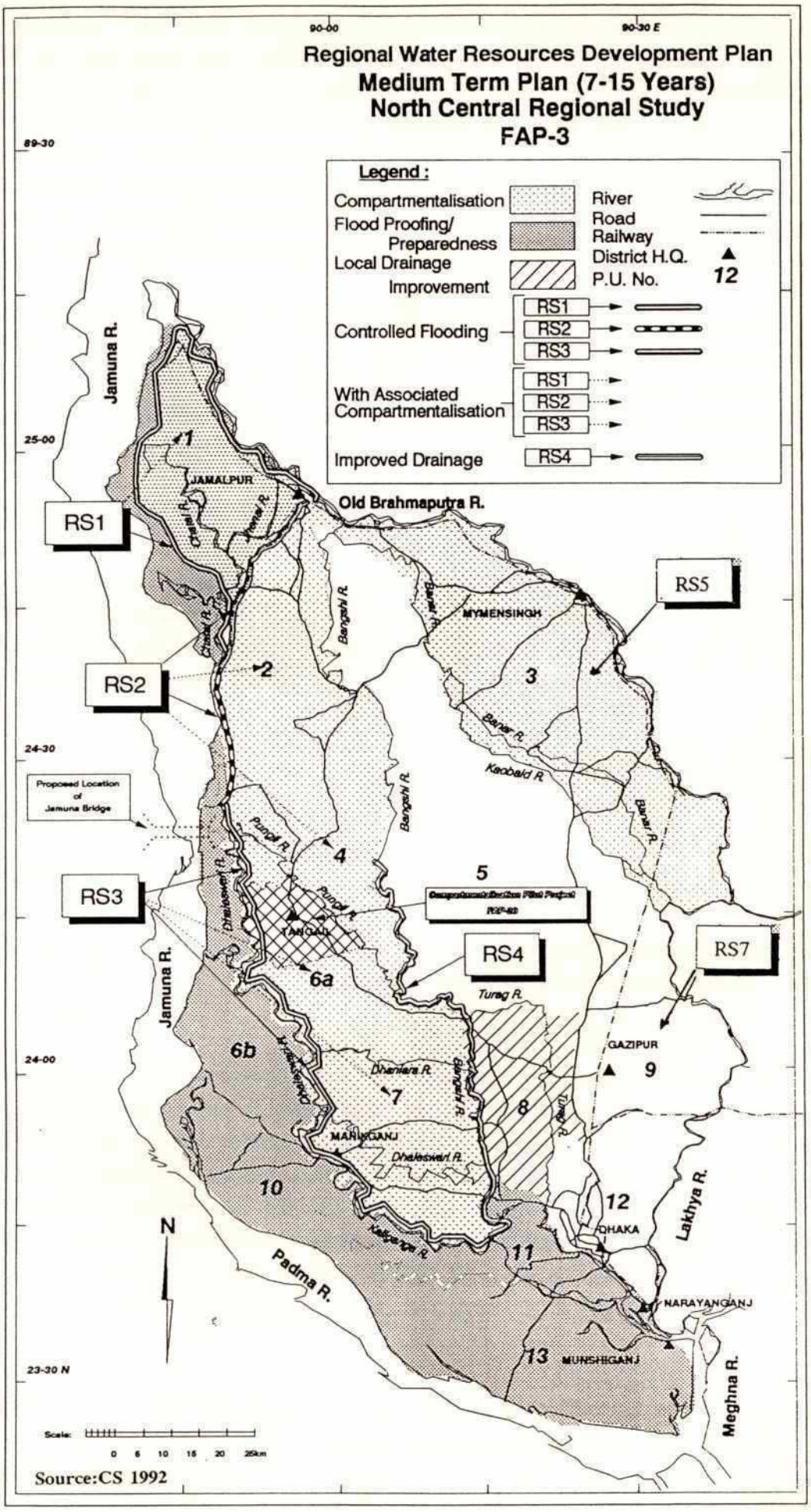

Regional Water Resources Development Plan
Short Term Plan (1-6 Years)
North Central Regional Study
FAP-3
90-00
90-30 E
89-30
25-00
24-30
24-00
23-30 N
Legend :
Compartmentalisation
Flood Proofing/ Preparedness
River
Road
Railway
District H.Q.
P.U. No.
12
Controlled Flooding
RS1
RS2
With Associated Compartmentalisation
RS1
RS2
Note : 1. R.S. = Regional Scheme 3. Structures not shown
Jamuna R.
JAMALPUR
Old Brahmaputra R.
Jhenai R.
Bangshi R.
Banar R.
MYMENSINGH
Kaobaid R.
Pungli R.
Dhaleswari R.
TANGAIL
Proposed Location of Jamuna Bridge
Compartmentalisation Pilot Project FAP-3
Turag R.
GAZIPUR
Dhanlara R.
MANIKGANJ
Kaliganga R.
Padma R.
DHAKA
Lakhya R.
NARAYANGANJ
MUNSHIGANJ
Meghna R.
Scale:
0 5 10 15 20 25km
Source:CS 1992

Figure : 6.3



Source:CS 1992

(ii) **RS4**. The investigations of regional drainage has shown that the high water levels at the south-west corner of the region (the Padma-Meghna influence) create a serious restriction to the drainage out of the region. Although local drainage improvement is still seen to be a viable option, see (iii), there is limited scope for effective improvements to the regional drainage. The pre-feasibility studies have revealed that improvements to the Bangshi river (scheme RS4) will bring justifiable benefits, but an improved regional model is required before this potential scheme can be recommended for feasibility analysis. In particular agricultural benefits in PU's 2,4,6a and 7 are expected through RS4 but it is not clear at this stage either to what degree the drainage improvements should be implemented or the extent of the benefits and other environmental impacts.

(iii) **RS5 and RS7, Compartmentalisation and Local Drainage**. Although not a high priority in terms of major flooding, agricultural production in areas of PUs 3, 8 and 9 have been found to be hampered by local flooding primarily caused by impeded drainage. It is recommended that after observation of progress on compartmentalisation and local drainage improvements recommended in the short term plan (FAPs 20, 3.1 and RS2), that consideration be given to carrying out feasibility studies for similar programs in PUs 3 and 8.

(iv) **Flood Proofing and Mitigatory Measures**

Flood proofing will be required in those areas impacted by RS3. This may include large areas of PUs 6b, 10, 11 and 13. Consideration should also be given to carrying out flood proofing in these areas, even without RS3. The viability of RS6 (see below) has to be questioned and thus flood proofing may be the most appropriate development option for these areas.

Other mitigatory measures may be required, as described in short term (iii) above. Fisheries are particularly significant in the RS3 area and the feasibility study should consider the impact on this sector in detail before recommendations can be made.

Long Term

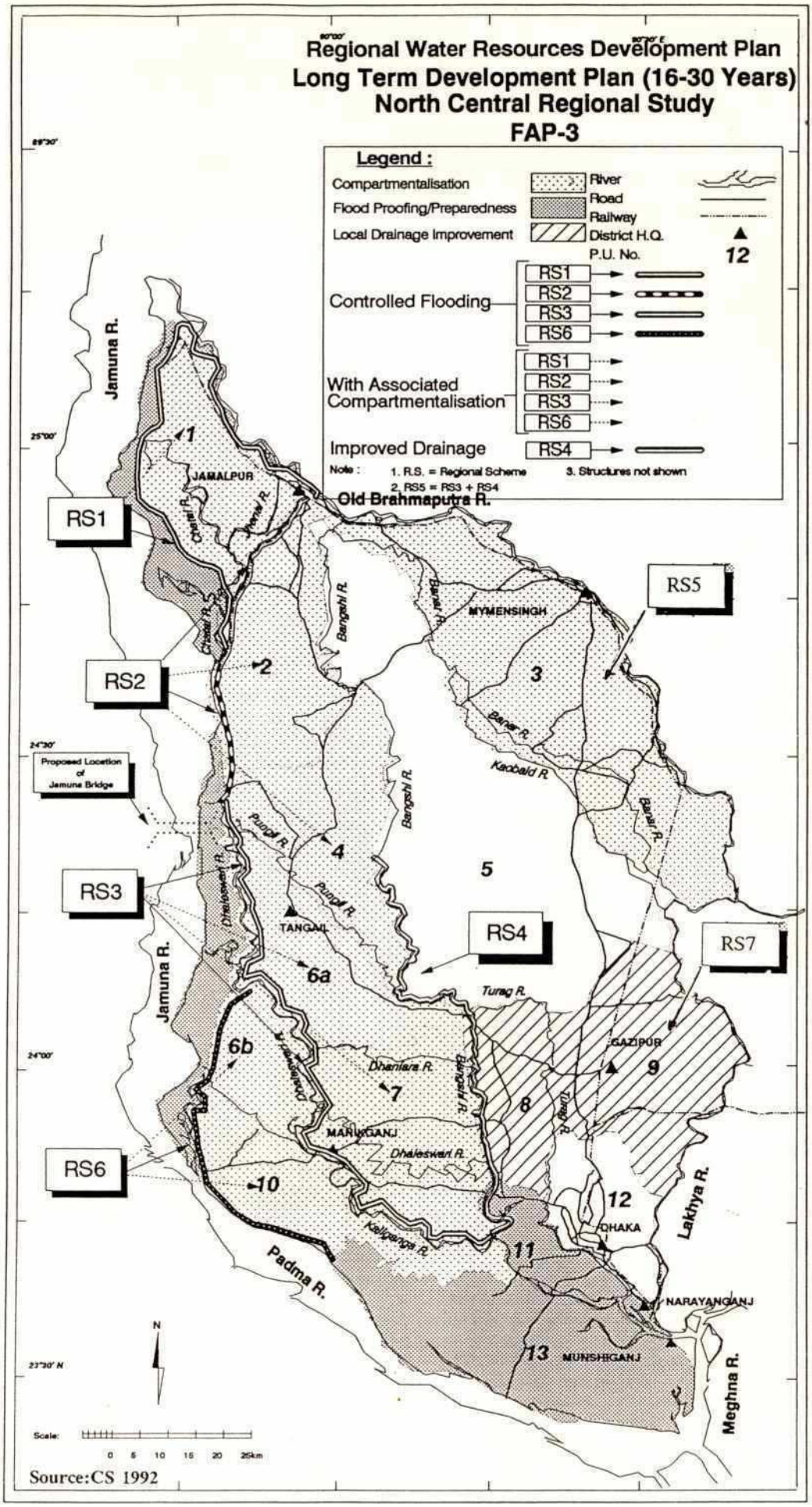
The long term plan (16 to 30 years) is shown in Figure 6.4. This gives a view on the possible long term development that best utilise the natural resources of the region. The time scale given is arbitrary being dependent on so many unpredictable factors.

(i) **RS6**. The possibility of controlled flooding being extended to incorporate PU10 and 6b has been investigated. This option has the potential of making major changes to the flooding characteristics of the region but only shows marginal economic viability. The scheme would be consistent with the south-west Dhaka project plan (proposed in the 1960's and part completed) but is an option which should be viewed with caution as if completed it would have major environmental impacts. The scheme would potentially change the hydrological system dramatically. Advice has previously been given (FAP 1990) that such drastic measures should not be contemplated at this stage. However the possibilities still remain of such a development becoming practicable and it has therefore been included as a possible development in the long term plan.

(ii) **Other Measures**

In addition to the other short and medium term measures already described, there is the potential for making local drainage improvements to PU9. However this again is limited by the high water levels in the Lakhya-Meghna-Padma system.

Figure : 6.4


Regional Water Resources Development Plan
Long Term Development Plan (16-30 Years)
North Central Regional Study
FAP-3
Legend :
Compartmentalisation
Flood Proofing/Preparedness
Local Drainage Improvement
River
Road
Railway
District H.Q.
P.U. No.
12
Controlled Flooding
RS1
RS2
RS3
RS6
With Associated Compartmentalisation
RS1
RS2
RS3
RS6
Improved Drainage
RS4
Note : 1. R.S. = Regional Scheme
2. RS5 = RS3 + RS4
3. Structures not shown
Old Brahmaputra R.
Jamuna R.
JAMALPUR
Dhaleswari R.
Jhenai R.
Bangshi R.
Banar R.
MYMENSINGH
Kaobald R
Pungli R.
TANGAIL
Turag R.
GAZIPUR
Dhanlara R.
MANIKGANJ
Dhaleswari R.
Kaliganga R.
DHAKA
Lakhya R.
Padma R.
NARAYANGANJ
MUNSHIGANJ
Meghna R.
RS1
RS2
RS3
RS4
RS5
RS6
RS7
Proposed Location of Jamuna Bridge
N
Scale:
0 5 10 15 20 25km
Source:CS 1992

6.5.6 Development Programme

The RWRDP, as described above, has been scheduled to fit into a regional development programme as shown in Figure 6.5.

The program allows for development to place in a logical sequence and for maximising the benefits of complementary activities (such as RS1b with RS2; and RS4 with RS3) where possible. It also allows for making the best use of existing facilities, by concentrating on RS2 and RS1b in the first years.

The schedule is fundamentally one of implementation from upstream to downstream (RS1b to RS2 to RS3). This is an indication of the fact that the worthwhile regional initiatives are seen to be these of controlled flooding (with associated compartmentalisation and local drainage) rather than regional drainage.

The investigations have shown that there is only limited scope for regional drainage (through RS4) and thus major downstream initiatives are limited.

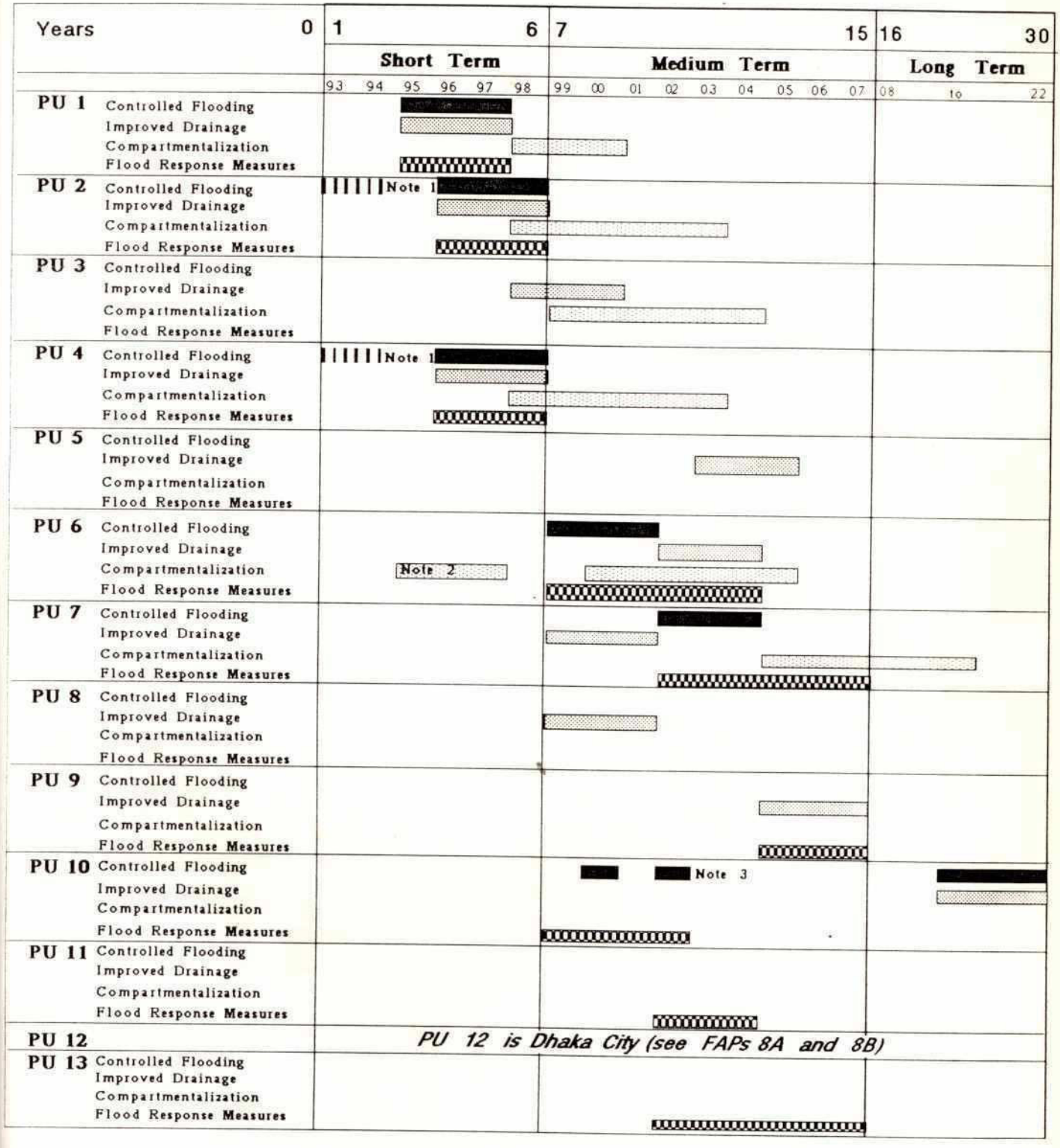
An overall planning horizon of 30 years has been used for the plan, but only those schemes that would fit into the first 15 years are considered worthy of further investigation at this stage.

A study programme for the next 3 years is set out in Figure 6.6. The figure shows the need for comprehensive feasibility studies to be carried out; and for significant interaction between FAP studies.

The financial requirements in the medium term (first 15 years) are shown in Table 6.9. These figures are based on the estimates given in Table 6.2 plus an allowance for feasibility study and designs of 3% and 5% respectively. The costings for the institutional measures required for compartmentalisation and the costs of flood response measures have not been included and should be added as soon as sufficient experience of these types of development is achieved (through FAPs 20, 3.1, 14 and 23).

Figure : 6.5

Regional Water Resources Development Plan- Programme



Controlled Flooding

Improved Drainage

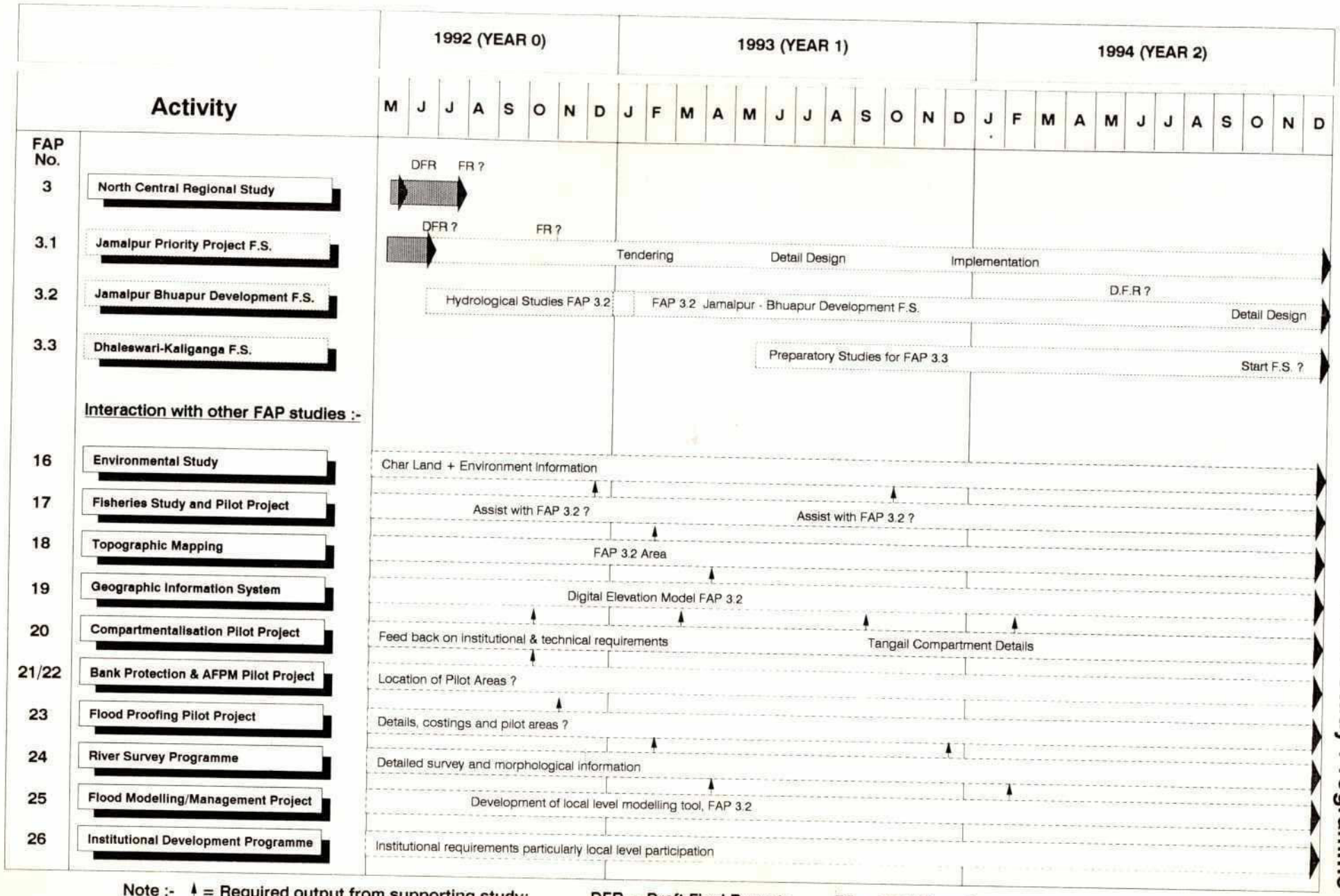
Compartmentalization

Flood Response Measures (e.g. flood proofing/preparedness/early warning)

Note :

1. Existing BWDB embankment is to be improved by RHD under funding from Jamuna Fertiliser Factory in 1992/93.
2. FAP 20's compartmentalisation is expected to be implemented in PU6
3. Embankment works will be needed associated with developments on the Dhaleswari-Kaliganga in PUs 6 & 7.

Source:CS 1992



Note :- ↑ = Required output from supporting study; DFR = Draft Final Report; FR = Final Report

Figure : 6.6
Future Study Programme

TABLE 6.9

Financial Requirements of the Short and Medium Term Plans (Tk. million)

Description of Works	Plan Year															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	(Tk.ml.)
Regional Schemes (1)																
RS1 Jamalpur Priority Project	41.7	69.6	500.8	500.8	500.8											1613.5
RS2 Jamalpur to Bhuapur Development		36.0	60.0	400.0	400.0	400.0										1296.0
RS3-Phase 1 Dhaleswari to Kaliganga Devpmnt.			14.2	14.2	23.7	23.7	255.5	255.5	255.5	85.2	85.2	85.2				1097.8
RS3-Phase 2 Dhaleswari to Kaliganga Devpmnt.						21.6	21.6	36.1	36.1	360.6	360.6	360.6	120.2	120.2	120.2	1557.9
RS4 Bangshi River Improvement			197.0	197.0	197.0	197.0	197.0	197.0	197.0	197.0	197.0	197.0				1969.9
Flood Response Measures (2)			*	*	*	*	*	*	*	*	*	*	*	*	*	Note (2)
Fishery Initiatives (3)			*	*	*	*	*	*	*	*	*	*	*	*	*	Note (3)
Institutional Strengthening (4)			*	*	*	*	*	*	*	*	*	*	*	*	*	Note (4)
Total Financial Requirement	41.7	105.6	772.0	1112.0	1121.4	642.3	474.2	488.6	488.6	642.8	642.8	642.8	120.2	120.2	120.2	7535.3

Notes: 1. The Regional Schemes include for the capital cost of compartmentalisation

2. * Flood Response Measures include for Flood Proofing, Preparedness and Early Warning. Costs should be determined after FAPs 10,14 and 23 have reported.

3. * Although fishery initiatives are described in PSR III, the costs are to be determined after FAP 17 has reported.

4. * Institutional strengthening costs to be determined after FAP 20 and 26 have reported.

5. Annual operation and maintenance costs have not been included in the Table.

REFERENCES

BBS	1990a	Statistical Yearbook of Bangladesh, BBS, 1990
BBS	1990b	Current Levels and Trends of Mortality, Fertility, Nuptiality Patterns and Internal Migration in Bangladesh, BBS, 1990.
BIDS	1989	Consumption demand for fish in Bangladesh. Bangladesh Institute of Development Studies, Dhaka.
BIDS	1990	Analysis of Poverty Trends; Projects 62 Villages Survey, BIDS 1989-90
BIDS	1991	The Anatomy of Mora Kartik, An Enquiry into the Economic Health of the Countryside, Rahman H.Z and Hossain M., Oct. 1991.
CEFEB		Guidelines, for Project Economic Analysis Andre Bussery - CEFEB-CCCE.
DA		Decision Aids - Christian Marmuse University of Lille - France.
FAP-1	1991	Brahmaputra Right Embankment Strengthening, 2nd Interim Report, FAP-1, December, 1991.
FAP-25	1992	Flood Hydrology Study, Draft Final Report, FAP-25, February 1992.
FPCO	1991a	Guidelines on Economic Analysis.
FPCO	1991b	Flood Action Plan: Guidelines for Project Assessment, FPCO, Ministry of Irrigation Water Development and Flood Control Dhaka, July, 1991.
FPCO	1992	Guidelines on Project Assessment, February 1992.
GOB	1990-91	Cyclone Damage of various crops and 1990-91 Boro prospect. Joint Assessment by Government of Bangladesh and Development Partners.
JMBA	1991	Dhaleswari Mitigation Plan, Draft Final Report, Dhaleswari Mitigation and Land the Master Plan for the Jamuna Bridge Project Areas, GHK/MRM International Ltd., November, 1991.
Maurice	1991	Controlled Flooding in Bangladesh, An Attempt to Quantify the Macroeconomic Impact on Growth Prospects; J. Maurice and A. Diallo, CCCE September 1991.
MPO	1991	National Water Plan Project - Phase II; Draft Report, Master Plan Organisation, May 1991.
NCRS	1990	FAP-3, North Central Regional Study, Phase-I Reconnaissance.
NCRS	1991a	North Central Regional Study, Draft Inception Report, FAP-3, May 1991.
NCRS	1991b	North Central Regional Study, Revised Inception Report, FAP 3, June 1991.
NCRS	1991c	North Central Regional Study, Interim Report, FAP 3, November 1991.
NCRS	1992	North Central Regional Study, Draft Regional Water Resources Plan, March 1992.
OFAUS	1990	Outlook for the Aman crop and Early Prospects of 1989-1990 Wheat and Boro Crops. Office of Food and Agriculture US Agency for International Development Dhaka, January, 1990.
UNRI	1987	A profile of Absolute Poverty in six villages of Bangladesh (Mosharraf-Hossain) United Nations Research Institute for Social Development, June 1987.

APPENDIX A
Impact Assessment for the Multicriteria Analysis

APPENDIX A

Impact Assessment for the Multicriteria Analysis

A.1 Components of the Human and Biophysical Environment

A systematic approach to assessment of the NCR's environment[1] has been developed (see SR X.5) and each component (or subsystem) concerns natural resources, biophysical constraints, economic activities, socio-economic life style, socio-economic infrastructures, cultural matter etc. A basic list has been setout, see Table A.1 for identifying interested parties, regional issues and consequently types of impacts on flood control and water management projects.

TABLE A.1

Environmental Components

<u>The Natural Environment</u>			
ea.	**Hydrology** :	*Surface*	- Flooding
			- Drainage
		Groundwater	- Irrigation
			- Domestic Water Supply
		Erosion	- Jamuna-Padma
			- Madhupur Tract
		Sedimentation	- Jamuna
			- Within Project Area (Clogging, Soil Fertility, Navigation)
eb.	**Freshwater Ecology** :	Water Quality	- Domestic Water Supply
			- Agricultural Irrigation Water
ec.	**Land Resources** :	*Soil*	- Quality/Chemistry
			- Erosion
			- Topography
			- Agro-Ecological subregion
			- Soil (structure and fertility)
ed.	**Ecology** :		- Flora
			- Fauna
ee.	**Seismic Activity** :		
<u>The Socio-Economic Environment</u>			
sa.	**Economic Livelihood**:		- Population (demography)
			- Risk
			- Settlement
			- Land Tenure (Scarcity, Values)
			- Household Structures
			- Common Resource Rights (Fish, Fuelwood, Grazing, Fodder)
			- Main Economic Activities
sb.	**Agricultural Output**		
sc.	**Fishing**		
sd.	**Forestry and Fuelwood**		
se.	**Livestock**		
sf.	**Wage Paid Employment**		
sg.	**Industry**		
sh.	**Drinking Water**		
si.	**Human Health** :		- Waterborne Diseases (Malaria, Japanese Encephalitis, Filariasis)
			- Drinking Water Quality
			- Sanitation
			- Nutrition
sj.	**Access and Transport Infrastructure:**		- Water Transport (Jamuna-Padma, Within Project Area)
			- Railway
			- Road
sk.	**Archaeology and Cultural Sites**		

[1] In its broader sense, including socio-economics

A.2 Socio-Economic and Biophysical Issues and Interested Parties

Various consequences will result from flood control and water management actions as well as regional socio-economic development projects. These environmental and socio-economic consequences will have positive and negative effects and will imply various kinds of response from the interested parties. Table A.2 gives a list of regional issues resulting from a Flood Action Plan. Although it may not be an exhaustive list, it illustrates the real diversity of interested parties.

For the NCR's Flood Action Plan to be successful it will be obliged to integrate all aspects of the regional development. From Table A.2 it is possible to draw up the following list of the principal interested parties:

G	Government Authorities
I	Institutional Actors (officials in various departments)
NGO	Non-Governmental Organizations
NB	National Funding Banks
IB	International Funding Organizations
FH	Various types of Households and Land tenure situation
L	Landless
PT	Petty Traders
RI	Rural Industry and Cottage Industry
F	Fishing and Boating Households
W	Female Headed Households

When we analyse how each socio-economic party is interested in each regional issue, directly or indirectly related to the NCR's FAP (see Table A.3), it becomes apparent that governmental, and national or international organizations as well as general public are involved in almost all regional issues. On the other hand economic actors have more specific interests. The points of view of these parties, however, may be different, and in some cases divergences of opinion may appear (see Table A.4).

Four main types of interested parties can then be differentiated:

- National and International Institutions interested by National objectives
- Environmental Protection Organizations which may have a divergent point of view with regard to the others
- Agricultural and Non-Agricultural sectors of production having above all profit objectives.
- Population and Local Communities in matters of cultural and social yearning.

Non-Government Organizations (NGO) can co-operate and adopt the same points of view as National Institutions or Environmental Organizations or local communities.

The impacts of the new situations generated by the NCR's flood control and water management projects are seen to be both positive and negative, see Figure A.1. It seems necessary in this context, to assess each kind of projects through the various points of view. In this way the assessment matrix groups together the following impacts:

- Economic Financial and Institutional Impacts which concerns specially National and International Institutions.
- Agricultural and non-agricultural impacts concerning the principal regional production sectors.
- Socio-Economic impacts which involve local communities generally speaking on their life style.
- Natural environment impacts concerning all organisation in charge of the regional environment.

TABLE A.2

Environmental and Socio-Economic Issues Involving the Various Interested Parties

Components Involved*		
	Biophysical Issues	
ea to ee	**Education & Mass Awareness**	
	ED 1	Education about health measures, diet, environment management through the secondary school
	ED 2	Professional training
	ED 3	Awareness campaigns through all forms of media about environment preservation, health, diet
ea to ee	**Environment Management**	
	EN 1	Monitoring system implementation
	EN 2	Institutional measures
	EN 3	Flood proofing, emergency measures for any disaster (service activity)
ec	**Land**	
	L 1	Land preservation and reclamation
	L 2	Bank protection, river training and dredging
ed	**Tree Cover**	
	TC 1	Preservation policy
	TC 2	Fiscal policy
ed	**Wild Life**	
	WL 1	Strengthening of the preservation organizations
	WL 2	Organization co-ordination
ea	**Flood Control, Drainage and Irrigation**	
	FCD 1	Irrigation development (presently around 39% NCR area is irrigated)
	FCD 2	Drainage development
	FCD 3	Flood warning
	FCD 4	Hydraulic infrastructure development in the Jamuna & Padma flood plain(45% of the NCR area)
	FCD 5	Supporting services
	FCD 6	Monitoring system implementation
ed	**Forest**	
	F 1	Institutional measures controlling over extraction in the Madhupur Tract (Garh Gazali)
	F 2	Afforestation
	Socio-Economic Issues	
sa	**About Basic Needs of People and economic livelihood**	
	BN 1	Security and life style improvement
	BN 2	Settlement
	BN 3	Flood proofing and Flood preparedness
sb	**Crop Agriculture**	
	CA	Agricultural Development Actions (CA1 Technical, CA2 Economic, CA3 Organizational and Institutional) for reducing negative effects of soil deterioration, narrowing of the cereal genetic base, indiscriminate use of pesticides, decreasing crop diversification, shortage of draught power.
sc	**Fisheries**	
	Fi 1	Mitigation actions for reducing the loss of fish capture production
	Fi 2	Fish culture development.
sd	**Energy and Fuelwood**	
	I 6	More wider use of piped Natural Gas, & other mineral resources in order to reduce fuel wood consumption
	I 7	Increasing of biomass production.
se	**Livestock and Poultry**	
	LV 1	Development actions for proper feeding on new cropping patterns.
sf	**Wages and Employment**	
	EM1	Employment improvement measures (for women and men)
	EM2	Equitable income distribution for the poor
sg	**Industrialization**	
	I 1	Thinking of Institutional & technical measures to control emissions, when creating industries-reducing pollution near Dhaka.
	I 2	Flood proofing
	I 3	Development of cottage industry for mitigating the uncertainties of livelihood among the rural poor especially in the District of Dhaka and along the Jamuna-Padma and Meghna flood plains having the highest population densities of the country.
	I 4	Development of nitrate fertilizer production
	I 5	Industrial and agro-industrial development
sh	**Water and Sanitation**	
	WS 1	Development of domestic water supply
	WS 2	Management of the multipurpose ponds
	WS 3	Preservation of ground water resources
si	**Food and Human Health**	
	Fo 1	Agriculture and fishery development policy in order to change the patterns of the diet towards more non-cereal crops, particularly those derived from horticulture, and to improve protein consumption.
	Fo 2	Assistance to women to improve homestead production
	Fo 3	Improvement of post harvest technologies and of grain storage.
	Fo 4	Improvement of social infrastructures
sj	**Urbanization - Rural Household Assets and Transport infrastructure**	
	URS 1	Land use plan for reducing use of good horticultural and three crop land, deforestation and water pollution and for mitigating resettlement.
	URS 2	Proper embankments to improve transport and communication networks taking into account rural household settlement
	URS 3	Mitigation and improvement of waterway
	URS 4	Flood proofing.
sk	**Archaeologic and Cultural sites**	
	A1	Flood proofing
sb-sg	**Marketing System**	
	MS 1	Adjustment of marketing infrastructures(packaging,equip.,agricul.product preservation & storage)
	MS 2	Better access to small villages and land

* Refers to Table 5.2

TABLE A.3

Interested Parties Involved by the Main Regional Issues

	Governmental, National and International Organisations					Economic Actors (Farming and Non-Farming)						Population & local communities
Regional Issues	G[1]	I	NGO	NB	IB	FH	L	PT	RI	F	W	LC
About Basic Needs of People	x	x	x	x	x	x	x	x		x	x	x
Education & Mass Awareness	x	x	x	x	x	x	x			x	x	x
Environment Management	x	x	x	x	x				x	x	x	x
Land	x	x	x	x	x	x				x	x	x
Tree Cover			x			x						x
Wild Life	x	x	x									
Water Management	x	x	x	x	x	x	x			x	x	x
Forest	x	x	x	x	x				x		x	x
Crop Agriculture	x	x	x	x	x	x		x	x	x	x	x
Fisheries	x	x	x	x	x	x	x	x		x	x	x
Food	x	x	x	x	x	x	x	x		x	x	x
Water and Sanitation	x	x	x	x	x	x	x			x	x	x
Transport & Rural Settlement	x	x	x	x	x	x	x		x		x	x
Industrialization	x	x	x	x	x		x		x		x	x
Energy	x	x	x	x	x				x		x	x
Marketing	x	x		x		x		x	x	x	x	x
Archeology & cultural site	x	x	x	x	x							x

Notes 1. Abbreviations : G = Government Authorities, I = Institutional Actions, NGO = Non Governmental Organisations,NB = National Funding Banks,IB = International Funding Organisations

TABLE A.4

Possible Divergence of Opinions Between Interested Parties

Interested parties		Governmental, National and International Organizations		Economic Actors				Rural Communities and Population
		I (G,NGO)	II (G,NGO,NB,IB)	III (FH)	IV (F)	V (R1, PT)	VI (T)	VII (LC)
I	Contribution to Environmental Preservation System (G, NGO)	NA	x	x	o	x	x	x
II	Contribution to Flood Control & Water Management (G,NGO,NB,IB)	x	NA	o	x			o
III	Agricultural Sector (FH)	x	o	NA	x			o
IV	Fishery Sector (F)	o	x	x	NA	x	o	
V	Rural, Industrial and Non-Agricultural Sector (RI,PT)	x			x	NA		o
VI	Transport Sector (T)	x			o		NA	
VII	Population and Local Communities (LC)	x	o	o		o		NA

High divergence : x
Moderate divergence : o
NA : not applicable

A.3 Impact Specification

Except in the environmental impact matrix, both quantitative and qualitative criteria are used in determining other impact matrices. A large number of qualitative criteria can make the assessment very subjective. Thus in order to strengthen and control the quality of such an assessment some basic references have been taken into account (see PSR IV) when preparing the present impact assessment. Some of these qualitative references are supported by quantitative indicators so that the assessment is less subjective than it may appear. Furthermore investigations and specialist consultations have allowed to judge assessment characteristics and make some useful reservations for the decision makers.

Beyond this problem of subjectivity there is a problem of the significance of the impacts. The matrix of valuation describes impacts in term of their magnitude, but it is necessary to give more information in terms of :

- Impact development process (because effects may be direct, cumulative or affected by synergy related to other effects).
- Geographic, chronological and temporal extent and variability
- Reliability of information for the present situation
- Sustainability
- Reversibility
- Uncertainty of long dated estimates

As far as sustainability is concerned the concept can be defined by the following logical criteria:

- The rate of resource use should not exceed that of natural regeneration or production (by a human activity).
- The rate of development of a renewable substitute and the rate of pollution should not exceed that of assimilation and breakdown
- The rate of development of a socio-economic event should not exceed that of regeneration of natural or economic resources used.

Geographic extent refers to the total area affected; Geographic variability means that impacts have not the same magnitude everywhere. Temporal extent or duration refers to the length of time the impact lasts for, while chronological variability means that impacts may be different during a construction phase and after when the project is in operation. Furthermore, some impacts may decrease in magnitude over time while others are permanent and irreversible. Tables a, b, c and d in PSR X, Annex-2 give an explanation about the significance of this assessment through each matrix and for each category of impacts.